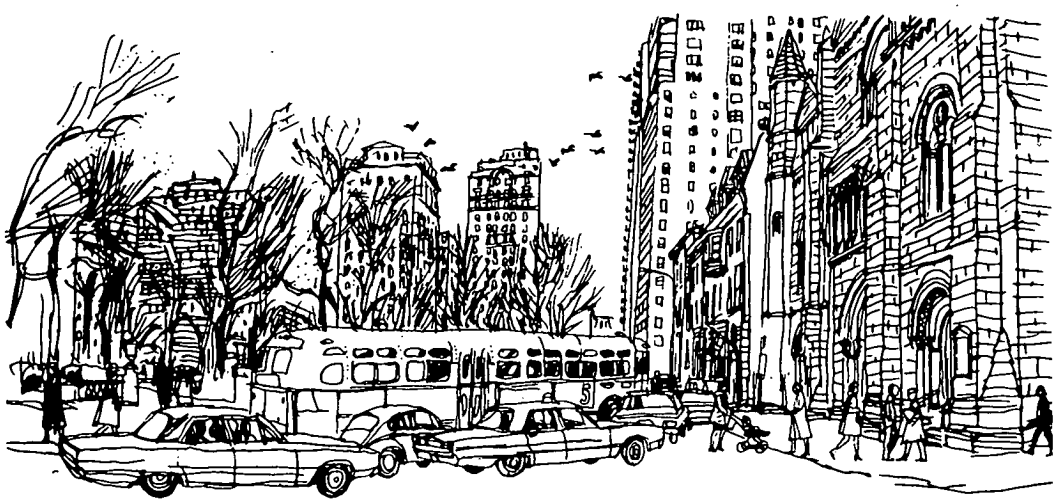
TRANSPORTATION SYSTEM MANAGEMENT



SPECIAL REPORT 172

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TRANSPORTATION SYSTEM MANAGEMENT

proceedings of a conference held November 7-10, 1976, conducted by the Transportation Research Board, and sponsored by the Urban Mass Transportation Administration and the Federal Highway Administration of the U.S. Department of Transportation in cooperation with the Institute of Transportation Engineers

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INTRODUCTION

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University of Texas at Austin

On September 17, 1975, the Urban Mass Transportation Administration and the Federal Highway Administration issued a series of joint regulations embodying a concept known as transportation system management or TSM. These federal regulations recognized that fiscal and nonrenewable natural resources are declining while the travel demands of the American public are continuing to increase. However many urban areas have a significant investment in existing transportation facilities and resources—an investment that may not be fully used. Therefore, the regulations require urban areas to more fully use their existing infrastructure and capacity before they seek federal assistance for the development of additional facilities.

The TSM concept articulated by the regulations was clearer in theory than it was in implementation; the joint regulations have given rise to a number of significant procedural, substantive, and political questions at all levels of government. At the Conference on Transportation System Management, conducted by the Transportation Research Board at the request of the Urban Mass Transportation Administration and the Federal Highway Administration, more than 400 people from throughout the United States discussed, debated, decried, and learned about these regulations and their significant implications.

Criticisms of the TSM requirements arose out of several different perspectives and at a number of operational levels. First a number of critics doubted not the soundness of the normative principle but rather the possibility of its actual application in an urban area, given the large number and kind of governmental units involved. This criticism reflected a not unjustified skepticism about the ability of one series of federal regulations to bring order and stability to a complex set of metropolitan relations that had defied the determined efforts of other federal and state agencies in the past. In particular, many professionals were concerned that the regulations mandated a role for metropolitan planning organizations (MPOs) that they had neither the resources nor the authority to carry out. They were critical of the U.S. Department of Transportation (DOT) for giving new time-consuming responsibilities to MPOs without giving them additional resources to carry out those responsibilities. In addition, since most MPOs were voluntary organizations only representing the local units of government that for the most part would carry out the actual implementation of TSM actions, many MPOs were worried that they could not devise a TSM plan that would both meet the transportation department's standards and be undertaken by the many governmental units in their regions. Should the MPO's TSM plan not be implemented, many MPOs were afraid the region would be penalized.

Other criticisms charged uncertainty and ambiguity in the language of the regulations themselves and in their interpretation by different DOT units. The regulations did not make it clear whether the long list of TSM actions contained there was a shopping list from which a locality might choose appropriate activities or whether every urban area must undertake every suggested action or justify their failure to do so. Planners were uncertain whether the TSM regulations required certain conservation activities as a procedural prerequisite to applying for federal capital assistance or whether TSM conservation measures were intended as a substitute for planned or even programmed capital expansion. Other terms in the regulations seemed unclear and did not appear to apply equally to UMTA- and FHWA-funded projects. The ambiguity in the language employed was heightened by what many professionals perceived as differences in interpretation and emphasis by officials of UMTA and officials of the FHWA.

Another perspective on the TSM regulations was that of traffic engineering professionals, who maintained that many of the TSM elements under consideration had been part of sound traffic management programs for decades and did not represent either new local options or new approaches to transportation problems. These critics noted that all of those TSM actions that would be readily accepted by the public already had wide operational experience; the only TSM techniques that did not have wide exposure were those that involved severe automobile disincentives or imposed high penalties on automobile drivers. These critics questioned the wisdom of approaching TSM as an innovative concept to be handled at a regional level by an MPO or regional planning organization when actual experience with the individual TSM elements resided at the local and at the state level in traffic and transportation departments. Some critics questioned whether an

MPO had any greater authority or ability to implement controversial TSM actions than local traffic departments had in the past.

Public involvement and political acceptance of potentially controversial TSM elements were significant concerns of many professionals grappling with the TSM regulations. Operational experience with such techniques showed a mixed record; Portland and the Twin Cities area, for example, had great success with such measures, while the preferential lane on the Santa Monica freeway in Los Angeles seemed to illustrate the worst possible consequences of such actions. There was even a mixed record with a far more coercive approach than the TSM regulations provided, that of the transportation control plans of the U.S. Environmental Protection Agency. Philadelphia and Pittsburgh failed to implement EPA-mandated measures, while Boston and Seattle were successful in doing so.

Some of these problems had already been addressed by DOT officials before the conference; the "shopping list" of potential TSM activities had been identified as just that and demoted to the Appendix of the revised regulations, some ambiguities in the language of the regulations were straightened out, and some perceived inconsistencies in the intentions of FHWA and UMTA were explained. The role sought for the MPO was also more clearly described, but the "bottom-up" model of the regional generation of TSM plans raised as many questions as it settled. In addition many of the other concerns described above had not yet been clarified, and the knowledge of the clarifications and modifications that had taken place was not widespread. Therefore, the conference was needed as a forum in which substantive data and official information could be provided and where the serious airing of controversies could take place.

The conference was structured to address three objectives: to provide the latest information on DOT policies and requirements, to provide the latest information on experiences with the actual implementation of a range of individual TSM actions, and to examine the emphasis of the regulations on a regional or metropolitan planning perspective. The conference program committee felt that one way to achieve all three objectives was to highlight throughout the entire structure of the conference urban areas that had had or were having success in implementing TSM actions. Because there was so much information to impart to participants, the committee established five plenary sessions. A series of small evening workshops allowed participants to interact with one another on a more personal basis and to delve more deeply into explicit topics or specific TSM actions. Papers on each of the major topics were commissioned and appear in this volume. Also included are reports of the workshop discussions and the case studies of the cities in which TSM actions have been or are being implemented.

SUMMARY AND FINDINGS

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During the 3½-day conference, three major issues arose continually in the substantive and informational presentations as well as during the discussions of the implementation of individual TSM actions: TSM as a planning process and the role of metropolitan planning organizations in that process, perceived conflict between short-term and long-range transportation objectives, and public involvement and acceptance of TSM actions.

TSM AS A PLANNING PROCESS

During the course of the conference, UMTA officials stressed their view that TSM is a process involving a systematic perspective on the needs and the resources of an urban area. It is not "product" oriented nor a program consisting of discrete components or TSM elements. UMTA Administrator Patricelli stressed that TSM is a process involving both planning and implementation in a unitary urban transportation system; Associate Administrator Orski described TSM as a "planning concept" that ties together the network of existing facilities and resources into a single urban transportation system. Other U.S. Department of Transportation (DOT) officials also implied that, consistent with a unitary system approach, the TSM regulations required attention to the full range of environmental, energy, social, economic, and aesthetic components of the urban transportation network.

In answer to criticisms about the inability of metropolitan planning organizations (MPOs) to bring about this unified transportation system, DOT officials suggested that the appropriate role for an MPO was, as a sort of broker, coordinating the various TSM actions suggested by the MPO's local units of government and local elected officials and at the same time suggesting other appropriate TSM actions to those localities. This approach, which came to be identified as "bottom-up," implied that those local officials who would eventually implement TSM actions should be the ones to determine the region's TSM plan. This view seemed to remove the implication that an MPO must formulate a sensible TSM plan for its region and then force localities to implement the actions contained in it. But the suggested bottom-up approach raised serious questions for many transportation professionals. One concern was how well a unitary urban transportation system could be achieved by aggregating ad hoc and marginal responses to local problems at the local level. Another concern was how active MPOs could be in inducing localities to consider relevant TSM actions and in coordinating and rationalizing local TSM responses to urban transportation problems.

Superimposed on this last set of issues was an understandable concern with not what was possible for an MPO to do but rather what UMTA and the FHWA expected MPOs to do. This concern was shared by MPOs, academics, traffic engineering professionals, and local elected officials, although the reasons for their concerns were often different. One speaker noted that in many ways TSM regulations are just another integration requirement in a long list of DOT integration requirements and that the successful planning and implementation of many TSM actions in a metropolitan area could depend in part on how strongly DOT chose to enforce this new planning requirement. Some regional representatives at the conference despaired of introducing controversial TSM actions without strong federal incentives or sanctions or both.

Other participants raised questions of how well TSM plans could meet the goal of addressing environmental and energy problems if DOT did not require coordination between TSM plans (and planners) and regional and state environmental and energy conservation plans.

Many participants also raised the issue of institutional difficulties encountered in a metropolitan area. In his concluding statement, conference chairman Thomas B. Deen said that institutional variables required DOT to be flexible in its enforcement of the TSM requirements and to be careful in specifying a rigid set of structural or substantive requirements for all urban areas. Deen noted that MPOs and regional agencies that had had some success in the past in planning and implementing creative TSM actions were having the least problem with the concept embodied in the new regulations. In general, MPOs and councils of government that had good working relations among local, state, and regional transportation professionals and between pro-

fessionals and local elected officials were far more successful in formulating innovative concepts. Those MPOs that lacked such cooperative mechanisms found the TSM regulations to be the most threatening. Unfortunately such observations also leave DOT faced with the problem of specifying planning mechanisms for those areas that have been unable to develop them themselves.

SHORT-TERM VERSUS LONG-RANGE OBJECTIVES

A number of conference speakers noted the need to more fully integrate the short-range TSM planning process with planning for the future or for major capital investments. This integration was sought in large part to resolve the controversy over whether TSM actions were intended as an accompaniment or as a substitute for capital expenditures, an issue that has not really been resolved in most urban areas.

Several discussions centered on the danger that long-range needs might be ignored because of the recent enthusiasm for TSM actions. As one participant noted, this emphasis on TSM actions might provide first-aid for problems requiring surgery. Since some TSM actions are not short-term, are not cheap, and are not easy to implement, it might be possible for an urban area to use up all available funds on TSM projects and not have enough money to address its longer term needs. One critic warned of the danger to the entire transportation network if such a situation forced urban areas to "live off" and use up past capital investments.

John Kain, the Harvard University economist, and others present at the conference have noted that, since TSM activities can be highly significant and have extreme and measurable environmental and economic impacts, they must not be treated lightly. Some critics have noted that actual experience shows that lengthy delays, skyrocketing costs, public outcries, and increased traffic congestion have been associated with TSM actions as well as with major capital improvements. There was a general consensus that many TSM activities have been treated lightly in the past, and the real relation and impact of such activities on longer range transportation plans and systems have been ignored. Because TSM activities are often extremely significant, most participants found that it is crucial that those planning such actions interact with those involved in long-range planning and programming of capital investments in the transportation system.

PUBLIC INVOLVEMENT AND ACCEPTANCE OF TSM ACTIONS

Many of the suggested TSM actions clearly had the potential to be highly controversial because they imposed significant penalties on automobile drivers or restrained traffic in ways the public was unused to. Operating experience has shown that severe public protest over actions like preemption of a lane of the Santa Monica Freeway for use as a high-occupancy vehicle lane could cause disruptive public and political protest. But many participants and speakers at the conference pointed out that it was hard to obtain meaningful, official, and public acceptance of even noncontroversial TSM actions because they were too small to generate much interest or support.

One speaker noted that transportation projects in the past generally had clear-cut support from one or more segments of society; he questioned just who provided a constituency for the kind of TSM actions being considered. Participants suggested that both controversial and noncontroversial TSM actions require a strong constituency to initiate the action and to defend it against its critics. Conference discussions, however, centered on how difficult it is to generate a positive interest either in low-profile actions that did not provide direct benefits to the public (such as new jobs) and had no dramatic impact or in controversial actions whose benefits were perceived as too abstract or external to most individuals.

One concern of many participants was that almost all TSM elements were viewed benignly at their inception. Public hearings could be held, press conferences called, and many public statements made about a forthcoming TSM action but rarely did this type of activity unearth any meaningful opposition from the public or elected officials. Once the project was implemented, however, strong opposition or just strong resistance could and often did develop from those directly affected by the measure or their local elected representatives or both. Participants were concerned because, in the absence of a constituency or strong support for a TSM action, minor protests or resistance could halt the implementation of even noncontroversial measures.

Some participants viewed this problem as simply one of poor communication between professionals and the public; some speakers suggested that planners in MPOs and other relevant public agencies had not sought visibility for their activities in the past and did not know how to use the media effectively. Other participants, however, suggested that the poor communication channels were between transportation professionals and elected public officials. Both sets of participants suggested ways to improve these communication networks at the local level.

The problem of creating a real constituency for either a controversial or an uninteresting TSM action seems to go beyond the need to improve communication and media relations. Most conference participants felt that professionals in MPOs should take significant responsibility for involving the public and all concerned public officials in the design, publication, and implementation of TSM activities. Several participants noted that planners should also work with affected interests like the business community to try to generate concern and support for the activities of the MPO.

The problem of how to handle controversy when it does arise unexpectedly was another major discussion topic. Speakers pointed out how bewildering such protests can be and how difficult they are to anticipate or handle. Other participants pointed out that it might be the responsibility of planners to see that the TSM project design could not and did not generate unexpected controversy and that contingency plans existed for those potential conflict situations that had been identified in advance.

All of the discussions seemed to imply an active and significant role for transportation professionals in state, local, and regional agencies. MPOs in particular were called on to devise good TSM actions, recognize possible sources of support and opposition, encourage the former and diffuse the latter, and at the same time maintain good communication networks with the media, the public at large, affected interests, local elected officials, and other local planning professionals! Conference chairman Deen suggested that TSM planners ought to have a better feeling for the pulse of the public, not pushing controversial items when it is obvious that they will not be accepted but preparing the groundwork to achieve their acceptance, and recognizing potential public acceptance when it is achieved. In Deen's word, "We cannot be smarter than the public, but we cannot be dumber than they are either."

SUMMARY

The 3½ days of discussion, debate, and communication answered some questions, resolved some debates, and strongly suggested some issues in need of further clarification. Two key issues stand out.

1. The first issue is a question of the appropriate role for a planning professional in an MPO and the appropriate role for the MPO given its authority and resources. Planners and their agencies have the responsibility for a lengthy list of tasks in the TSM process including devising and designing TSM actions, coordinating and rationalizing local TSM activities, educating the public and local elected officials to the virtues of TSM, creating support and constituencies for planned activities, anticipating and defusing conflicts and controversies, coordinating TSM planning and long-term planning so that one does not conflict with the other, and making sure that a region's FHWA and UMTA funds are never in jeopardy. Given an MPO's voluntary organization and limited resources, such responsibilities seem unrealistic in the absence of strong DOT support and assistance.

2. The second issue arises out of a frustation felt by many conference participants when hearing case histories of both successful and unsuccessful TSM actions. Basically there seems to be little way at this time of determining not what Los Angeles did wrong and Portland did right but more important how "wrong" and "right" can be identified before a project is begun. Most of the successful case histories presented to the conference were remarkably unselfconscious; planners from Madison, Minneapolis, Seattle, and Portland had a hard time explaining what they did right and an even harder time in understanding what everybody else did wrong. Planners from cities with failures had spent far more time analyzing the underlying workings of the complex transportation system than had planners from cities where things went well. The result is that, while we know a great deal about how to make things go wrong, we know far less about how to make things go right.

The TSM conference was a worthwhile educational experience for all participants from MPO planners to DOT officials. A number of serious anxieties were allayed and some problems have come closer to solution because of their being openly and frankly aired at this conference. But it would be a mistake to gloss over the remaining anxieties felt by transportation professionals or planners and a serious error in judgment to ignore the significant issues that have been raised but unresolved by this conference. It is to be hoped that this conference has given DOT policy makers a clear idea of the real problems and concerns with the TSM regulations at the local level and has, at the same time, given local planners and policy makers a better idea of the opportunities that TSM can offer.

WORKSHOP REPORTS

TRAFFIC OPERATIONS IMPROVEMENTS TO MANAGE AND CONTROL THE FLOW OF VEHICLES

David R. Koski
Minneapolis Traffic Engineering Division
Workshop moderator

Those attending this workshop were employed by departments of transportation for states such as Michigan, West Virginia, Colorado, Minnesota, New York, and California. Representatives of national consulting firms, the Federal Highway Administration, private industry, city traffic engineering departments, and metropolitan planning organizations were also in attendance.

All participants expressed satisfaction that there is now a realization that traffic operations is a vital part of transportation system management. They agreed that efficient use of existing public rights-of-way will be the most important factor in operating existing and developing future transportation systems.

Considerable discussion was held on the value of long-range (20-year) transportation planning in the implementation and operation of transportation facilities and on administering federally funded transportation programs through the metropolitan planning organizations (MPOs). A municipal traffic engineer pointed out that he spends countless hours on developing long-range transportation plans, goals, and objectives that frequently cannot be implemented, will never be funded, are not realistic, and do not mean much for basic neighborhood transportation operations. He raised the question: How do you get basic traffic and transportation operations incorporated into TSM long-range plans since frequently the long-range plans are developed by a metropolitan planning organization that may not be sensitive to what is required at the local level?

Participants stated that in certain instances metropolitan planning organizations may hinder transportation development because they are not in touch with what the state's needs are and have no responsibility for plan implementation.

It is clear from the discussion that metropolitan planning organizations operate quite differently throughout the country and have widely varying capabilities for developing or planning basic operations projects. In most instances, MPOs do not consist of elected officials and are thus not directly accountable to the public. But they are also not generally subject to political pressures.

Participants felt that the development of a system of warrants to authorize the installation of basic traffic control measures to accommodate transportation vehicles on streets is difficult. In many instances the warrants developed at the federal and state levels are unrealistic since they frequently preclude the possibility of installing basic traffic control devices in many areas where they are needed. On the other hand, traffic control devices cannot be indiscriminately installed without regard for their effects on traffic on main thoroughfares.

The conclusions of the workshop are as follows.

1. Long-range (20-year) transportation planning is clearly necessary; however, those long-range plans must be flexible and subject to change since frequently they do not deal adequately with local transportation operations, funding cannot be secured to implement them, and transportation modes, methods, and attitudes change because of fluctuations in the economy, environmental concerns, and development.
2. Transportation system management does not mean

that everybody travels by transit but that all forms of transportation are integrated to obtain optimum efficiency within the public right-of-way provided. The demand to use and subsequently accommodate the private vehicle (no matter what form it may take) will continue. Participants felt that, if given the choice, everyone prefers to travel in a private vehicle rather than in a mass transportation vehicle.

3. Transportation system management should not become overly complicated and cannot be tied up in red tape. Much of the funding for improving existing transportation facilities and developing new ones comes from federal sources, and the tendency to require such extensive administrative procedures in both acquiring and accounting for those funds may render TSM inefficient and even impossible to accomplish. Federal representatives in attendance indicated that procedures and methods are constantly being developed to simplify the paperwork associated with federal funding.

4. The authority, capability, usefulness, and procedures of MPOs vary throughout the country. MPOs that are not properly structured should not approve federally funded programs. Although it is necessary to establish and administer transportation programs on a metropolitan and areawide basis, the state department of transportation may provide more efficient transportation system programming, planning, and implementation in those states that are primarily nonurbanized.

5. Metropolitan planning organizations should not be given responsibility for implementing transportation programs. In the development of transportation plans and programs, they should solicit and incorporate the recommendations of those who are responsible for transportation system operation.

PREFERENTIAL TREATMENT FOR TRANSIT AND OTHER HIGH-OCCUPANCY VEHICLES

Leon Goodman
Transportation Planning Division, Port Authority of New York and New Jersey
Workshop moderator

Transportation system management programs can consist entirely of low-capital projects or can be effectively integrated in programs that have low-capital and high-capital elements.

No single type of bus or car-pool preferential treatment has to be used at all locations. There is a tremendous variety of treatments that can be effective under different circumstances. Most exclusive bus lanes (an exception is the one on Interstate 495 in New Jersey) have eventually been converted to bus and car-pool lanes. The tendency to remain a bus-only lane is not confined to I-495 in New Jersey but is common to all freeway contraflow bus lanes.

Another issue still outstanding is the use of bus lanes by deadheading buses and empty taxis. This has not been resolved yet in the New York-New Jersey area, although the recently opened Blue Lane on the Brooklyn-Queens Expressway does allow taxi use.

Participants felt that traffic volume as a warrant for implementing bus lanes was not so critical as policy objectives. However, extremely low volumes do lead to safety and enforcement problems.

In New Jersey, eligible bus-lane vehicles were those vehicles that accommodate 16 or more passengers except school buses because of their generally poor structural characteristics and the lack of a professional driver.

The workshop noted the critical importance of enforcement. For the I-95 bus and car-pool lane and the South Dixie Highway bus and car-pool lanes in Miami, close cooperation was required between county and city police. The level of enforcement and the degree of compliance are closely correlated.

In Miami the court ruled against two challenges to the legal right to operate an exclusive bus lane. The legal basis for operation of the I-495 bus lane in New Jersey was provided by establishment of the Department of Transportation. The commissioner of this new department, through his public transportation responsibilities, was empowered to establish special lanes for transit vehicles, whereas there was some doubt whether the previous commissioner of highways had such power. In Virginia, special legislation had to be enacted to allow establishment of exclusive car-pool lanes, but not for exclusive bus lanes. The California legislature mandated that the California Department of Transportation take positive steps to provide priority treatments for high-occupancy vehicles.

Primarily because of safety considerations, a major current issue is whether to permit car pools in contraflow, high-occupancy vehicle lanes. The presumption is that the drivers of car-pool vehicles would be less experienced and less competent than professional bus drivers and, further, that the privately maintained automobiles would be subject to a higher breakdown rate than professionally maintained buses. No data are offered relating to the potential greater accident hazard, but there are some data on breakdown rates for buses. During its first year of operation, the New Jersey I-495 bus lane experienced three "reportable" breakdowns per month, which were handled by an on-station tow truck.

Participants thought that car pools could be admitted to contraflow lanes on a permit basis, thus allowing some type of screening and education for potential operators in the lane. This program might include a brief training course for authorized car-pool drivers. These courses could also be attended by the bus driver. However, if there was no shoulder or buffer lane available for use as a breakdown area, then car pools, even with permit, should not be admitted to contraflow lanes.

Successful implementation of high-occupancy vehicle lanes or other similar programs is dependent on a carefully planned public information and education program. If there are to be serious initial relocations and delays, the press, and through it the public, must be fully informed. There should be a minimum of "surprises" during the implementation. Public reaction is often based not on what the conditions are but on how the conditions are perceived. In addition, adverse public reaction can be minimized if programs are initiated in stages or

on a partial basis.

Attempts should be made to implement preferential programs that might have adverse initial impacts. Under current political and economic conditions, it may be impossible to successfully implement preferential schemes that radically (and relatively permanently) worsen conditions for regular motorists.

Preferential treatments should be used to develop new transit ridership in predominantly automobile-dominant territories as well as to maintain existing ridership in areas where transit services are already established. Some evidence indicates that preferential schemes have helped existing transit services retain ridership despite adverse factors such as fare increases. High-occupancy vehicle lanes should be considered if they serve more people as priority lanes than they do as nonpriority lanes.

Priority treatments should not be used only for buses and other rubber-tired vehicles. The advantage of priority or preferential treatment is not related to any particular transit technology. It is the separate right-of-way and not the rubber tire or the steel wheel or the air cushion that produces quick and reliable transportation service. Therefore, old trolley rights-of-way may be converted to busways, trolley cars (now called light rail vehicles) may operate on an exclusive right-of-way within a freeway median, or an exclusive right-of-way may be provided for electric, rubber-tired vehicles such as trolley coaches.

Financing of preferential treatments could come from a variety of sources. Federal-aid primary and urban system funds for car-pool demonstration projects might be used to finance the signing, enforcement, and operating costs of an exclusive lane for car pools on any street or highway at a 90-10 federal-local rate. Any of the classes of federal-aid highway system funds are eligible for the construction of exclusive or preferential bus or car-pool lanes as federal highways.

Preferential treatment for high-occupancy vehicles helps to promote transit usage. Advertisements for new real estate developments frequently cite available preferential facilities as a benefit.

A preferential treatment that can be readily seen by motorists has a greater potential for automobile-to-transit diversion than a treatment that improves transit travel but is not too visible. Thus, an exclusive bus roadway within a freeway right-of-way would divert more motorists than an equivalent bus roadway on a separate alignment away from the freeway.

A study in New Jersey is considering high-occupancy vehicle lanes on the I-80 and I-95 approach to the George Washington Bridge and on sections of the Garden State Parkway. The bridge approach studies are keyed primarily to commuter travel, and the Garden State Parkway analysis is focused on recreational travel. A proposed potential transit improvement on the Palisades Interstate Parkway in New Jersey and New York is to allow buses to use the parkway (they are currently banned). This then would be an institutional rearrangement rather than a technical proposal. The notion was advanced in the workshop that in urban areas some close-in freeway sections (entire directional roadways) could be devoted exclusively to high-occupancy vehicles, and regular traffic could be diverted to available parallel routes.

As long as highway capacity is continually increased, vehicle travel will also increase. The question was asked, Should it be required that all new urban freeway construction have some provisions for preferential use by high-occupancy vehicles? The New York State study for the Long Island Expressway in Queens is specifically considering a widening, and the additional lanes would be exclusively for high-occupancy vehicles. The consensus of the workshop was that special facilities for high-occupancy vehicles should be considered for all highway-widening projects, particularly those that are radially oriented.

MANAGEMENT AND CONTROL OF PARKING

Edward J. Twomey
U.S. Environmental Protection Agency
Workshop moderator

Workshop discussion centered on an example of some problems that are encountered when attempts to manage parking are undertaken. Possible solutions to these problems were explored.

In the example, a surplus of both municipally owned and private parking exists in the central business district of a city. These two parking sources are in direct competition with each other and, since supply exceeds demand, the rate structure is quite low, about $1.75 for all-day parking. The city does not feel that it can raise the rates at municipal facilities because it would then lose business to the private operators. The city also feels that it cannot effectively institute a general parking tax because ample free or low-cost parking is available in the fringe areas surrounding the CBD. And even if it were possible for taxing to induce modal switches, there is not enough transit capacity to handle additional peak-period ridership. Finally, car-pooling and van-pooling programs have yet to catch on in that community.

This example illustrates the pragmatic problems that urban areas face in seeking to gain some control over previously unchecked and unplanned parking construction. Dramatic changes in parking pricing and availability simply are not feasible in the majority of urban areas where sufficient alternatives to single-occupancy vehicle travel are missing. However, the difficulties should not serve as an excuse for inaction, at least in the view of some of the persons in attendance. Several U.S. cities as well as many foreign cities are in various stages of managing parking, and there are enough successful examples to conclude that it can be done.

For the example discussed at the workshop, several possible solutions were explored as a means of achieving some controls over parking. The solutions focused on measures that affect the most regular and easily controlled parkers: the work commuters. Incentives such as reserving some of the excess supply of convenient CBD parking to car poolers at little or no cost could act as an effective incentive, especially if attempts were made to implement a comprehensive areawide car-pool program that focused on major employers. Appeals to major CBD (as well as urban-wide) employers to provide

car-pooling and van-pooling services to employees not served by transit have been effective in many metropolitan areas. In addition, improved transit services, especially express services in the peak periods, can divert persons from automobile to transit travel. Attempts to implement disincentives such as increased parking rates, parking taxes and surcharges, and restrictions on parking hours and supplies, although potentially effective, often give rise to strong opposition from various groups and must be planned and implemented carefully.

A more long-range and gradual solution was also discussed. This involves changing present zoning laws, which typically require a minimum number of parking spaces per unit of development, to a zoning law that would place a maximum ceiling on the number of parking spaces per unit of development. The advantage of this approach is that gradual restrictions on the supply in a given area can be achieved without adversely affecting the mobility of the population. Only new developments would be affected and, if done properly, the restrictions would not be so strict as to place the new development at a commercial disadvantage with competitors. This latter point became the subject of some discussion at the workshop. Concern was raised about the willingness of mortgage bankers to lend money to projects that are impacted by supply restrictions. This appears to be an important, often overlooked factor that must be better understood before an area begins to seriously limit parking.

The role of parking in TSM, although not discussed at the workshop, is an issue that needs further exploration. Some have even questioned the value of its inclusion within TSM. An answer to that question is that the transportation network consists of many interrelated and dependent parts, of which parking is one. Until recently, parking has often been overlooked and ignored even though it serves a vital role in the network. In short, management of parking under TSM is transportation planning, and it should be a part of any regulation that purports to influence noncapital transportation improvements.

The motives for managing parking can be diverse: congestion relief, CBD revitalization, air pollution reduction, energy savings, transit support. It can be attempted through one or more individual parking control measures that may or may not be coordinated. Alternatively, it may be attempted in a more comprehensive manner through formalized parking planning that consists of a process as well as a plan. The measures implemented would be a part of a considered scheme. This approach requires institutional coordination, a defined planning process with goals and public involvement, political commitment, and technical analysis. Although more difficult and expensive, the comprehensive planning approach may result in better and more defensible strategies than the individual measure approach. However, present evidence is lacking on which to judge the planning approach.

MANAGEMENT OF DEMAND

Michael A. Kemp
Urban Institute
Workshop moderator

The phrase "management of demand" could be applied to virtually every TSM policy under discussion at the conference. The U.S. Department of Transportation has employed the phrase with a much more restricted meaning, however, in its published material concerning transportation system management. The department's usage appears to be limited to just two concepts: (a) pricing policies for highway and transit use and (b) adjustment of work schedules. (Those are the actions listed under paragraph 4a5 of the Appendix to Part 450.1 of the federal highway regulations, 23 CFR.) The scope of the workshop discussion was even more restricted; since pricing policies were discussed by another workshop, we were concerned only with the manipulation of work schedules to influence the patterns of demand for using transportation facilities.

The status of work schedule adjustment policies as a means of influencing travel demand is a little ambiguous. On the one hand, we are told that flexible and staggered working hours have a long history and that the personnel departments of major companies are currently rushing to introduce them. On the other hand, few transportation professionals as yet have any experience in promoting the adjustment of work schedules with the specific aim of reducing the peaking of demand for highway and transit use. In consequence, the attendees at the workshop (whose varied backgrounds appeared to provide a reasonable microcosm of the full conference) could contribute little that was drawn from personal experience. Most of the time was spent instead in questioning the author of the resource paper, who has managed relevant projects in New York City and in Newark and who is an articulate and enthusiastic proponent of this type of policy.

Of all the policies discussed at the TSM conference, work schedule adjustment might perhaps be claimed to come the closest to Pareto optimality. The experience accrued to date suggests that the abandonment of uniform working hours is popular with all of the interests involved. Employees certainly like it. The employers, although negative or hesitant at first, generally find after adjusting schedules that there are several pecuniary or nonpecuniary benefits accruing to the company. And society at large gains too from the reduction of peak-hour congestion on transportation facilities. The costs and disbenefits of the policy, on the other hand, appear to be small and comprise principally the expense of promoting the idea to the public.

As far as maximizing the beneficial transportation consequences is concerned, the best form of work schedule adjustment appears to be the most radical: flexible working hours. Each employee is (within limits) free to arrange his or her own work schedule in such a way that he or she finds optimal, considering factors such as travel times and conditions and coordination with other family members. Since minimization of the time delays and the discomfort associated with traveling under congested conditions has a high priority for many employees, this "free market" in work starting times will usually imply a significant smoothing of the travel peak.

The New York City experience suggests that flexible working hours are more difficult to promote to employers than are less radical forms of schedule adjustment, and most of the companies adopting flexible time do so only after an initial period of work-hour staggering or of limited-scale experiments. Although a central agency might easily coordinate staggered work hours for a single employment center (like a central business district) or a single transportation corridor, the successful coordination of a citywide program is a far more complex problem, requiring possibly the use of a highway and transit network simulation model. The widespread adoption of flexible time, on the other hand, ought to be somewhat self-regulating in its effects on a network of transportation facilities. At the other end of the scale, localized congestion problems (such as those at particular transit stations or freeway ramps at specific times) may often be relieved quite easily by staggering the hours of nearby workers.

The 4-day workweek (still of 40 h) appears to be the least popular form of schedule adjustment with employers, and to a lesser extent with employees too. Unlike staggered work hours or flexible time, it may imply a reduction in the total volume of travel. (There appears to be no empirical evidence as to whether employees travel to a greater or lesser extent on the days they do not work than on the days they work.) To the extent that the total vehicle travel does decrease as a result of the 4-day week, fuel consumption and noxious vehicular emissions would be reduced as well as transit revenues.

Do the various forms of work schedule adjustment lead to modal shifts? The experience to date has produced little evidence that they do. Do they break up car pools? Again, there is no strong indication that they do, assuming that employment densities in the area are reasonably high. Indeed, evidence from Toronto and elsewhere suggests that car-pool formation can sometimes be helped rather than hindered.

Most of the experience accrued to date has principally involved office workers with jobs in the central business district. Among these groups, no major differences in receptiveness among different types of company or industry have been detected in the New York City project. But how about blue-collar workers who work in industries like production-line manufacturing outside central areas? Workshop members acknowledged that the flexibility to stagger hours would probably be more limited in such a case, but did not regard the problems as insurmountable.

Much valuable practical advice for promoting work schedule adjustments, drawing mostly on the experience accrued in New York City and Newark, emerged in the workshop session. For example, if one wishes the adoption of staggered work hours to produce adjustments in travel patterns, the new work starting time should be at least 30 min different from the previous one or employees may not respond. Employers are not attracted to starting times that are at minor divisions of the hour (such as 8:25 or 8:50); they prefer to stick with the more conventional ¼ or ½-h times. As to promotion itself, the New York City project has benefited from free television spots and pro bono publico assistance from advertising and public relations agencies. It is wise to make the first contact with the chief executive of a company rather than at a lower level, and it helps to enlist the services of prominent local business people as a promotional task force for the project. There are some indications (based on only limited experience) that direct approaches to employee associations and unions can be helpful also.

All of the work schedule adjustment programs to date have relied on the voluntary cooperation of employers. However, a local government that is strongly committed to promoting such a program could consider creating fiscal or legal incentives for firms to participate. Some workshop members doubted whether this was either necessary or wise.

ACTIONS TO REDUCE VEHICLE USE

Ronald J. Fisher
Urban Mass Transportation Administration
Workshop moderator

At the start of the workshop, participants were asked to state their major interest in transportation system management. These included TSM strategies for pollution reduction, impact on long-range urban development, relation of TSM to implementing agencies, automobile-restricted zones, need for an institutional basis for continuing strong local actions, a hope to find in TSM "the political answer to the automobile," and relation between metropolitan planning organizations and operating agencies. The remainder of the workshop discussion then revolved around those issues concerning TSM and less directly involved the limited set of TSM actions aimed at reducing vehicle use.

The TSM method was compared to "old-style" planning in which planners looked for the "big solution" that would solve everybody's problems at once, but really ended up focusing just on downtown trips. TSM, on the other hand, is many small solutions based on an acceptance of land use patterns as they are today. It is the responsibility of planners to reach the community, rather than vice versa. TSM actions to reduce vehicle use are generally regarded as a negative thing; these projects will fail unless people see the need for them. Restrictive aspects of TSM should not be emphasized as much as they are, for TSM is not restrictive. The focus should be on improvements to the system.

A need for establishing criteria and standards was suggested. They would help in predictions of the positive aspects of projects, such as increased pedestrian volumes for center city actions, and thus in gaining the support of merchants. They could also be used to determine if weather protection, which enhances sales in shopping centers, would do the same in downtown retail districts. Would standards have helped to convince the antibarrier people in Berkeley of the value of the traffic diverters?

An example of an institutional arrangement for a TSM project that successfully brought together various agencies is the El Monte Busway task force, in which state, regional, county, and municipal agencies worked together to develop a commitment within the task force to the project. However, the experience with the Santa Monica

diamond lane appears to have set back this working relation by creating a lot of controversy and defensiveness on the part of some, especially the city traffic department, which felt that traffic from the freeway was being dumped onto city streets. There was also little public understanding of why the diamond lanes were introduced. It was somewhat of a case in which people who usually support environmentally oriented projects were themselves the objects of a restrictive measure and did not like it. Intense public opposition even turned initial supporters (e.g., those on the city council) of the diamond lane project against it.

How does one find a consistency for an experimental project, such as the Santa Monica Diamond Lanes? There appeared to be no answers. This raised the general question, How reversible should an experiment be? If it is too easily undone and obviously of a temporary nature (as in the case of the diamond lane or experimental street closings), the experiment may not have a fair test. An automobile-restricted zone project in Boston cannot be easily closed by protests from a small group of opponents. Credible data are needed to sell such projects, and a great deal of data do exist, for example, on the advantages of mall projects to merchants. However, it would be even more effective if the head of Dayton's Department Store, which has directly experienced benefits of the Nicollet Mall in Minneopolis, were to come to Boston and discuss that experience. Projects will accumulate a constituency of people who are benefited by the project (as with resident-only parking schemes) and who will then not want to give up those benefits. Such projects may survive with a strong vocal minority base of support.

Those responsible for the automobile-restricted zone in Boston hope to build a constituency through the phasing process. Once the Washington Street mall is completed, a constituency of users will build up. The support of merchants is crucial, and the larger merchants have agreed to the street narrowing.

A reason for the general success of planning in the Twin Cities area is that the state legislature played a major role in designing the institutions there, particularly the Metropolitan Council, which was established with a mandate to produce its "development framework." Likewise, the legislature gave strong direction to the council and declared a moratorium on the construction of six remaining Interstate highway links in the Twin Cities area. Some of this strong legislative leadership can be explained, however, by the fact that more than half the population of Minnesota lives in the Twin Cities area.

One participant suggested that discussion of too many project details with the public should be avoided. Instead, one should talk about the larger objectives and develop a dialog with the public about how to improve the quality of life. He further stated that in the 1950s, when he was the traffic engineer in Richmond, Virginia, a neighborhood that felt threatened by encroaching deterioration demanded traffic barriers as a means of preserving their neighborhood. However, the initiative in the Twin Cities area came from planners. Neighborhood people then picked up the ideas of the planners and went to their elected representatives to push them with the city engineer. This often involved considerable political risks for the elected representative.

This formula was offered: Go to the community, learn their needs, and then develop a solution tailored to those needs. Do not start out with a list of actions and look for places to put them!

The public does not always demand projects, even those for which there is general support. This was the case with many highway projects. There may not be a particular problem for which a TSM project is the answer. When we make a proposal for a TSM project, we must think of whom it serves and whether it is really needed. The "constituency" for TSM may also be seen as a general one, based on a desire for conservation and tax reduction. It is thus a policy constituency to which we should respond.

The following list of objectives and constituencies was offered as being relevant to TSM.

National objectives
1. Preserve CBDs and prevent loss of human scale and personal contact
2. Stop abandonment of central city housing and neighborhoods and consequent fiscal loss of investment in infrastructure
3. Preserve neighborhoods from bad effects of through traffic

Citizen participation objectives
4. Preserve the natural environment
5. Minimize relocation of families and breaking of neighborhood ties
6. Reduce demolition of housing for freeways

Transit objectives
7. Improve transit service and keep transit routes from getting choked by automobile congestion
8. Serve the transit dependent

Taxpayer objective
9. Reduce drain on taxes caused by major new facilities

Local and national government objectives
10. Improve municipal finance
11. Conserve natural resources and energy

Some cities do not have much interest in TSM. The cities, which are automobile oriented and have less infrastructure, still have capital programs on their agenda. What should be the federal response to a city that is not interested in any TSM projects? Federal representatives in the workshop felt that their planning process would have to be reviewed and, if found to be satisfactory, the government would have to accept the position of the cities. Some cities simply do not have a lot of problems. In fact, in many places, the transportation system is reasonably good, and there is no clamor for change. In some cases, there is a need for a mix of high- and low-capital projects. A related question was asked: If money now coming from Washington is not spent, will there now be fewer or no capital grants? Federal representatives felt that there would be more attention to determining the most cost-effective alternative.

What kind of feedback from the implementation of TSM actions is needed? The U.S. Department of Housing and Urban Development requires extensive regular evaluations from its grantees; perhaps the Urban Mass Transportation Administration and the Federal Highway Administration should have similar requirements. TSM is coming into its own because of concerns over resource limitations, especially fiscal limitations; however, there is not yet much consensus on where TSM is going.

Several general conclusions may be drawn from the workshop discussion: There may be negative reactions to TSM, especially if it involves reducing vehicle use. However, these should not be emphasized, for the goal of TSM actions is to leave the public better off overall or there is little reason for the action. A careful understanding should be developed of local public objectives of such actions, and public involvement and support of broad objectives should be reached before one goes forward with TSM actions. Waiting for a public outcry of needs, however, may lead to inaction and directionless effort. Efforts must be made to define local transport problems

and to analyze closely alternative solutions in which the public is involved. In that way, the constituencies needed to sustain solutions are assured, assuming a positive feedback on the objectives desired. This action should be initiated locally, but certainly there are many actors and some form of regional forum is essential. TSM may be viewed as a set of projects, but more important it is a planning process emphasizing short-term, low-capital solutions that may also complement long-term capital-intensive solutions, which are the traditional focus for this process.

ACTIONS TO IMPROVE TRANSIT MANAGEMENT EFFICIENCY

Ray A. Mundy
University of Tennessee
Workshop moderator

Workshop participants included directors of transit bureaus for state transportation departments, directors of metropolitan planning organizations, transit operators, and federal agency representatives.

They began by listing the following areas in which improvements can be made in the management efficiency of transit operations: service standards, commuter market approaches, organization of planning and operations, integration of paratransit, use of standard cost information, role of state departments of transportation, integration of control, small capital improvements, marketing, parking strategies, and payment of transit fares. Because of limitations of time and active participation from a large number of the workshop attendees, only the first four topics were fully discussed.

SERVICE STANDARDS

There is lack of adequate service standards in the transit industry, and what good transit service is needs to be more clearly defined. Service standards will be increasingly needed as more public money is used in transit operations so that providing transit in some areas and not providing it in other areas can be justified. Several participants, however, felt that standards could represent a potential danger to urban transportation because they could be used to justify only one type or level of service to a community—that of traditional fixed-route, fixed-schedule transit operations. Participants feared that traditional service standards would prevent urban communities from developing innovative approaches to public transportation. Such innovative experimentation might include route-deviation schemes, substitution of taxi service on lightly traveled routes, contracting peak-time commuter services to private operators, and variations of dial-a-ride schemes. The workshop agreed that service standards were needed but that provision should be made so that new forms of public transportation would not be hindered by strict adherence to such service standards.

COMMUTER MARKET APPROACHES

Some participants felt that management efficiency coul be improved if ridership were to be improved and that the most likely time for this ridership increase would be during peak commuting times. Other members of the workshop pointed out that the marginal cost of providing additional peak service far outweighed the marginal revenue received under present operating conditions and thus management efficiencies would be severely hindered by servicing additional commuters. Considerable discussion ensued as to whether it was beneficial for transit systems to increase service for commuter markets. The majority of the participants agreed that the cost of providing service to these markets with additional fixed-route, fixed-schedule transit systems or even express systems appeared to outweigh the benefits derived. Alternative ways are needed by which commuter markets can be approached. Discussed were approaches such as express services using existing capacity of the transit system, subscription bus service using premium fare plan with existing transit, subscription bus service using private transportation firms, and a variety of ride-sharing approaches including van-pool and car-pool operations. Institutional and organizational problems have prevented these approaches from being used.

INTEGRATION OF PARATRANSIT MODES

Paratransit activities offer some hope for revitalizing public transportation in the United States. Veterans of public transportation planning cited, however, that paratransit is often suggested to be something that will always be just around the corner but never quite reaching fruition. How are paratransit options implemented? Some organizational form, other than that of traditional transit, needs to be used. The "brokerage" concept being tried in Knoxville was discussed for its implications to paratransit. With this concept, the city acts as an interested but unbiased third party to bring together and if necessary subsidize transportation suppliers, private or public, to provide transportation services. This approach may maximize the urban transportation subsidy dollar and achieve broader urban transportation goals of less congestion, clearer air, and overall improvement in quality of urban life. The discussion concluded with the general feeling that no one approach can be viewed as a panacea but that experimentation is needed with a variety of approaches to see what can be achieved in various urban areas.

PLANNING AND OPERATIONS ORGANIZATION

Where should planning be done for urban public transportation? Two schools of thought were brought forth by the participants. One suggested that those on staffs of metropolitan planning organizations were the most technically qualified individuals for urban planning and therefore should do transportation planning. Opponents of this viewpoint suggested that, when planning and op-

erations are separated, a great deal is lost in the final implementation of the service. The workshop participants discussed the alternative approaches but reached no conclusion other than the realization that closer coordination is necessary between planning and operation. They generally agreed that an organizational form that encompassed both these functions with appropriate control mechanisms could operate more efficiently than one that had separate control units.

CONFERENCE PAPERS

DEFINITION, OBJECTIVES, AND IMPLICATIONS OF TSM

Robert E. Patricelli
Urban Mass Transportation Administration

Transportation system management is a process for planning and operating a unitary system of urban transportation. Its key objective is conservation of fiscal resources, of energy, of environmental quality, and of quality of urban life. Broader implications of and issues raised by the TSM concept include (a) the need for a national policy on urban conservation (the federal government cannot set local land use policy, but it must restore locational neutrality to its programs); (b) institutional challenges (all elements of the urban transportation system cannot be treated in a unitary way unless the various governments cooperate fully); (c) federal support of TSM (UMTA may need transit operating funding to seed TSM operations); and (d) urban transportation and private ownership (UMTA should attempt some demonstrations of private ownership of multipurpose urban transportation systems).

One of the problems with transportation system management is that it tends to mean all things to all people in the transportation business. It is the collective stew of transportation policy and has many cooks busily adding their own ingredients. To mix metaphors, but with no political symbolism intended, it is an elephant that all of us blind men are patting on different anatomical parts and then describing in whole in learned addresses and articles (or, more dangerous yet, in federal regulations and rules.)

What is TSM, aside from something in the category of "we know it when we see it"? The cowardly way to define it is to quote from the federal regulation:

> Automobiles, public transportation, taxis, pedestrians, and bicycles should be considered as elements of one single urban transportation system. The objective of urban transportation system management is to coordinate these individual elements through operating, regulatory and service policies so as to achieve maximum efficiency and productivity for the system as a whole.

That is not bad, for a federal regulation, though perhaps it is only a beginning. Let me try it a little differently.

First, TSM is preeminently a process for planning and operating. It is a way of thinking about the unitary system of urban transportation. It is not a fixed set of programs, but it must produce hard program applications to pass federal muster.

Second, its key objective is conservation, a term I prefer to "efficiency and productivity," for it connotes broader values than saving money. And it is conservation of several elements simultaneously—of fiscal resources, of energy, of environmental quality, and of urban quality of life.

There are also some things that TSM is not, and there has been a tendency to fuzz the definition in some of the departmental literature I have seen. It is not, for example, the same thing as the Annual Element of the Transportation Improvement Program. An area's TSM plan may be found in the Annual Element, but there is more to both TSM and Annual Elements than that simple equation implies.

Nor is TSM all transit operational planning. UMTA has been trying to reorient its section 9 planning funds and its metropolitan planning organization (MPO) work programs more toward short-range operational planning and away from an overemphasis on long-range plans and alternatives. But some operational planning may not be TSM oriented, and some TSM planning and programming are long range. So let us not make that mistake.

Nor is all action to increase internal transit management efficiency properly a part of TSM, even though the official Appendix to the Joint Planning Regulations implies otherwise. Here I think the federal language has gone too far in terms of adding ingredients to the stew. If improved transit cost accounting and other management tools or improved vehicle maintenance can be counted as TSM elements, then why not improved methods of roadside grass cutting or improved railroad work

rules? If TSM is to retain any core meaning, it has to be understood as something different from any and all actions involving better internal management.

Finally, it would also be a mistake to think of TSM—in alternative analysis terms—as the maximum bus alternative. Although it is true that one of the hoped-for benefits of TSM planning is to reduce unnecessary emphasis in transit planning on new high-cost fixed-guideway solutions, some maximum bus alternatives may not be responsive to the TSM conservation ethic of saving money, energy, environmental quality, and urban quality of life.

Well, whatever it is, it is taking hold worldwide. I was struck by this at an international conference on transportation and urban planning that the U.S. Department of Transportation hosted in Washington for the Economic Commission for Europe—a UN-sponsored group of some 20 east and west bloc industrialized nations. In country after country, the predominant theme was urban conservation and low-capital transportation planning that is responsive to it—TSM, in our terms.

Let me now proceed to some thoughts on the broader implications of, and issues raised by, the TSM concept. I offer four points.

NEED FOR NATIONAL POLICY ON URBAN CONSERVATION

The preservation of urban centers and their quality of life are high national priorities. I have operated UMTA with an emphasis on this principle to an extent never approached before in the relatively short life of the agency. In fact, most of the principal innovations during 1967 and the latter part of 1975 have been responsive to this objective—funding of transit mall and automobile-restricted zone experiments, people-mover programs, stress on joint development and value capture opportunities, and the TSM policy itself. Where we have made commitments to new rail starts, it has been with important attention paid to the developmental and land use impacts of the proposal.

But, as has been said repeatedly, an urban transit program oriented to preservation and conservation needs to be part of a broader effort at all levels of government. Well-intentioned transportation policy alone is obviously not enough. If a region's housing and business locational patterns and markets continue to stress suburban sprawl and low-density development, conservation-oriented transportation policy is obviously going to have limits. New roads will have to be built; new bus or paratransit service will have to cope with low densities. Transportation policy, in the face of these surburban development trends throughout the country, has become compensatory in character. We use improved transportation infrastructure to compensate for the long distances that have to be overcome for us to suit our preferences in residential and job location.

The situation is akin to other kinds of compensatory programs we operate. Take federal aid under the Elementary and Secondary Education Act—called "compensatory education." Because we chose to live in patterns of economic, social class, and racial segregation, we created conditions of inferior educational opportunity in inner-city schools. But rather than dealing with the cause of the problem, we seek to compensate for it by putting extra money into those schools to raise their quality. The same is true of most of the human resources, block grant, and revenue-sharing programs the federal government operates; they are attempts to compensate for the consequences of the spatial living patterns our society has adopted.

Federal aid to urban transportation infrastructure has been no different. In building new commuting highways and radially oriented transit and commuter rail systems, we have made it easier for people to live longer distances from their jobs. The transportation system is part of both the cause and cure for the land use problem.

Having recognized this character of our program, perhaps the question then becomes, Is it wrong? What social policy should guide the urban transportation program? Should the federal government adopt a policy stressing high-density, economically integrated living patterns? Should we discourage people from living in single-family dwellings on half-acre suburban lots? Here I must quote Adlai Stevenson to the effect that, in a democracy, the leaders cannot be smarter than the people. And the fact is, for the foreseeable future at least, the people seem to want it that way.

I believe that change is coming, but that it will come incrementally and slowly and in response to economic factors. Above all, it must come locally. The federal government simply cannot, as a pragmatic political matter, set local land use policy contrary to the wishes of the electorate. But, at the very least, it would seem fair to ask that federal policies be more or less neutral as to residential and business location decisions between cities and suburbs. In the past, I do not think they have been. Highway programs, transit programs, water and sewer grants, housing mortgage guarantees—all have facilitated outmigration of people and jobs from cities.

What we need at the federal level is a conscious effort to restore locational neutrality to our programs. In transportation terms, that seems to me to involve devoting funds to highway and transit capital plant maintenance in cities. It means focusing new transit fixed-guideway infrastructure, with its positive developmental and tax base impacts, on central cities and close-in neighborhoods that choose redevelopment and high density. And it means UMTA being prepared to give preferences to communities and regions that, at their own volition, develop urban conservation strategies cutting across transit and other functional areas. It means that suburban residents will have to help pay for the problems that suburban life-styles leave behind in the central cities and that the federal income tax is one way for that geographic resource reallocation to take place.

I do not want to imply, with this bit of social philosophy, that TSM policies are not needed in a setting of increasing suburban sprawl. It is simply a matter of observing that they will not work so well. They will not be assisted by locational patterns that tend to reduce the number of trips. In such settings there remains a strong need to get the maximum capacity out of our infrastructure to accommodate increasing trip generation. But the broader goal of urban conservation, in such settings, is likely to have to await changes in regional land use patterns.

INSTITUTIONAL CHALLENGES OF TSM

The second point I want to make has to do with the intergovernmental institutional challenges raised by the TSM philosophy. It is impossible to treat all elements of the urban transportation system in a unitary way unless the various governmental bodies that control those different elements are cooperating fully.

At the local level, I believe that TSM strengthens the rationale for the role of the MPO as a forum through which local and state governments can work out common plans. City traffic departments, municipal parking authorities, state highway and transportation departments, and public and private transportation agencies must all be part of the picture. The tactical basis for the MPO strategy is the idea that all the participants can cooperate best on some neutral territory that is not strictly the province of one level of government. The weakness of MPOs derives from the same principle, however;

since the MPO represents no level of government, it has no direct powers of implementation.

From the federal point of view, I continue to think that the MPO is the best of a series of less than satisfactory alternatives through which to encourage the kind of cooperative planning that TSM requires. Moreover, the federal government is probably wise to stay out of questions of the structure of MPOs and to continue to leave to local decision making the issues of relative voting strength among jurisdictions, the direct participation of the state government or the transit authority, and the like. We are for whatever works—the output, not the structural input. At the same time, though, UMTA will be placing increasing emphasis on the pass-through of planning funds from the MPO to state and local governments and the transit authority. They are the real actors and must be directly involved in the planning and committed to it; therefore, they must have a large share of the money. Probably the greatest enemy of a cooperative TSM plan and an effective MPO is the creation of a large MPO staff that develops a life of its own and that is not responsive to the wishes of the public agencies it serves. I do not envy the lot of the MPO director; it is a narrow line he or she must walk.

TSM also poses a challenge to the organization of the federal government and the Department of Transportation. Given the separate existence of UMTA and FHWA, and with rail and airport planning outside of either, we are not structured to facilitate a unitary approach to urban transportation. I am convinced that most aspects of UMTA and FHWA programs should be merged and the administrations consolidated, but that this must be done incrementally and carefully. We need more and better coordination with our TSM allies in the Department of Housing and Urban Development, the Environmental Protection Agency, and the Federal Energy Administration as well.

Finally, there are two other institutional issues that good TSM planning must face. One is the need to plan for goods movement, a subject constantly overlooked. The other is the need for broad citizen input. I left this to last, but it may be the most important. One of the conclusions that emerged from the international conference I referred to earlier was the observation that citizen involvement almost always had a conservative impact on transportation planning. It may be that the most important self-executing device to facilitate TSM planning is to closely involve citizens who do not wear the jurisdictional blinders or have the high capital preferences evidenced by many transportation planners.

UMTA SUPPORT TO TSM

A third question has to do with how the federal government should support, encourage, and evaluate TSM activities at the state and local levels. I am struck by the fact that we may have to devote some targeted money to the job, at least at the outset, rather than hope that TSM planning and implementation can be accommodated within existing funds.

From the planning point of view, there is less of a problem. I believe that planning funds from UMTA and FHWA can support most necessary TSM planning if priorities are set properly. Transit operations are another matter, however. Most transit authorities simply cannot—in the face of their spiraling deficits and funding agency pressures—free UMTA section 5 funds for innovative TSM implementation, especially where there is additional front-end cost involved. Nor is it possible for UMTA, through the research and demonstration program under section 6, to stimulate direct TSM activity throughout the country. The appropriations will never be large enough to permit that.

The answer may be for the Congress in 1977 to give UMTA some transit operating funding (in a new subpart of section 5) that can be awarded on a discretionary basis and in sufficient magnitude to seed TSM operations broadly throughout the country. Such a discretionary federal operating assistance program might also include among its objectives furtherance of other federal priorities, such as increased energy efficiency and service to the elderly and handicapped. In short, our experience with section 5 to date raises serious questions about the extent to which it can function as a change agent in our current context of rapidly rising operational deficits. As much as I generally dislike new categorical programs, we may not be able to stimulate improved transit efficiency and productivity without devoting some earmarked federal resources to the task.

URBAN TRANSPORTATION AND PRIVATE OWNERSHIP

Finally, I want to deal with an issue that is raised in part by TSM considerations, but that has broader implications as well: Should we make some effort to reverse the trend toward public sector delivery of urban transportation services?

With the arrival of the UMTA capital program in the 1960s, the federal government assisted in the conversion of the transit industry from one characterized by multiple private owner-operators to monopolistic public ownership and operation. Faced with the need to get tax subsidy into the transit capital and operating accounts, we seem to have assumed that could only be done by converting the industry to public ownership, even though public subsidy and public ownership are potentially quite different.

In accomplishing this change, we have exacerbated the situation in at least two respects. First, it seems to be the case that some of the incentives for cost-conscious operation have gone out of the transit picture. By that I do not mean that public managers are inherently less efficient than private managers—although that is an interesting debate in itself. It is not so much internal management as it is external pressure. Transit has been opened up to a series of political influences on fare policies, service policies, and labor work rules and pay scales that have had the result of vastly increasing operating deficits. Things just seem to cost more when they are run by government.

The 1976 Study of American Opinion Concerning Public Attitudes Toward Business and Government, conducted for U.S. News and World Report and based on a random sample of about 7000 household heads, asked the following question: What would happen to costs if government ran the railroads, airlines, and buses? Seventy-three percent of the respondents said costs would go up, and 30 percent put the increase at 25 percent or more.

Second, public takeovers of transit services have created problems in terms of coordination of urban transportation services between the public and private sectors. This is a TSM-related problem. Where the public sector controls passenger movements on buses and trains while the private sector predominates in automobile use, van pooling, parking, taxis, and goods movement, there are obvious ownership barriers to the TSM objective of managing urban transportation as a single unitary system.

I would like to see UMTA attempt some demonstrations of increased private ownership of multipurpose urban transportation systems as a response to these problems. For example, could we not experiment with

urban transportation companies that offered a variety of products and used a variety of vehicles—a company that, through greater versatility, avoided the labor waste between peak periods that is at the heart of the labor inefficiency of transit? Could we not hypothesize a company that combined bus and taxi functions—one that used bus drivers in the off-peak period to drive taxis and other paratransit vehicles or that took on off-peak movement functions such as mail and parcel delivery and distribution of newspapers to outlying delivery points?

Such a company would not have to be shut off from public subsidy. Many or most of its vehicles could be bought by public authorities and leased to the company at little or no cost. Operating subsidies could be provided subject to public utility type of controls.

The point is that, if the TSM view of urban transportation as a single system is sound, should not our institutional delivery system move in that direction and, it is hoped, be under private ownership?

CLOSING REMARKS

I hope I have helped to clarify the meaning and some of the implications of transportation system management. If one is still not sure what it means, then I can only say that—whatever it is—it is the most important program direction UMTA is emphasizing.

HEADING IN THE RIGHT DIRECTION

Norbert T. Tiemann
Federal Highway Administration

This paper discusses how the Federal Highway Administration arrived at the policy of transportation system management, why FHWA thinks TSM is important, and just how it will contribute to improving urban transportation.

In the past 25 years, the federal and state governments have jointly responded to the nation's need for increased mobility by constructing more roads for automobiles, trucks, and buses to get into, through, and around urban centers. The result is that Americans today are the most mobile people in history and have many choices of where to live, work, or relax. But the effort has not been an unqualified success, especially in many urban areas. Traffic congestion still exists on urban streets and has recently become compounded by the twin problems of environmental pollution and unrestrained energy consumption. Obviously, relying solely on the "more-roads" approach to give urban areas some moving space is not the answer.

At the Federal Highway Administration, we have come to realize (as have the people in the Urban Mass Transportation Administration) that we can no longer say that we will solve urban transportation problems in the future and expect people to endure those problems in the present. While doing long-range planning, we must also direct our attention, skills, and resources to the daily problems encountered now by people who live, work, shop, and move around in urban centers. As managers of a transportation network that is impressive both in terms of size and cost, transportation professionals, transit operators, and public officials must cope directly with the problems resulting from the inefficient use of this public and private investment.

We cannot settle for a posture that looks only to the distant future for capital-intensive, long-term methods of improving urban transportation. Rather, acting together, we have the responsibility—and the capability—to take the initiative in implementing short-range as well as long-range solutions to transportation problems. And in doing so, the objectives of mobility improvements, energy conservation, and urban environment enhancement must be weighed, not as competing pressures to be dealt with independently or traded off against one other, but as the mutually related forces they indeed are.

FOCUS OF TSM

Many individual TSM strategies are not new and, in fact, are the bases of good traffic engineering. Techniques such as channelization, signalization, and computerized traffic control systems can significantly help to accommodate traffic demand. Progress has been good in improving highway efficiency by using these techniques and further improvement will certainly be made, but our accomplishments will be limited if we take only those actions that improve the capacity of the highway to handle the ever-growing traffic.

We must also concentrate on ways to decrease that traffic. Several TSM strategies, such as preferential treatments for transit and car pools, have convincingly demonstrated their effectiveness to do this. For example, the reversible exclusive bus and car-pool lanes on the Shirley Highway (I-95) in northern Virginia during rush hours serve three times the number of persons per lane at an excellent level of service as the normal lanes do at a badly congested service level. Before being suspended (a court ruled that environmental assessment procedures had not been followed properly), the controversial Diamond Lane in the Santa Monica Freeway was serving the same number of persons in approximately 10 percent fewer vehicles.

These accomplishments were brought about by dramatic increases in car-pool and bus riders. Other preferential treatment projects for car pools and buses in places as diverse as Honolulu, Seattle, Portland, San Francisco, Miami, and Boston are confirming our conviction that such efforts can reduce traffic congestion and thus increase the efficiency of urban highways.

AUTOMOBILE-RESTRICTED ZONES

I would like to single out one particular TSM strategy—a relative newcomer to the American urban transportation scene—that can also change the nature of user demand and that, I believe, will become a common feature in many of our cities. That strategy is the automobile-restricted zone (ARZ).

Automobile-restricted zones in downtown areas have a special appeal to a large number of people for many reasons. Redesigning the use of urban space and making walking a more pleasant experience can help resolve

a variety of urban problems: air and noise pollution, traffic congestion, deteriorating retail sales, and loss of an ambience that can only be found in dynamic city centers.

I have seen many pedestrian malls that some 70 or so American cities have created on one or two blocks of a downtown shopping street, but the real positive impact of downtown automobile restriction did not strike me until I saw what the Germans had accomplished in Munich. They have closed off an extensive portion of a major urban thoroughfare and have established a network of attractive, pedestrian-only streets well served by public transit.

More than 300 other European cities have implemented similar automobile restrictions in carefully selected areas; in fact, this measure has become an integral part of comprehensive urban transportation planning. Several U.S. cities have taken similar action by restraining automobile and truck traffic from certain areas while granting free entry to public transit and taxis. These "transitways" are becoming increasingly popular as cities follow the lead set in Minneapolis with Nicollet Mall, Philadelphia with Chestnut Street Mall, and now Chicago with State Street Mall.

Successful ARZs are positively influencing pedestrian and commercial activity. Traffic-free areas attract and appeal to people as pleasant places to be because the conflict with vehicles has been reduced or eliminated; there is less air and noise pollution, and the design of the area can be on a human scale. Greater numbers of pedestrians lead to increases in retail sales for almost all merchants. Frequently, it is the once-skeptical merchant that becomes the ardent advocate of the ARZ and the chief supporter for enlarging the area, as is the case in Chicago. The ARZ, in effect, acts like a magnet for people and business. In Minneapolis, Nicollet Mall and Skyway network are credited with helping to attract the the $350 million in new building that has occurred in the area.

Paying careful attention to the needs of pedestrians can change the demand placed on urban highway facilities by making walking an attractive alternative to the private or public vehicle, especially for short trips.

Pedestrian improvements and traffic restraints must go hand in hand with efforts to improve public transport services. It is unlikely that totally vehicle-free urban centers are going to spring up in the immediate future, nor is this necessarily the intent of automobile-restriction measures. However, a reduction in nonessential vehicle traffic could be achieved in stages that would include selected expansion of traffic restrictions, better transit service, and improved capacity on adjoining streets. In short, an effective areawide traffic-restricted zone depends on successfully joining a variety of TSM actions: preferential treatment for transit, rational parking policies, signal control, and capacity improvements on alternate routes.

At FHWA, we are encouraging states and local areas to actively consider ARZs. We have notified state transportation agencies and local planning agencies that federal-aid urban system funds can be used for both planning and constructing ARZs. In line with our procedures that give local government options on how these urban system funds are to be spent, local elected officials can work through their appropriate local forum and with the state agency to propose such projects for funding.

Since 1975, when we began to stress the eligibility of ARZs for urban system funding, we have been encouraged by the interest and enthusiasm that we have encountered. Some 30 urbanized areas across the country are in the process of considering or planning a traffic management strategy that includes an ARZ. For example, Chicago is using $2.2 million in federal-aid highway funds to help construct the State Street Mall, and I expect many other cities will tap this funding resource in order to give substance to their desire to improve the downtown environment. I personally am pleased that states and cities are beginning to exercise the flexibility of federal-aid funding that many of us worked hard to get written into the 1973 Federal-Aid Highway Act.

LOCAL INITIATIVE VERSUS FEDERAL ACTION

I am pleased to see an increasing number of local areas taking the initiative in making the really tough decisions that have to be made if energy consumption is to be reduced and air quality standards achieved. I believe that most people do not want further intrusion by any agency of the federal government into the affairs that can—and should—be solved in the local forum. So it is really up to state and local officials to take full advantage of these opportunities to improve transportation-related air quality and energy conservation efforts. This local initiative can make it unnecessary for the federal government to prescribe to local areas the methods by which these objectives must be met. The flexibility of federal-aid highway funds to be used to support a wide range of locally chosen TSM actions is just such an opportunity, and we stand committed to assist state and local agencies to use this funding flexibility.

INSTITUTIONAL FRAMEWORK FOR TSM

What is really new about TSM is not the techniques themselves, but the institutional framework, the cooperative way the individual techniques are put together into a package of strategies by the various partners in the urban transportation business. In the past, urban transportation management was characterized by a number of disparate groups, each acting more or less independently and each more or less influencing the efforts of the others. Traffic engineers tackled the day-to-day operational problems of the highway system, planners wrestled with the problems of 20 years into the future, and transit operators tried to keep their fleets on the road—or the track. How much more effective it would be if all these partners would sit down together, discuss their problems, and agree on specific actions each could take that would complement the action of the others so that mutual problem solving is achieved.

We believe that metropolitan planning organizations can serve as appropriate forums for such problem solving. We know they are controversial, and we hear complaints about the presumed rigidity of the institutional aspects of our urban planning regulations. In fact, however, our recently completed urban system study shows that extremely wide variety and flexibility do exist in actual operations. It appears that, where state and local officials are committed to cooperation, MPOs can and do work well.

CLOSING REMARKS

As this nation enters its third century, I think it is obvious that our thinking and habits will have to change if we are to create more livable urban centers. The future of our cities will depend on how well we accept today's challenges:

1. To produce increments of growth that are less hostile to humans and their environment;
2. To extract more and more from dwindling resources, including financial and natural resources, or

find acceptable substitutes;

3. To meld the special skills, disciplines, and talents of people who have historically acted in isolation into a cohesive forum for mutual problem-solving; and

4. To explore new ways of getting things done, including new forms of joint enterprise among planners and engineers and transit operators, and among all levels of government.

The Federal Highway Administration believes that the thrust of TSM is aiming all of us in the right direction. If we have the wit to perceive the raw materials around us and the will to use them creatively, often in nontraditional ways, we can shape a present and a future that can promote better transportation management, improve downtown commercial activity, and enhance the livability and environmental quality of the urban center.

IMPROVING PUBLIC FACILITY SYSTEMS

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This paper seeks to evaluate TSM within the larger context of the problems and characteristics of transportation and other public facility systems. Necessary to this are two other objectives: identifying the problems and characteristics of public facility systems and identifying strategies for improving their performance. The discussion is cast at the level of a class of systems. No attempt is made to evaluate the degree to which each public facility holds to the characteristics of the class of systems, although particular systems will be referred to in order to illustrate points or where an exception is illuminating. TSM is addressed at the end of the paper to provide a perspective on the problems it seeks to solve and on our expectations from it.

The term public facility systems refers to public and private transportation systems, electric and gas utilities, telephone utilities, water supply and sewage systems, public schools, welfare programs, health services, and other goods and services supplying activities that are either in the public sector or in the private sector in a public utility format.

The systems appear in diverse forms. They have differing histories and differing institutional forms; some are completely within the public sector, and others have certain private sector features. Their similarity is in the extent to which they exist within a strong context of public sector rules, organizations, and decision making.

Public facility systems are not the only entities affected by government actions. Governments provide legal context for free markets—including providing for property rights and their transfer and assuring competitive conditions. The public sector affects the distribution of the income and wealth; its actions express social preferences for good things (preservation of historical artifacts, for example) and against bad things (elimination of unsightly billboards); and it attempts to stabilize the economy. Public facility systems are not uniquely related to governments; government interaction is everywhere.

Economists distinguish usefully, but not absolutely, between private goods and public goods. Private goods are privately consumed and the consumption of the good by one person excludes consumption by all others. Public goods are those for which the principle of exclusion fails for one reason or another. In some cases exclusion may not be desirable either for public or efficiency goals. Although it would be possible to exclude some children from the education system, it would not be socially desirable. Although it would be possible to keep some licensed drivers from using the roadway system, no efficiency would be gained as long as roadway capacity is available. The results of some activities, such as the cleaning of the air, are so widely diffused that there is no way to exclude individuals from enjoying them. As a result of these features of public goods, voting is substituted for the market mechanism, and the public expresses its preferences in a collective way.

Distinguishing between public and private goods is useful. It is one cornerstone for the theory of public finance, which enables economists to apply normative economic principles to public sector matters while recognizing the differences between the public and the private sectors. But while useful, the distinction between public and private goods does not neatly distinguish public facility systems from other systems. Many public goods are provided by the private sector (armorments, for example), and many private goods are provided by the public sector (lumber from the national forests).

Another point to be considered in approaching public facility systems is the potential for spatial monopoly combined with the efficiencies to be gained from spatial monopolies: In a service area, one water supply facility is less expensive than many, one highway system is less expensive than many, and one electric utility is less expensive than many. The spatial monopoly potential and government activities to deal with that potential are another consideration bearing on public facility systems. Again, however, this is not a distinguishing dimension, for there is potential monopoly in most if not all forms of endeavor. The neighborhood drugstore or a steel rolling mill serving a regional market enjoy degrees of monopoly power from their spatial location.

So when considering public facility systems, one should bear in mind that their common feature is the degree to which they perform within the context of public sector rules and organizations. On other dimensions, some of which were mentioned, they are quite different.

This context of public organizations and processes should not be dismissed as an accident of history or as incidental to other major dimensions. Each facility system was brought into a strong public format for good reasons. Attentive publics claimed rights, and politicians responded to these rights as political imperatives. Politicians crystallize claims, and they use those claims to rights as a basis for political power and political action. Although not all rights recognized by attentive publics result in the creation of public facility systems, all public facility systems were knit in a response to claims to rights. The systems' past, present, and future turn on the manner in which those rights are viewed by the public and treated in the political process.

The right of access to the transportation system was

well established in medieval Europe; that right continues to be expressed about the public road system and common carriers (1). The right to health, first recognized in this country around 1900 as public health, accelerated the deployment of water and sewage facilities; and the right to health, somewhat more broadly expressed, is currently a matter of great public debate. The right to service from electric and telephone utilities, in parallel with monopoly and efficiency issues, left strong imprints on those systems earlier in this century, and rights continue to be a matter of public debate.

It is important to note that, to the extent that service from a public facility system tends to be claimed as a right, the political process treats that service as an absolute and a thing by itself. As Braybrooke and Lindbloom (2) point out, activities become disjoint; trade-offs, benefits, cost, and program coordination become secondary matters. The economists cry for rationality, the consideration of costs and benefits, the consideration of the impact of one program on another, and the consideration of efficiency takes second place in the debate. The plaints and protests of economists collide with the logic of political process: the logic of "fair shares" and "rightful entitlements." Equity concerns, mediated by political power, must be considered along with efficiency before economic rationality can claim strategic value.

The concerns of this paper are the problems of public facility systems and what might be done to ameliorate those problems; transportation system management is of particular concern. The remarks just made provide a strong, overarching context for those concerns. The context of rights to goods and services, the political process and the manner in which it treats those rights as imperatives, and the intertwining of political institutions with public facility activities are a first consideration for individuals or institutions striving for change.

CHARACTERISTICS OF PUBLIC FACILITY SYSTEMS

Public facility systems are shaped by their response to rights and goals framed in terms of those rights, and they operate within a public sector context. The characteristics to be emphasized in this section are those reflecting goals and context. One normative criterion would be that of how facilities perform under those conditions. Another appropriate normative criterion might stem from the ways in which attentive publics judge the systems: Is the public unhappy or not? A few normative statements will be made in the discussion to follow; for the most part, these are based on the criterion of public satisfaction. Public satisfaction is noted for two reasons: (a) Dissatisfaction is a basis for system change vis the political process, and (b) satisfaction is an effectiveness measurement. It is a measure of how the public views the relations between resources used and outputs obtained, and their distributed impacts.

Control

While the day-to-day control of public facility systems is in the hands of facility managers, overall control is housed in regulatory or standard-setting agencies, such as the Interstate Commerce Commission, and sometimes funding agencies, such as the Environmental Protection agency and state and federal education agencies (3). Regulatory and standard-setting agencies are creatures of legislative processes, and both are hierarchical, representing local, state, and federal interests. Consequently, control is fragmented.

Fragmented control leads to conflicting outcomes depending on divergencies in interest and conflicting control procedures and policies. For example, electric power sold at wholesale by a public utility in California to a local community for distribution is price regulated by the federal government; retail prices to other customers are controlled by the state public utility commission. Procedurally, federal regulators admit implementation of a price increase at the time it is requested, and the state public utility commission does not implement until after proceedings. Consequently, in California higher prices for electricity are currently paid by final users who purchase from city delivery systems than by those purchasing directly from the utility. Differences between regulation of intrastate and interstate transportation and telephone charges also lead to discrepancies between prices charged and services received. A within-state phone call or shipment often costs more than a longer interstate activity.

The facility manager operates the system from day to day within a context of standards and regulations. Mechanisms controlling managers' actions are revised from time to time through legislative and political processes. The style today is for changes in circumstance or public expectations to lead to a debate about a public facility; boards and commissions are established, studies are made, legislative revisions are made, and action is taken. Once action is taken there is a tendency to shield the day-to-day operations of the facility from the political process. Institutions such as boards of education or highway commissions are created and serve as surrogates for the political process in dealing with small matters affecting the operations of facilities. When major issues arise, they are redebated through the political process and solved through institutional revision. So a debate about transportation results in revising state highway commissions into state transportation commissions or boards and giving them new authority and responsibility. For example, an act recently revised (or attempted to revise) the authority and responsibility of the Interstate Commerce Commission with respect to the railroads.

So there is always a low level of public debate about facility control. In the main, it emerges as statements of frustration about fragmented responsibility, facility managers' lack of responsiveness and authority, and unevenness in performance. From time to time major matters are debated and major control mechanisms are recast in order to change a system. (The ability to obtain change and the cooptation of control by those with special interest in a system are discussed later.)

The cost of control, usually expressed as a cost of regulation, and the inequities associated with regulation are not a matter of much public debate, although regulatory control reform growing out of efficiency arguments is much pressed by professional economists.

The question of degree of control is not much discussed for public facilities; they are nearly completely controlled, although government control of activities generally is much discussed. As Weidenbaum points out, public control extends into every nook and corner of modern life. But that control is not total system control; it is control of an aspect of a system and a constraint or subsidy under which it operates. The debate runs to whether the government should require air bags in cars, fair employment practices, fire exits from buildings, and safe working conditions. We leave this debate aside for purposes of the present discussion.

Bargaining About Rights

There is a strong spatial-population content to claims of rights. This stems from the spatial-population basis of

political power in this country. Congressmen, senators, and state representatives serve places and the people who live at those places. As a consequence, there are claims for the provision of goods and services and the rights they represent throughout the country. One consequence of this is that there is gross cross subsidy from one part of a facility to another. In many of the facility systems, it is less costly to provide the good or service in a dense market than in a sparse market. So the pattern of subsidy has been from cities to rural areas and, in transportation, water supply, telephone, and sewage systems, from densely used routes to lightly used routes.

These cross subsidies have had enormous impacts on national developmental patterns. Cross subsidy has made public facility infrastructure everywhere available in some equalized way regardless of the cost of providing the good or service. The availability of telephone, sewers, water, and transportation has surely supported the explosion of the suburbs. The magnitudes of these cross subsidies are enormous, and they have been staked out to a degree in literatures with respect to particular facilities. The cross subsidy in telephone service is rather well known; approximately one-half of the telephone system income is in connection with charges for long-distance calls. This income from long-distance calls subsidizes other telephone operations, particularly the operations of companies serving relatively sparse markets. Gasoline taxes collected in the larger cities subsidize the provision of rural roads, and fares charged on long-distance air flights subsidize short-distance flights.

By and large the geographic claim to rights and the resulting spatial cross-subsidy are not subject to public debate. (The shift of political power from rural areas to the cities has had little effect on the older public facilities. However, some urban-centered rights have been recognized as new political imperatives, e.g., the right to have transit service.) On occasion, professionals debate the causes of suburbanization and professional economists debate pricing and efficiency issues.

Service is not only a right with respect to space but also a right with respect to time. There are two consequences of this: (a) Facilities are sized to the highest level of demand, and (b) costs to users, whether in taxes or in user charges, do not reflect the cost of their demanding a service at a particular time. Electrical networks must continue to function in spite of the millions of turkeys being cooked in electric ovens on gray, cold Christmas eves; highway systems are not supposed to overload; Friday afternoon air travelers expect space to be available at the usual price; and everyone wants to telephone home on New Year's Day. Every user has rights, and these rights are to be met regardless of when they are demanded.

Temporal service costs and prices are debated by economists, whose central concern is that the marginal user pay marginal costs. Economists suggest that much demand for capacity could be averted if the marginal cost of capacity was charged to the user during congested periods. But this is not, by and large, a matter of debate by the general public, and temporal pricing does not appear as an imperative on any politician's agenda. From the point of view of system users, there is a simple reason for this. Over and above the claim that the service is a right, users are not just people who make claims for services at particular times; they make demands on public facility systems at many times. They may heat their water at night as well as during the day or drive during congested periods as well as during noncongested periods. There is in general no neat division of users into black hats, those who are occasioning all the cost, and white hats, those who are not occasioning costs, a division that might provide a power base for political action.

Claims to rights are put forward by interest groups, by actors, or by institutions acting for interest groups. One class of claim has deprivation as its base. It is argued, for example, that the elderly are transportation deprived and the poor have the right to telephone service. Exceptional children form a special group with a special claim on education rights.

There is another way in which claims to rights are formed. The products of public facility systems are valued more highly by some groups than by others, and a group that values a facility system product is naturally quicker to claim the right than are groups that place less value on the product. So industry and commerce have demanded that the public school system train students in business arithmetic, and professional groups press the universities to provide professional training. The (sometime) users of railroads are vocal on matters of railroad branch-line abandonment.

Rights are thus expressed at the extremes; groups that are deprived are as quick to argue rights (or someone argues rights for them) as are groups that are advantaged. These groups bargain for their rights against less attentive publics. Attentive groups argue for representation on control mechanisms. A government regulatory agency typically contains representatives of geography and special interests.

From time to time, bargaining over rights has led to political action and major revisions of public facility systems. The 1916 highway legislation, which brought the federal government into the highway business, was responsive to the mobility rights of rural dwellers, as an examination of the preamble to that legislation will reveal. The Rural Electrification Administration was created to provide electric energy to spatially disadvantaged consumers, and public utility commissions are currently being pressed to provide life-line rates for utilities. This pattern of the claim to rights and bargaining about rights is thus one force of change in public facilities systems. The pattern is also a strong brake on change, for it is difficult to deprive any group of an existing right, and change that would do so is not likely to succeed. (The attitude of the Congress with respect to gasoline prices is most illuminating. In spite of the inevitability of petroleum energy problems and professional advice with respect to letting price increase dampen demand, the Congress seems to regard inexpensive gasoline as the right of the public. Possibly inexpensive gasoline translates into the right to transportation.)

Capital Intensiveness

For a variety of reasons, public facility systems are biased toward capital intensiveness. Rate making for utilities based on return to capital is one source of such bias. Another source of bias is the shelter of regulation under which a number of the facilities operate; bankruptcy is not at issue (many railroads excepted), and the cost of capital does not provide for such risk or other market tests. Consequently, capital is relatively cheap. Finally, those facilities that are entirely within the public sector reflect legislative and voter biases toward expenditures to capital as opposed to operations. Excepting some recent thrust for better management of urban transportation as opposed to solving urban transportation problems by additional investment, this matter is not one of public debate.

Technology for Public Facility Systems

Creation and deployment of technology for public facility systems suggest several issues. The nature of the systems is such that the technology is typically purchased from suppliers as a physical product. Suppliers are often oligopolies, and there may not be competition among suppliers based on creation of new technology. In addition, the bias toward capital intensity occasions emphasis on corresponding technologies. Consequently, new technology is readily available for larger pipes and pumps for sewage systems, stronger pavement for freeways, larger capacity generating and transmission facilities for electrical facilities, and electronic aids to learning suitable for use in large schools. In short, technology competition may be limited; technology responds to the capital intensiveness and scale economies of the facilities; it is produced by suppliers whose profits result from technology in physical forms. Again, the technologies are aimed toward the large-scale facets of the system where efficiencies can be readily captured by increasing scale.

Suppose these facilities did not provide cross subsidy to small-scale markets. Would a family of technologies have been developed for those markets? Air service is a case at point. Aircraft have been designed for dense, line-haul routes; that is where the profits are. Cross subsidy has been used to provide service to sparse markets. The airlines have directed efforts to reducing service in those markets; there has been little or no effort to develop technologies suitable to sparse markets. This is a sensible question for which there is no answer.

There is great pressure for standardization of technology. This is in the interest of suppliers, for it enables them to produce many copies of a given product. Efforts by standard-setting and control agencies to ensure that a right is indeed served are also a force for standardization. It is easy to see why not too many decades ago the school books to be used in state-supported school systems were adopted by the state legislatures. This assured the legislatures that the quality of education was everywhere the same, and it served the interest of the larger textbook companies. Today, this adoption process is mainly in the hands of state or local school boards, which is consistent with the comment made earlier about shielding public facilities systems from day-to-day political processes.

The need for system articulation also is a force for technological standardization, a point to be discussed later.

There are two primary results of standardization. One result is that there is little market segmentation; the products of public facility systems are the same everywhere. The product is standardized so that it fits somewhat to every need but fits few needs perfectly. Standardization also serves as a brake on technological change. Any new technology that changes the nature of the product has to meet the standards (which means that the technology may not be so new after all) or obtain a revision in standards. Because so many actors are involved, obtaining a revision in standards is resource demanding, and generally only large suppliers have the resources necessary to occasion a change in standards. Aircraft under instrument landing control used to descend at 153 m/min (500 ft/min) and queue for landing under a first-come, first-served system, according to standards adopted by the Federal Aviation Administration for air traffic control. Modern jet aircraft do not perform well when restrained to those standards, and their introduction required a change in the standards. Certification of a new aircraft is, of course, an enormously expensive undertaking.

Each public facility system has been professionalized to a considerable degree, and acceptable technologies for a system tend to be those acceptable to the styles and tools of the profession dominating that system. Some of the system's needs for technology and suitable technologies are selected through civil engineering paradigms. Education technologies dictate appropriate technologies for the public school systems, and electrical and (now) nuclear engineers make the judgments for electric utilities. Transfer of a technology not within an existing professional paradigm is difficult for reasons that are completely understandable. The power and prestige of a profession are based partly on the jobs in systems, and there is a great reluctance to give jobs to others.

Most issues with respect to technology are hardly debated at all, not even by professionals. The public does not seem to be sensitive to lack of market segmentation. It does respond to "small is beautiful" and "if we can put a man on the moon why can't we..." assertions, and this response is sometimes a base for political action and change.

There is some public debate about the results of deploying technologies. Some of the debate is location specific, dealing, for example, with the location of particular large electric generating plants, high-capacity freeways, or large schools. There is some debate at a general level with respect to location policies and the location-impact implications of deployment of particular technologies.

Incremental, Disjoint Decision Making

Public facility systems are such that once a technology is adopted and is the basis for a growth path, that growth path is difficult to change. This is partly a matter of capital intensiveness, as mentioned before. It is also a matter of facilitywide integrity and the incremental, disjoint character of decision making that characterizes these facilities. With respect to facility integrity, this is specially marked in transportation and communications systems. Freight cars and, increasingly, locomotives must be able to operate anywhere on facilities. Incremental changes in braking systems or track gauges are unthinkable given operations requirements. Terminal switching and transmission requirements impose similar contraints on communications and electrical facilities. This need for standardization and commonality is reinforced by the interest of equipment suppliers, who naturally desire aggregated, standard markets.

In incremental, disjoint decision making, any single actor is constrained so that he or she cannot make a unilateral decision to change the path of system evolution. Shippers' desires for larger and larger rail cars are constrained by the reluctance of the railroads to operate them. The junior high school graduate must be ready for high school; teachers are thus constrained in what they can do. Sewage plant operators' desires for homogenous inputs to their plants are thwarted by the unthinkableness of arranging the pretreatment of sewage at every origin. Decisions are constrained as well as disjointed, and new directions for system evolution would require agreements between many parties, suppliers, users, and operators.

As a consequence of the pattern of decision making, change undertaken by facility managers is incremental and facility system improving rather than system changing.

There are some sharp conflicts between how facility systems are able to change and public expectations about systems. Demands for changes in goods and services lead to political action and the creation of new programs,

retitled government agencies, and changes in levels of funding. But the incremental, disjoint decision making within systems is hardly touched, and public facility systems tend to operate much as they did before, perhaps with more money. Money thrown at shcools, transportation systems, law enforcement, and health care and the resorting and renaming agencies have hardly made any difference. These actions have only served to frustrate the public whose expectations are not being met. Public facilities systems are slow to change.

Robustness

Public facilities are systems; each is an interconnected network, and some form physical networks. To varying degrees, the functioning of facilities is affected by network interdependencies. There are gross robust issues of concern, for example, the functioning of the networks when subject to natural or man-made calamities, including strikes. Lack of this type of robustness comes into public view in the form of a crisis, and there is not much continuing public debate about these crises or demand for changes in public facilities systems in light of these crises. The broken sewer line is repaired and forgotten, or the strike is settled and business continues as usual.

Robustness enters into public facility matters in a more subtle way. Again, the facilities are systems. Changes for better or worse are continually being made in their individual parts as facility managers and other actors strive to improve performance and as they react to forces beyond their control. To what extent do the systems have robustness in that they can (a) adapt and support improvements made in a part of a system or (b) adapt to deterioration in performance in some part of the system? In this sense, public facility systems are not very robust. If a child's reading problem is not corrected by the elementary school, the rest of that system will not react to correct that problem. Improved sewage plant operation is limited by infiltration in collector sewers. Efforts to achieve economies of transit service are hampered by the failures of collector and distributor systems. Efforts to achieve economies of density in trunk-line railroads are thwarted by inability to deploy supportive technologies in collector, distributor, and yard operations. The failings of child health programs cannot be corrected by other health programs.

The systems' lack of robustness of the type just described is a matter of much agony for system managers and professionals within systems. Otherwise, it is rarely recognized.

Location Conflicts

In those instances where public facility systems have physical links there are continuing location conflicts. Freeway location and pipelines-versus-railroads conflicts are recent cases at point, although location of electrical transmission lines, trunk sewer lines, and other facilities brings location conflicts into sharp debate.

Location debates involve conflicts of rights. On the one side are those claiming the right to a clean and healthy environment and related government programs dealing with the control of environmental insult. Arrayed on the other side are the managers and users of public facility systems, systems that are providing a good or a service as a right. Debates about these rights in conflict tend to be in absolute terms, and the courts are heavily involved in the arena.

Development Instruments

Public facility systems are viewed by private developers, planners, and policy makers as instruments for development or for control of development. Canal, railroad, and road programs were early used to foster settlement and development. The Tennessee Valley Authority and the U.S. Bureau of Reclamation have been viewed as development instruments. Recently, provision of facilities has been an important ingredient of regional economic development programs, and the Federal-Aid Highway Act of 1976 noted needs for highways that are necessary to increase coal production. Nonprovision of facilities has also been proposed as a way to prevent development, and some communities have attempted to control urban sprawl by limiting water and sewage supply.

The use of facilities as instruments for control of land development or nondevelopment is a matter of considerable public debate. Debate is often somewhat incomplete; it focuses on one or two of the facilities without recognizing that all are necessary for development. And debate often focuses on instruments without attention to the working of land markets and supply and demand forces. For instance, considerable attention is currently being given to the use of rail transit as an instrument to create activity centers in urban areas. That debate fails to use the recent evidence from Toronto, Philadelphia, and San Francisco, where it is clear that transit has not as yet been a sufficient instrument to induce activity center development.

Organization and Roles

The organizations that provide and operate public facilities and the individual roles within such organizations reflect the characteristics of the systems, the goods and services that they provide, and the constraints within which they operate. They also reflect historical circumstance. Those created early, such as railroad, water supply, and sewage facilities, have a paramilitary character. The bureaucratic precedent for the railroads was the military establishment; the Public Health Service is paramilitary in character. The geographic expanse of systems is reflected in the strong geographical divisions of the organizations, and railroad divisions and geographically organized divisions of highway departments provide examples. The division between line and staff roles within those organizations is sharp, as are the divisions between line operations.

In light of the systems' functions of providing for the general welfare (health, mobility, energy, and so on), the performance measures used by the facilities seem, at first glance, rather strange. There is a tendency to describe performance in terms of throughput quantities or the size of the facility managed: The school superintendent discusses the number of pupils in his district, the county highway engineer describes the number of kilometers of road he or she builds and maintains, and the electric utility operator refers to joules produced and sold. Status, organization to organization, is based on such measurements of size. Performance effectiveness is measured by comparing cost to the number of units managed or processed, and measurements run to cost per joule, cost per student, or cost per megagram-kilometer. There are other kinds of measures that are sometimes used such as accident rates and the percentage of on-time arrivals (for air operations) or departures (for railroad freight trains).

That performance is discussed in this manner is completely explainable. First, the facility manager has little or no control over the shaping of grand goals or over programs for their pursuit. These goals and

programs are a matter for public, political processes. Often the manager is a technician who advanced through a particular facility, and the traditions of a facility profession may not be articulated in terms of social goals. Moreover, the entrepreneurship opportunities left to the manager are severely constrained by regulations, standards, and so on, and about the only outlet for his or her managerial skills is cost cutting. Preoccupation with cost cutting in management circles in public facilities is unlike that in most large enterprises, where cost management is forced down within an organization to profit centers. Another preoccupation is that of trying to increase or maintain the size of the organization. One can readily understand why highway organizations want to build more highways and electric utilities want to increase generating capacity; for, within their ground rules, increased size means increased importance.

The organizations are bimonopolies and to some extent trimonopolies. They are bimonopolies in the sense that there is a facility monopoly and a labor monopoly that operates the facility. They are trimonopolies to the extent that suppliers of equipment and construction organizations (and shippers, in the particular case of railroads) also have various degrees of monopoly power.

There is a tendency for management to pursue capital intensiveness as a method of reducing cost. However, labor monopolies in some instances thwart this effort through job rights agreements. At some organizations, job rights have geographical territory.

That organizations have narrow views of their roles and behave accordingly is a matter of some public debate. Disenchantment with highway department bureaucracies and telephone and electric utilities is much discussed, and other facilities organizations have been the targets of similar discussions in the past. The bimonopoly character of labor negotiations results in negotiations only in a limited sense. The tendency of management to accede to any labor demand and pass the cost on to the public is currently a matter of some rather unfocused debate about transit systems.

Other Characteristics

Not all facility systems characteristics have been described. In particular, the systems enjoy degrees of public subsidy, and, if prices are charged, there are some distinctive characteristics of those pricing patterns. These matters of costs and pricing are treated in the literatures of cost allocation; federal, state, and local taxation; and public system economics. These characteristics reflect the dimensions of social purposes and government control in a manner similar to the reflection of those dimensions throughout public facility systems.

CHANGING PUBLIC FACILITY SYSTEMS

This section poses and addresses the question of change in public facilities. In approaching the problem of change, one should note that these systems have changed, are changing, and will change, because of

1. Improvements in the technologies used by the facilities and improvements in the human resources that manage and work within the organizations;
2. Changes in demands for their goods and services and in public expectations about goods and services;
3. Changes in the availability of resources for the provision of facility goods or services; and
4. Improvements in the theory and practice of public finance.

There will continue to be improvements in facility management and operations. Other changes will occur through processes of public debate about the systems and realignment of the resources available to them, the standards to which they are expected to perform, and the control mechanisms that condition their operations.

These changes and improvements provide one future for public facility systems. Might there be other, more desirable, futures? Could creative system changes be imagined and implemented so that the systems evolve on paths closer to the evolution of public expectations? These changes should be creative in the sense that they improve the ways in which public facilities provide for grand goals. In addition, they must pass tests of feasibility and implementability in light of systems characteristics.

Public Facilities in the Service Society

Most public facilities were deployed some decades ago, and at that time the role of those facilities in society seemed rather clear. For when society was primarily extractive-industry based, and when it became manufacturing and extractive-industry based, the relations between what public facilities provided and production and consumption activities were relatively clear. The relations are less clear today as society has become more service-industry based and as consumption patterns have changed with increasing incomes and increases in the discretionary time available to individuals.

The puzzle posed by the service industries and by the changes in consumption patterns, life-styles, social expectations, and so on is of interest to social theorists, and there has been some exploration of that puzzle under the rubric of the post-industrial society. The puzzle is more than an intellectual exercise for social theorists, however; it is an important practical matter. The need for increased productivity in the service industries is an integral part of the problem of increasing the general welfare, providing for the expansion of employment opportunities, and managing inflation. The issues of what citizens want from their society in the last decades of this century is an important practical matter for those concerned with national planning and those who govern.

Public facility system matters enter the puzzle in two ways. First, many of the systems provide services, and the question of how to increase productivity in the service sector applies directly. Second, the goods and services that the systems provide have very much to do with the way productivity can be achieved and the ways in which society uses the fruits of that productivity. This is certainly true for educational activities, for the supply of human resources is critical; and personal transportation and communications surely have much to do with the way in which the service industries perform and the ways in which the goals of individuals are now sought.

The first recommendation for creative change is easy to make: Align the public facilities with the contemporary and fast-growing service society. This alignment is, of course, difficult because no one has much of a substantive idea of how to better align public facility systems with the service society. Interestingly, the recommendation would not seem to founder on either implementability or feasibility grounds. Political processes are such that there is a continuing effort to restate social purposes and adjust the workings of government, including the workings of public facility systems, in light of political imperatives defined around social purposes. Facility managers are well aware that the performance measures with which they have been comfortable in the past are no longer very acceptable, and

they likely would quickly accept some more convincing description of what their business is about.

Given sufficient time, public facility systems will be adjusted to the changed nature of society; so, subject to enough time, the present recommendation does not lie outside of trend changes described earlier. However, it is desirable to press the alignment of public facility systems with the service sector as a specific change because that force for change needs to be more explicitly recognized.

How are public facilities to be better aligned with the service sector? Understandings about this sector are bound to come slowly. Service activities are heterogeneous; some are public facility systems, and others are completely in the private sector. Although analysts and social theorists are concerned with the service with postindustrial society, they are few in number. Nor do our government institutions seem to recognize the service society. Governments have institutions for industry and agriculture, but not for service activities except in those cases in which government is a producer of service. Government economic accounts say little about the service sector.

If political actors, actors in control institutions, and facility managers were to recognize more fully the service facets of society, then they might behave somewhat differently. Knowing that change is needed, there might be less resistance to suggested change. Knowing that change is needed and that the required nature of such change is unknown, they might be more willing to experiment, monitor, and learn from experiments. The mechanism for change would simply involve wider recognition that we are dealing with unknown needs and a willingness of all actors involved to behave more flexibly to try to meet those needs.

Scaling

It might be useful to adjust the boundaries within which public facility systems operate. There are two or three aspects of this, depending on how the topic is viewed. One aspect has to do with the extent to which the provision of goods and services is monopolized by a public facility system. A related matter is the extent to which a public facility system is institutionally with the public sector. Public facility systems in the United States range from public utilities to activities completely within the public sector. Recently, the device of the public corporation has been to provide goods and services. In spite of the nation's long experience with degrees of public control and willingness to experiment with new institutional forms, not much is known about which institutional form is best for which purpose. One grand effort to develop such insights comes to mind, namely, the argument that the TVA was to provide a yardstick for measuring the performance of public utilities; but a comparative evaluation has never been made. The existence of the public and private school system side by side is an important exception to the monopolistic characteristics of public facility systems, and it is an interesting exception. It provides a choice for the consumer, at least for those who are wealthy enough to make the choice, and, more important, it provides a yardstick for the performance of the public system in the delivery of educational services.

So one suggestion about boundary conditions is that it might be useful to change the boundaries that circumscribe public facility institutions. The boundaries on present institutions were set to some extent by trial and to some extent by historical accident, and there is no reason to believe that institutional arrangements are optimal. Trying out some other forms with experiments supported by studies and educated guesses would seem a most reasonable suggestion. Furthermore, with several institutional forms and players, there would be a semblance of competition in the delivery of public goods and services. This would provide, at least to a limited extent, increased range of choices by consumers: Markets might be better segmented. It would also provide the public and politicians with information about alternative ways that goods and services might be supplied.

This suggestion is easy to state and understand; it also is likely to be feasible and acceptable as historical precedent suggests. It may fail, however, on the criterion of not amounting to very much. For as the discussion of the characteristics of public facility systems stressed again and again, the institutional arrangements of particular facilities seem somewhat incidental. Systems would be very much as they are today, even if they were in different institutional forms.

Another class of boundary condition changes is suggested by observations made recently about electric power systems and energy conservation. Analysts have suggested that ways to increase efficiency and achieve conservation in electric power systems would be through cogeneration of electricity by industrial plants, conservation techniques by residential consumers, and certain changes in consumption patterns such as heating hot water during off peak. A class of coactivity suggestions might have wide applicability throughout public facility systems. The boundary between what is supplied by the public facility system and what the user does would be shifted.

This class of boundary condition change is easy to imagine and would have the desirable feature of giving the consumer some considerable sovereignty about the goods and services that he or she chooses. With the technologies and skills now available, it would be easy to undertake certain educational activities in the home (using program learning, TV instruction, and so on), cogenerate or adjust (or both) use of electric energy in the home or industrial plant (steam cogeneration, solar energy, seasonal heat storage systems), provide for interplant and interneighborhood communications (telephone-like systems), provide for neighborhood transportation (neighborhood ownership and control of local access streets), and provide fire extinguishers in the home and spend less money for fire departments.

Another way to describe this kind of boundary change would be to term it scaling. The conjecture is that, if we rethought the way the good or service might be delivered, facility technology and facility control might be rescaled spatially. This idea is in the air currently, and it surfaces in discussion about developers providing integrated utility systems, about how valuable Sesame Street is for children, and about the desire of residents of neighborhoods to control the quality of local streets and the quality of their local environment.

However, the issues of implementability are real. There is the problem of standards. Also, rescaling would be threatening to public facility managers. For managers, it is clearly a bigger job to run an 80 000-km (50 000-mile) road system than a 40 000-km (25 000-mile) system or to run a school system with 50 000 students instead of one with 35 000. Consequently, public facility managers have a bias toward increasing their output and span of control. Public facilities managers have tremendous bias against privately owned roads, customers using their own phone systems, cogeneration of electric power, parents undertaking to teach students, independent package sewage plants, and anything else that individuals or groups might do to reduce the quantity of the output of a public facility. Public facility managers

find rationale after rationale for protecting the spans of their systems. Of course, some of this rationale is sensible.

The discussion of boundary shifts or rescaling leads quite naturally to a related recommendation: the undertaking of shadow activities. The suggestion of moving a facility boundary so that the user of the good or service would produce it suggests the alternative that the user might shift consumption. A firm locating its headquarters in the suburbs would expect its employees and customers to use the urban transportation system. To the extent that those employees or customers might impose new burdens on the system, system managers might ask that the firm engage in the supply of transportation services; they might be asked to put on a bus line connecting their site to an existing arterial route. The firm has another option, namely, not placing a burden on the transportation system. Perhaps the firm would choose a site having excess capacity in transportation. The activity engaged in as an alternative to transportation may be described as a shadow project, and shadow projects can take a number of different forms, some of which overlap with actions mentioned when boundary shifts were discussed. A meat slaughtering plant, for example, placing heavy demands on a sewage treatment system might choose to engage in the pretreatment of sewage or storage of sewage. This would reduce facility service cost.

The term scaling was used as the heading for this section, and that term seems to characterize the class of changes suggested by the language of the discussion—shadow projects, privatization, increasing efficiency, achieving conservation, and market segmentation. The actions required for rescaling are

1. Restructure public facility systems geographically so that they are scaled to markets and to technologies appropriate to market segments (this may also involve shifting the boundary between what is private and what is public and may involve breaking some of the public monopoly characteristics of facility systems);
2. Provide appropriate interfaces between the system parts; and
3. Provide necessary institutional, control, and financial mechanisms for rescaled systems and develop necessary technology.

These steps may be illustrated by subjects discussed in the previous part of this section. Some of the changes in electric energy production and conservation involve creation and deployment of technologies, including conservation technologies, other than at the central generating plant. System scaling is required. Cogeneration of electricity by manufacturing industries, solar energy generation and use at the residential site and elsewhere, seasonal and temporal storage of energy, and so on require the rescaling of the system so that these technologies become viable. They would require appropriate interfacing of the parts of the rescaled system. Interfacing is a tough problem. The quasi self-contained utility system in the home, industrial plant, or other activity would generally require that self-contained unit to interface the larger system in some way. The same is true for the rescaled communications systems, rescaled educational systems, and so on.

Suggestions for improving intercity freight transportation are scaling suggestions. Both line-haul and collector-distributor routes now use the same technology. It is suggested that line-haul traffic be densified and appropriate technologies deployed so that economies of scale may be achieved. At the same time the technology for collector-distributor systems needs to be readjusted so that it better tailors to markets. There is need for vast improvements in switching capabilities to connect line-haul and collector-distributor operations.

To a degree, the public school system involves a set of activities using different technologies and scaled to particular functions. To the extent that the highway system involves local access streets provided by one unit of government, arterials and major highways provided by another, and expressways provided by another, there is some scaling of that system. But in both of these cases the scaling is very partial. In highway transportation, for instance, the roadways are scaled but vehicle technologies and control systems are not.

The notion of scaling is not separate from the concentration-dispersion debate that surfaces in discussion about urban growth centers and regional development, government organization, provision of recreational facilities, and on and on. The notion of scaling presented here simply focuses that public debate on public facility systems. If the concept could be sharpened somewhat and focused on particular public facility systems, then scaling might enhance the matching of goods and services to public expectations, scaling might permit the deployment of technologies appropriated to segmented markets, and scaling opportunities might become political imperatives and a base for political action and system change.

TRANSPORTATION SYSTEM MANAGEMENT

Transportation system management is an intervention strategy for a part of a public facility, namely, the urban part of the transportation system. Will the previous discussions of the characteristics of public facilities and intervention strategies for public facilities provide a basis for the evaluation of TSM? How do TSM intervention strategies relate to the processes of system change? The discussion will first present TSM and then move to these questions.

TSM appears to stem from three postulates. The first is that the dollar cost and direct and indirect energy requirements of new facilities are now sharply limiting. The capital is simply not available to continue capital-intensive programs as in the past, and forecast petroleum fuel shortfalls or increased costs or both mandate that adjustments to the urban transportation system begin. New capacity is simply unthinkable unless it drastically reduces petroleum fuel requirements. A second postulate is that the physical transportation system is essentially in place. Priorities should now go to better management of existing facilities, especially in managing the system as a whole. The third postulate is that urban transportation serves clientele unevenly. The right to transportation of the transportation deprived is not being met by automobile transportation. Transportation system management is to ensure a diversity of service to all.

The tools of transportation system management flow from the notion that managerial action should be taken to improve the operating efficiency of the urban transportation system. Strategies involve the rationing of roadspace through pricing and traffic management and giving preferential treatment to high-occupancy vehicles. Staggered and flexible workhours are to be sought, and movement efficiencies are to be sought through car pooling, van pooling, subscription bus services, and expansion of transit service.

What of TSM? Is TSM too small to matter? Will it, at the other extreme, force change in urban transportation? Might it serve to exemplify how change might be sought in any public facility system?

A perspective on TSM may be obtained by comparing it with public facility system characteristics. A convenient way to do this is through a set of summary statements.

1. Control. TSM is a facility manager's activity. It is not an activity in the political process that might lead to major institutional revisions. If facility managers are limited in their actions, we should expect little from TSM.
2. Claims to rights. Spatial-population claims to rights are ignored; temporal rights are challenged by TSM. The rights of a minority are advocated (transit users); the rights of the majority are challenged (automobile users). If facilities supply goods and services that are rights, TSM is inconsistent with facility purposes.
3. Capital intensiveness. TSM undertakes to deploy management solutions to avoid continued capital investment. If there is a bias toward capital investment, capital intensiveness will not be avoided.
4. Technology supply. TSM will deploy certain technologies familiar to system managers (traffic engineering); other of its technologies are foreign to the delivery system (pricing, for example). If facility actors use only those technologies familiar to their professions, TSM will be a traffic engineering activity.
5. Incremental, disjoint decision making. TSM favors facility-improving measures to be deployed in a manner consistent with current incremental, disjoint decision-making procedures. If this decision-making procedure results in changes that are slow, change from TSM will be slow.
6. System robustness. TSM is addressed to heavily used routes. If improvements in one part of a system are limited by other system parts, then TSM will not be very effective even on those routes where it is applied.
7. Location conflicts. Again, TSM is addressed to heavily used routes. If facility improvements result in location conflicts, then there will be location conflicts.
8. Land development. TSM is focused on the transportation plant alone; development consequences are ignored. If facility services affect land development, there will be development consequences.
9. Organizational roles and perceptions. There are several organizations in urban areas providing transportation services (transit systems, local public works agencies, and so on). TSM is to orchestrate these organizations. In addition, TSM emphasizes operations versus facility deployment. If extant roles and perceptions limit change, then change from TSM will be limited.

TSM managers and those who formulate TSM strategies may wish to make their own evaluations of the correspondence between TSM strategies and the characteristics of public facility systems. They may wish to alter old strategies or adopt new strategies (5).

The opportunity to better align the transportation system with the service society is of special interest. TSM strategies ought to be formulated so that they can be quickly readjusted as it is learned whether they are counter to, neutral about, or supportive of present-day social activity patterns. The TSM manager will have considerable help discovering how effective strategies are. As strategies are deployed that are counter to today's needs, then he or she will be quick to hear about that. If those strategies are supportive of those needs, then those processes by which the rights to service are claimed, especially political processes, will begin to come into play to support TSM activities.

Urban transportation provides many opportunities for scaling. It is easy to imagine a rescaled system where special roadways, small vehicles, and appropriate traffic controls provide for those short trips, approximately half of all trips, that are neighborhood in orientation. This would increase neighborhood accessibility, reduce resources used in transportation, and improve the environment of the residential neighborhoods. Access throughout sectors of the city might be provided by urban cars operating principally on what are now arterials. Over-the-road vehicles or commuter cars might provide for the longer journey to work via freeways. Line-haul transit might be served by collector-distributor neighborhood transportation vehicles.

If urban transportation management seeks to direct the evolution of urban transportation in new directions, as opposed to making the present path of development work somewhat better, then transportation system management strategies of the very demanding sort are required, strategies that will have to be based on a rich understanding of the question of how public facility systems may be changed.

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FEDERAL PERSPECTIVE REGARDING TSM

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This paper focuses on the institutional dimension of transportation system management and suggests local and federal policy to promote understanding and agreement on the institutional roles and responsibilities so that TSM is not enmeshed in debilitating jurisdictional disputes.

There are, I suppose, two ways of viewing the institutional roles in transportation system management planning. The first way is to place transportation system management in the context of the classical system planning process: a process that begins with the adoption of systemwide goals and objectives, proceeds to the iden-

tification of deficiencies in the system, and then leads to the selection of appropriate implementing actions. In this process, the metropolitan planning organization plays the role of the systemic planner, designing and orchestrating a comprehensive, areawide TSM strategy, with the goal of optimizing the operating efficiency of the transportation system as a whole. The modal agencies—the transit operator, the state highway department, the city traffic engineer, and the parking authority—are placed in a subordinate role, one of implementing agents whose mission is confined to executing the individual pieces of the master plan designed by the MPO. For purposes of characterization, I shall call this the top-down approach to TSM plan development—an approach that tends to reflect the classical planning style employed by areawide planning agencies in their traditional long-range planning activities.

The other approach—which I shall call the bottom-up approach—takes a more realistic view of the real-world environment of metropolitan decision making. This approach tries not to ignore the hard realities of jurisdictional fragmentation, dispersed implementation responsibilities, and diffusion of political power prevailing within the typical metropolitan area. It recognizes the need for sharing power, for a negotiated process of resource allocation, for some ad hoc responses to local pressures, and for some willingness for political give and take. In this approach the process of TSM planning is viewed not as an idealized strategy of seeking optimum systemwide efficiency but as a piecemeal, project-by-project effort that relies heavily on negotiated solutions, that is quick to exploit unique opportunities, and that is not indifferent to public response and the probability of success.

Accordingly, the roles of the various metropolitan actors in this second approach will be different. The responsibility for initiating TSM actions will rest heavily with the operating agencies—the transit authority, the city traffic department, the police department, the redevelopment agency, the state and county transportation authorities—all the different bodies that have the power to make things happen. The function of the MPO will be to ensure that the individual initiatives are consistent with the area's overall transportation plan, that they do not interfere with but reinforce one another, and that they are implemented in a coordinated fashion. The MPO will also serve as a forum in which joint TSM ventures between two or more agencies are facilitated and in which new TSM initiatives are first broached. The MPO, in other words, will act as a convenor, a broker, and a conflict-resolver, but not as an overall architect of an areawide TSM strategy.

These, as I see it, are the two models for the TSM planning process. The systemic, top-down approach may possibly be workable, but the bottom-up, project-by-project, incremental approach is, in my view, far more compatible with the reality of metropolitan decision making. I have serious doubts that transportation system management lends itself to the comprehensive approach as practiced by the regional planning agencies in their long-range planning process. Those who try to apply the master-plan mentality to TSM ignore one key point: that the planning institutions at the metropolitan level are not in a position to make policy trade-offs at the regional or systemwide scale and that, lacking the power of implementation, their plans will remain "wish lists" unless they are supported by the implementing agencies.

What conclusions do I draw from all this for local and federal policy? Let me suggest the following agenda.

1. MPOs must work ever more closely with the operating agencies and must offer them positive inducements to stimulate TSM planning and implementation. One tangible incentive would be for the MPOs to pass through a portion of the planning funds that they now receive from federal sources. Important beneficiaries of such pass-through planning funds could be the transit operators, but they could also include city traffic departments and other municipal, county, and state agencies that have the power to initiate and follow through on TSM actions.
2. The MPOs themselves must develop a greater capability to do short-range operational planning so that they can effectively evaluate and coordinate the various TSM initiatives that come from the operating agencies. We want to see the MPOs devote more of the section 9 planning funds to operational planning, and we intend to use the annual review of the unified work programs as an opportunity to monitor progress toward this goal.
3. We need to consider how private transportation service providers can be effectively involved in TSM plan development and project formulation. Such projects would typically involve taxi companies in the provision of specialized services for elderly and handicapped persons, feeder services in low-density neighborhoods, and shared-ride community transit services to facilitate daytime circulation. UMTA has taken a significant step in the direction of facilitating private operator involvement by promulgating a statement of paratransit policy. The policy requires that private transportation providers (a) be given full opportunity to participate in the local planning and programming process conducted under the aegis of the MPO and (b) be given the right to propose and participate in the provision of local paratransit services. The local private operators and the planning and transit authorities must now give effect to this policy.
4. We need to consider how to involve the private sector in TSM plan development. Many TSM initiatives, staggered workhours or van-pooling programs, for example, greatly depend on the initiative of private employers. Today these initiatives, to the extent that they occur, are haphazard and uncoordinated. We need to make a greater effort to integrate them into the urban transportation management process.
5. We also must open the TSM planning process to greater public participation. Public attitudes and citizen involvement have played a significant role in the movement away from the philosophy of massive construction projects and toward the philosophy of urban conservation. The role of the public must also be recognized in TSM planning and implementation, since many types of TSM projects are based on neighborhood initiative and public acceptance.
6. We must make a determined effort, as part of the TSM planning process, to do away with laws, regulations, and local ordinances that hinder TSM implementation. Some of the more obvious examples of legal barriers to TSM implementation include zoning laws that require provision of a minimum number of parking spaces in new buildings, ordinances that prohibit the use of shared-ride taxi service, insurance impediments to cooperative van pooling, stringent design and construction standards for streets and highways, and banning of tolls on federally aided highways.
7. We must seriously consider the possibility of earmarked funding for TSM. Although TSM project implementation can be supported out of a number of UMTA and FHWA funding sources, the competition from established claimants may be too intense to allow TSM to compete fairly for the money. As a general rule, we should resist the temptation to create new categorical programs every time we wish to promote a new policy; however, this is a situation in which a modestly funded program

could have an enormous payoff in terms of its beneficial impact on the urban environment.

8. The MPO must become a true forum for cooperative resource allocation decision making. We recognize that the exercise of true programming responsibility is not an easy thing to accomplish. It will be an evolutionary process, and many MPOs will have to mature before state and local political leadership will tolerate the exercise of that responsibility at the regional level. Again, as with the planning function, the MPO will often act only as a referee. The specific project proposals may typically come from local governments and transit authorities. But where there is not enough money to go around, some tough resource allocation and priority-setting decisions will have to be made. Further, to ensure that certain of UMTA's special policy requirements are met, such as special effort on behalf of the elderly and handicapped, Title VI equity, and private operator involvement, somebody will have to bear the local responsibility. Although most proposals for individual TSM projects will be developed on a bottom-up basis, the requirements will have to be enforced and any competing demands resolved on a top-down basis, and we think the MPO will have to be the forum for doing that.

This, then, is our perspective on the difficult and sensitive issue of the institutional roles in TSM planning and implementation. My intent is not so much to prescribe a particular model of intergovernmental relations as to argue for a balanced allocation of roles and for a sharing of power among the various actors on the metropolitan scene.

Unlike highway building, traffic flow improvements, or transit operations, TSM does not have a powerful constituency of its own. If TSM is to succeed, it must win the support of a coalition of interests—business, civic, environmental, professional—and the good will of numerous metropolitan agencies that have the power to make things happen—or to block action if they are so disposed.

So, as one who sees great promise in TSM and wishes it well, let me plead for metropolitan and state cooperation, for I see the exercise of shared power not only as the best way but as the only way for TSM to succeed.

TRANSPORTATION SYSTEM MANAGEMENT FROM THE FEDERAL HIGHWAY ADMINISTRATION PERSPECTIVE

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This paper reviews the history of federal aid to highways as it relates to those improvements that are now considered to be within the scope of transportation system management. Examples are given of current federal programs that provide funds for TSM improvements.

The federal highway program began in 1916, but before 1933 federal aid to highways was largely devoted to improving rural roads. The first program that funded highway projects in urban areas was the National Industrial Recovery Act of 1933, which authorized $400 million for states to use for highway projects. Among the eligible items were the construction of routes to avoid congested areas, the construction of facilities to improve the accessibility and the free flow of traffic, and the cost of any other construction to provide safer traffic facilities or eliminate existing hazards to pedestrians or vehicular traffic. These were transportation system management issues.

It was not until 1944 that specific provision was made for a continuing urban area highway program. In the Federal-Aid Highway Act of 1944, Congress established a program that authorized the expenditure of funds on urban extensions of the federal-aid primary and secondary systems.

Early in 1959, the Bureau of Public Roads launched a study to determine the level of increased capacity that could be achieved by applying a combination of traffic operations techniques to an existing urban street. The study was carried out in Washington, D.C., and the results were published in 1962 as the Wisconsin Avenue Study, a document that gave new direction to efforts to help local areas improve street efficiency. The findings of the Wisconsin Avenue Study were translated into action in July 1966 in Instructional Memorandum 21-5-66 issued by the head of the Bureau of Public Roads and stating,

> The decision to construct or to reconstruct a street or highway in order to provide greater capacity and safety should be made only after a study of available alternatives. Particularly when the alternatives include a major investment (e.g., the taking of new right-of-way in an urban area to provide additional lanes), full consideration should be given to the alternative of improving the existing facility or a parallel facility to provide the additional capacity and greater safety.

In short, the memorandum provided that alternative measures (improved signal control, parking restrictions, turning prohibitions, reversible lane operation, and other traffic engineering measures) should be explored before urban area projects are undertaken. Seven months later, in February 1967, the Traffic Operations Program to Improve Capacity and Safety (TOPICS) was established administratively within the Federal Highway Administration to encourage consideration of these strategies. Recognizing the importance of reducing traffic congestion in urban areas, Congress, in the Federal-Aid Highway Act of 1968, formally authorized the use of federal-aid system funds in urban areas for improvements that directly facilitate and control traffic flow. As of June 1976, a little more than $1 billion in federal-aid funds for fiscal year 1975 was obligated to such low-capital transportation improvements.

The Federal-Aid Highway Act of 1973 made significant changes in the direction of the federal highway program.

The act made highway funds eligible for all forms of transit. In implementing the act, the Secretary of Transportation delegated responsibility for the urban planning process and the urban capital program sections that were multimodal in nature jointly to FHWA and UMTA. The urban system funds were drastically increased, and some new aspects were added to the delivery of the funds. These actions led to the issuance in September 1975 of the joint FHWA-UMTA urban planning regulations that required the development of a transportation system management element as part of the transportation plan in order to emphasize more efficient use of existing transportation resources.

Attached to the published planning regulations was an appendix of advisory (not regulatory) information listing TSM strategies that are recommended for consideration in developing the TSM element of the plan. It should be emphasized that UMTA and FHWA do not intend to prescribe efficiency standards or even the particular measures that must be implemented; that decision is a joint local-state responsibility, not a federal one. Furthermore, FHWA does not intend to precisely prescribe what form the TSM plan documentation should take. We have never done that for the urban transportation planning process. We do insist that there be a systematic method for describing the products of the planning process. Most urbanized areas will probably find it convenient to package the descriptive material for the TSM element in a separate, easily retrievable document.

The TSM element in the planning process reflects the evolution of national and local goals. Changing needs have brought about changing goals. The following seem paramount at this point:

1. Efficiency, both functional and economic;
2. Mobility, including equity for those without access to an automobile;
3. Environmental protection, including land use, air quality, and noise considerations; and
4. Energy conservation.

Although these goals are reflected at the national, state, and local levels, the reflection is not necessarily a mirror image. Local transportation goals and objectives must be defined and harmonized with national goals, e.g., air quality standards. Local decision makers must cooperatively articulate local priorities. State and local decision makers implement programs and projects based on defined goals and objectives and agreed-on priorities.

Within the context of local decision making, a variety of TSM actions is available for use by localities to improve the transportation system. These include

1. Actions to improve the efficiency of the existing highway network,
2. Actions to reduce vehicle use in congested areas,
3. Actions to improve transit service, and
4. Actions to improve internal transit management efficiency.

Metropolitan areas have great flexibility to tailor and package a wide range of strategies to meet their local needs and conditions.

Federal funding has become increasingly flexible to help local areas implement a variety of TSM improvements. In addition to UMTA section 3 and 5 funds, all major federal-aid funding categories can be used to support TSM activities. I want to highlight a few of those provisions.

1. The Carpool Demonstration Program was indefinitely extended in the Federal-Aid Highway Act of 1976. The program provides funding (90 percent federal and 10 percent state or local) from either urban system or primary system for the following activities: car-pool matching programs; public information and promotion activities; designating existing lanes, whether on or off the federal-aid systems, as preferential car-pool or bus and car-pool lanes; initial enforcement costs; and acquisition of van-pool vehicles with a pay-back provision.
2. Highway public transportation projects and special use highway facilities can be implemented on any federal-aid system. Examples are exclusive or preferential bus or truck lanes, bus passenger-loading areas and facilities, and fringe and corridor parking facilities.
3. Bicycle and pedestrian projects can be implemented on any federal-aid system. Types of projects include independent or incidental projects; bikeway networks; downtown or residential pedestrian improvements; and landscaping, lighting, traffic signing, parking facilities, and shelters.

Looking ahead, I think we can clearly see three major thrusts: greater emphasis on operational planning in order to maintain a high level of performance of transportation systems, greater flexibility in sources of funding, and continued emphasis on developing cooperative decision making and actions at the local level.

STATE TRANSPORTATION DEPARTMENT VIEWPOINT OF TSM

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This paper points out the problems with instituting federal highway programs at the state level and relates those to TSM programs. The Diamond Lanes, multiple-occupancy vehicle lanes on the Santa Monica Freeway, are discussed to illustrate the reactions that can come from innovative approaches to controlling automobile travel.

A distinction was made in the conference program between state transportation departments and state highway departments. It is true that we have in California a transportation department. Our major responsibility, however, remains the development and operation of the state highway system. Highways are the only kind of facility that we own and, out of our 14 000 employees, less than 200 are directly involved in activities having

to do with facilities or modes other than the highway or the automobile and truck. Most of our employees previously worked for the Division of Highways, which was absorbed into the transportation department when it was created 4 years ago. Out of our current yearly budget of about $1 billion, less than $50 million is devoted to purposes other than highways. I make these points because my prime experience in trying to make a more efficient use of existing facilities—a key TSM concept—is in the highway area, and my remarks will focus primarily on highways and TSM.

I believe that the application of TSM concepts to state highways should be a major direction of TSM implementation. At least in California, to focus system efficiency efforts on local streets, roads, transit, and bicycles is to ignore the backbone of the transportation system. In California, more than 95 percent of all passenger travel is by automobile, and more than half of all passenger travel occurs on state highways. This predominance of the state highway system is true for urban as well as for rural areas. Not only in Los Angeles (which we consider our freeway capitol) but also in San Diego and Sacramento a major part of travel within the metropolitan areas is on state highways and freeways.

The predominant role of state facilities in providing for local travel is an important reason for our interest at the state level in TSM, and it also creates some problems, which I shall return to later. The point I want to make now is that the notion of applying the techniques of cost-effectiveness analysis, of emphasizing better use of existing facilities, and of attempting to influence transportation demand as well as transportation supply is not an idea that should be limited to localized transportation networks. It applies equally to state transportation networks.

At the state level in California, we have been trying for a number of years to reorient our thinking along lines that parallel those now subsumed under the heading of TSM. This reorientation started well before the Brown administration. It was an outgrowth of three sets of factors: (a) a decreasing amount of revenues—in real terms—available to highway construction; (b) the environmental movement, which focused attention on costs that had not before been explicitly considered in our highway decision making; and (c) the creation of the Department of Transportation and the formal recognition that there are potentially multiple solutions to any given transportation problem. As we have tried to move toward better management of existing facilities, toward less expensive solutions to highway problems, toward projects that are more environmentally responsible, we have faced a number of problems and they generally overlap with the types of problems that I see with TSM.

1. The first problem is the federal government. The conference program stated, "Federal funds cannot be channeled into costly new capital projects without first maximizing the use of existing transportation facilities." Of course, this is not true. Moreover, while the federal government tells us that we should try to conserve scarce taxpayer resources, we note at several levels that the federal grant programs, in the highway area at least, operate in exactly the opposite fashion. With regard to total highway spending, the federal government urges and cajoles us to spend every dime of apportionment. We receive letters reprimanding us for not having obligated all the funds for which we are eligible, and we are criticized, not commended, if we have any outstanding balances in Washington. We seem then to be the object of a certain kind of schizophrenia. On the one hand, we are warned that resources are limited, that capital investment should be weighed against pricing and regulatory techniques, and that cheaper is better. On the other hand, we are pressured to spend that apportionment no matter what.

2. On a project-by-project basis, we are actively constrained from looking at inexpensive ways of making highway improvements through the application of design standards. These standards encourage expensive improvements. In California, for example, in rural areas we have many two-lane roads that we consider are providing adequate transportation services with their present designs. If, however, we want to use federal money to resurface these roads with 2.54 cm (1 in) of asphalt, we are told that we also must provide 2.5 to 3-m (8 to 10-ft) shoulders in order to be eligible for federal funding. In many instances the shoulders cost more than the resurfacing, provide insignificant safety benefits, and get us in trouble with environmental laws since this may increase road runoff or otherwise generate undesirable environmental costs.

3. The federal grant structure creates what I will call the "free money problem," and it is probably the most serious of the federal obstacles to an optimal allocation of total resources. The problem is an ironic one, and it exists precisely because we at lower levels of government do try to save our own money. One would think that, if a given transportation problem has two solutions with identical transportation benefits except that one costs $5 million and the other $10 million, we would pick the $5 million solution. If, however, we are eligible for 80 percent federal aid on the $10 million solution, it only costs us $2 million. The $10 million therefore becomes the cheaper solution and the one we will do.

There is a second kind of factor that I think has and will weaken TSM efforts and that is reliance on metropolitan planning organizations. I know that MPOs and regional planning agencies are dear to the federal government. I know that many problems are regional in nature, and I think regional planning is a good idea. However, I also think that just about anyone who has dealt with regional planning agencies would agree that they are a weak reed to spearhead any new or controversial approach to transportation. One reason is that the vast majority of MPOs have no implementing authority. They may be given power to veto and thereby effectively halt the activities of others and they may be able to devise good plans, but they have no power to carry out those plans or to force others to carry them out. Another reason is that in California MPOs are, with one exception, voluntary associations of governments. I believe this is the general pattern across the country. Members of the boards of directors of MPOs do not represent a regional constituency; they respect their own local constituents.

With regard to TSM, I believe MPOs with their local base have a special problem. Local governments, in California anyway, tend to see investment in new state facilities as an alternative to better management of the local street system. Congestion on local streets is viewed by local governments as a serious problem, and putting that traffic on new state facilities is often seen as the way to solve the problem. Conversely, any actions to manage existing state facilities that have the effect, even temporarily, of increasing local street congestion are viewed negatively by local governments, which make up the membership of the MPOs. Most damaging to the ability of MPOs to be responsible for new TSM solutions to transportation problems is their lack of stature and credibility among the public. The fact is that a good number of people have never even heard of their metropolitan planning organization. In

places where MPOs are known, they are not taken seriously.

This brings me to the last problem I would like to note with regard to TSM concepts, and that is public attitudes and perceptions. The public, for good reason, is naturally suspicious of government. It is particularly suspicious when government tries to influence private behavior. And insofar as we are operating on the demand and not the supply side of the equation with certain TSM techniques, we are likely to get a lot of opposition. When we build a new facility, we provide taxpaying travelers, at least in the short run, with more than they had before, or at least they perceive it like that. When we manage an existing facility, regulate it, or price it, we are likely to be seen as narrowing their options and impinging on their freedom.

I would like to relate the Santa Monica Diamond Lanes to some of the problems with TSM that I have just mentioned. The Diamond Lanes on the Santa Monica Freeway were a traffic management technique designed to encourage multiple occupancy on a state facility. The project was developed by the California Department of Transportation in cooperation with local governments as a response to the Clean Air Act and in an attempt to provide an alternative to an EPA-mandated transportation control plan (TCP) for the Los Angeles area. The Santa Monica project was designed as one of four alternative techniques for encouraging car pooling and bus ridership, each of which was to be tested and evaluated in a first stage of the program. In the second stage, those techniques that had proved most effective were to be extended to other freeways in the metropolitan areas. In the Santa Monica project, we took existing freeway lanes out of mixed use and dedicated them to buses and car pools. In a second project, which we have not yet implemented, we intend to add new lanes to an existing facility and dedicate them to preferential use. A third project is a separated facility for multiple-occupant vehicles (this is our El Monte Busway, which we recently opened up also to car pools). And finally, we are trying ramp-metering with by-pass lanes for buses and car pools on several freeways.

The Santa Monica project was in operation for 21 weeks and, on the merits, worked extremely well. At the beginning of the project, 6 percent of all travelers on the freeway in rush hours were in buses and car pools. At the end of the project, 18 percent of travelers were in buses and car pools. In terms of total use of the freeway, the facility was carrying 3 percent more people at the end of the project than at the beginning in 7 percent fewer vehicles. When the project started, use of surface streets went up by 10 percent, but by the end of the project no traffic was being diverted and travel times on the freeway itself were the same (for 1 and 2-person vehicles) as before the project. They were, of course, substantially less for riders in car pools and buses. We estimated that on an annual basis we were saving about 11 million liters (3 million gal) of gasoline. Air pollution sampling, although not definitive because of the limited scope of the project, nonetheless indicated a small but statistically significant decline in several major pollutants.

There was also a tremendous outcry against this project. We were sued by a business-backed organization, the Pacific Legal Foundation, on the ground that we had failed to comply with environmental laws in instituting the project, and it was stopped by court order 21 weeks after it started.

Let me briefly discuss the problems. First of all, the federal government was not a problem. It was very supportive. But there were a couple of interesting aspects to this. The federal government seemed reluctant to come out with strong, independent statements on the necessity for this kind of project for fear, I guess, of showing the heavy hand of Washington. We at the state level kept saying this is a project in response to a federal mandate—the Clean Air Act—and that the federal government believes strongly in transportation management as an alternative to expensive system expansion. We, at the state level, became the expositors and proponents of a point of view being pushed by Washington, while little came out publicly from Washington itself. Of course, new facility solutions to ever-increasing travel demand continued through the project to be built and to be discussed. We have not stopped freeway construction in Los Angeles (or elsewhere in California), and, at the time of the Diamond Lanes on the Santa Monica Freeway, we were putting together an application to UMTA and were being encouraged to seek a grant for a multimillion dollar rail rapid transit system.

The Santa Monica project was part of the MPO's regional plan. It had been discussed during a 3-year period. It was officially made a part of the plan and adopted by the MPO's governing body. It went through the citizen participation mechanism and all the rest. And yet we found that as soon as the Diamond Lanes opened (and as soon as they became controversial, which was right at the beginning) none of this meant anything. Most people in Los Angeles do not appear to have heard of the Southern California Association of Governments (SCAG), and when they do hear of it the common reaction is, "Who is SCAG to be telling us what to do? It does not represent us." We found ourselves giving a lot of publicity to SCAG, its mandates and its goals and objectives, just as we were doing for the federal government. We, and the public, heard very little out of SCAG itself. There was no visible movement by SCAG to explain or mobilize support for its plan now that it was under attack, and SCAG is not without resources. It spends several million dollars annually on planning, a major aspect of which is supposed to be community development.

Our most serious problem was, of course, public reaction—or more specifically public reaction as generated and focused by the press and the media. That in itself would provide, I think, a good subject for a thoughtful dissertation, and I am not going to try to analyze it in any detail here. But the reaction was strong, and it took some directions that I do not think had been anticipated. First of all, the project was seen as an ominous example of government coercion, restricting the freedom of the individual and restricting the rights of the private property owners (the automobile owners) to do what they want to with their property. We talked about encouraging car pooling and transit ridership. The press talked about forcing people out of their automobiles or into other people's automobiles, which is an invasion of privacy. We talked about making a more efficient use of existing facilities. The press and the public talked about the rights of persons—in a car pool or not—to use freeway lanes that had been built with their tax money.

There was another general line of reaction to the project, and this developed in response to the experimental nature of the project. When we explained that we did not necessarily view the Diamond Lanes as being the solution to congestion, air, and energy problems in Los Angeles and that we were trying it as one of four alternatives and would drop it if it did not work, we were accused of social engineering and using people as guinea pigs.

Finally, the incrementalism inherent in this kind of approach to transportation, as opposed to the "lumpiness" and permanence of capital investment actions, translated itself, in the eyes of the media and the public, into an insidious, creeping, conspiratorial movement to

destroy a life-style in small steps. The theme was, Stop it now before it spreads.

I do not want to end this on a negative note, yet I have no magical words of wisdom to put it on the upbeat. I will say that I think two things are essential. First, we in government have got to get our act together. We do not accomplish much if what we do with one hand is at cross purposes with what we do with the other. Second, public understanding and acceptance of TSM are crucial. We need to talk less to each other and more to the people. Transportation is less a technical matter than ever before and more a political one, in the good sense of that word.

STATE HIGHWAY DEPARTMENT VIEW OF TSM

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Transportation system management is not a new concept but has been practiced as long as there have been transportation facilities. The need now is to have a balanced transportation system in which each mode does the job that it is best suited to do and for which there is an expressed need or desire. In addition, one mode is not artificially enhanced by impeding the efficiency of another mode. Achieving a balanced transportation system requires the cooperative efforts of all agencies involved.

The term, transportation system management, is of relatively recent origin, but surely the activity is very old—as old as transportation itself. Transportation began in this country along the waterways and was centered on the port cities that grew up in proximity to them. In the nineteenth century, railroads emerged as the nation's dominant transportation mode; in the twentieth century, air travel became a significant mode for moving both people and freight.

In urban areas, commercial and social development helped dictate the location of transportation corridors and was enhanced by the fact that those corridors came into existence and worked well. That sort of symbiotic relation between transportation corridors and the neighborhoods through which they passed has continued to the present time.

The evolutionary development of the various transportation systems has been steady in pace and remarkable in scope as managers and owners proceeded to improve service to users. On rivers, woodburning stern and sidewheelers of sharply limited capacity and speed gave way to diesel tugs, whose tows of essential freight are refocusing our attention on the transportation importance of the nation's inland waterways. Improved trackage and roadbeds, larger and heavier freight cars, and vastly improved diesel locomotives have maintained the preeminence of the railroads in the long-haul moving of heavy and bulky freight.

In cities, small horse-drawn streetcars were replaced by sleek, air-conditioned, electrically powered rail vehicles, many of which make extensive use of computerized controls. Highways have gone from one-lane to two-lane facilities and ultimately to multilane expressways and freeways, whose capacity and safety features would have been undreamed of half a century ago. Access rights to these highways, bought and paid for by highway users, have reduced conflict and increased capacity on them.

This brief outline of the nation's transportation progress could be extended, but perhaps the point has been sufficiently made: Transportation system management is far, indeed, from being a new concept. We have been engaged in it for a long, long time.

Since World War II, transit systems and railroads have fallen on hard times. Business failures, mergers, and the necessity for increasing governmental involvement have sharply limited the share of the total transportation task of this segment of the transportation industry.

The reverse, of course, is true for highway modes. The U.S. family that does not own an automobile is rare, and the U.S. family that does not own two or more is becoming rare. Americans in overwhelming numbers continue freely and emphatically to express their affection for their private vehicles and for the highway systems on which they depend.

It is in this context, I believe, that we need to interpret all that we have lately heard about the concept of balanced transportation. I am sorry to say that much of what I have heard about balanced transportation has been burdened with the implication that excess capacity is currently available on highways. The simple historic fact is that the highway system has never kept up with the demands imposed on it. And certainly the peak-hour congestion that is a major cause of transportation concern in urban areas is still with us.

But it would be a mistake to suppose that traffic congestion in urban areas is connected in some special way with the emergence of the family automobile as the nation's basic transportation mode. Such congestion has existed since the days of horse-drawn vehicles. And in major cities throughout this country, traffic flows far more freely now than it did in horse-and-buggy days.

What is a balanced transportation system? A truly balanced transportation system is one that most efficiently allows each transportation mode to do the job for which it is best suited and for which there is an expressed need or desire. We are coming increasingly to realize, I think, that the critical elements of a balanced transportation system are the nexus points at which different modes come together. But surely any thoughtful transportation practitioner must reject that greatly simplistic concept of balanced transportation in which time, effort, and resources are equally allocated to each of the several modes.

The evolution of the several transportation modes has itself brought about many basic changes in the structure of American life. But it has been accompanied by another evolutionary process that has perhaps brought about even more: the process of exchanging rural free delivery (RFD) numbers for addresses in urban and suburban apartment complexes. Steadily through most of this century and at a greatly accelerated pace since World War II, Americans have become and are continuing to become a nation of city dwellers. As a result, transportation needs have increased and will continue to increase in cities.

The Transportation Research Board recognized the phenomenon of American urbanization early. And for many years now it has been actively engaged in promoting research, presenting its results, and otherwise enlightening the transportation industry about the nature and extent of urban transportation problems. The Transportation Research Board has not contented itself with identifying and describing those problems, but has offered specific solutions to many of them.

Most transportation professionals are well acquainted with the specific useful applications of contraflow bus lanes, special lanes for buses and vans, and parking lots at metropolitan fringes as aids to car pooling and van pooling. In Missouri we have had particularly good success with car pooling and van pooling and intend to pursue their potentials as aids to efficient transportation system management.

Means of increasing ridership per vehicle must be exhaustively studied throughout the nation. Admittedly, our efforts in improving traffic flow were vehicle oriented until rather recently. We have now become aware of and have spent more effort on moving more people in fewer vehicles. In this important continuing task, the resources and accumulated expertise of the Transportation Research Board promise to be of the greatest significance.

I know of no major metropolitan area in the country that plans to continue to build expressways or freeways. Most planned highway improvements within metropolitan areas are either in existing highway corridors or in corridors planned a number of years ago. What we urgently need in our cities at this time is not the construction of more expressway and freeway facilities but an improvement in the capacity and efficiency of those facilities that already exist or are planned.

That improvement in capacity and efficiency is a process, not a single event. And the process is continual. In Missouri, we have been actively and continually engaged in a process of upgrading the expressways and freeways in our metropolitan areas since the 1930s. And our efforts to upgrade freeway and expressway efficiency have not been confined to Missouri. Working with various other groups through the Transportation Research Board, we have participated in research in freeway ramp metering carried on in Detroit and Houston.

The Missouri State Highway Commission and the State Highway Department have the constitutional responsibility and authority for the road-building task as do other state highway agencies. But I know I speak for all my fellow state highway department officials when I say that we want and we intend to work with all appropriate modes and all properly constituted agencies—governmental and extragovernmental—in attacking the staggering transportation problems that confront us. Surely among responsible people there can be no thought of competition among agencies in transportation matters. The job we face is big enough to demand the best in dedication and skill that all of us working together can bring to it.

Efficient transportation system management will result from the cumulative efforts of all agencies and systems involved. However, efforts should not be duplicated through the establishment of additional layers of review and control. Our efficiency will also be hurt if we lose sight of two other important factors in the problem.

The first is that uniform applications of specific techniques that have worked well in one area not only are not possible but would be destructive of the ends we all seek. St. Louis is not Seattle, the District of Columbia is not Wichita, and Minneapolis is not Memphis. We must resist the notion that a technique that has worked well in one metropolitan area will automatically solve the urban problems of another.

The second is that there are just so much professional capability and so many resources to go around. Adding an administrative layer to the transportation planning organizational structure will by itself do nothing toward solving an area's transportation problems. Indeed, the introduction of such an additional stratum might well hamper and not help the quest for a solution. The imperatives of limited time and limited money will not accommodate to the organizational preconceptions of any of us. In the matter of organizational structure as in all other facets of the overall transportation problems, intelligent cooperation among agencies already in the field based on a prudent awareness of the demonstrated capability of each of those agencies will move us closer to solutions than the creation of new agencies or the reorganization of existing ones ever can.

Artificial enhancement of one mode through impediments to the efficiency of another mode should not be our goal. In Missouri, we have had it proposed to us, for example, that we further restrict lane flow on freeway sections in one of our metropolitan areas already exhibiting minimum service levels. The proposal was that we provide contraflow lanes where traffic patterns clearly did not indicate a necessity for them. The rationale for the proposal was a candidly expressed desire to impede lane flow to such an extent that people using the freeway would be virtually compelled to abandon their private vehicles for buses. Surely such techniques of compulsion have no place in our free society, particularly when those relying on them seek to conceal from the general public their real aims.

Other governmental agencies have other reasons for wanting to impact adversely the efficient functioning of expressway and freeway facilities in metropolitan areas. In a recent meeting on this subject, a representative of the U.S. Environmental Protection Agency told representatives of the Missouri State Highway Department that the federal agency would not approve the synchronization of traffic signals if the net result provided for the movement of more traffic, since such increased movement used more fuel and caused greater air pollution. Yet a basic principle of traffic capacity is improved efficiency of flow.

Many pressing problems face us as we attempt to manage urban transportation systems intelligently and efficiently. In far too many cases, we are not even attempting to tackle the problems. Let me give a couple of examples of the sort of thing I am talking about. In one major midwestern metropolitan area, buses serve the area's airport but do not provide direct service to any of the metropolitan area's convention facilities. The soon-to-be-implemented rail system serving National Airport in Washington, D.C., is obvious because of its elevated structure. However, a bus system has served that airport for several years, and I challenge you to find information at the airport on the location of those buses, their routing, or their schedules. Wherever and to whatever extent situations of this sort continue to exist, transportation system management can never be anything but a meaningless phrase.

Transportation system management must be more than that. It must be a dynamic element in transportation situations throughout this country. The state highway departments have the knowledge, the experience, and the dedicated interest in using transportation system management to create a totally efficient transportation system in all our cities. We welcome opportunities to share our concerns and ideas with other transportation people as we all work together for that desired goal.

TRAFFIC OPERATION IMPROVEMENTS

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Transportation system management applied to traffic engineering operations requires reevaluating basic transportation needs of those who walk, use public transportation, or drive automobiles. Replacing existing control mechanisms is not adequate. New ways must be devised for optimally sharing limited rights-of-way. Signs, channelization, traffic signals, reversible lanes, and ramp-metering policies are discussed in this paper.

Many urban communities have not applied all of the traffic engineering principles available for meeting the increasingly complex transportation needs. Traffic engineering in some less progressive areas has been viewed as a maintenance function, that is, replacing existing things in kind, rather as traffic system management. Transportation physical plants undergo constant change, and that change mandates more than keeping intact those things that worked in past years. The engineer's role is to provide improved service to meet changing needs. The resistance to change by long-established private sectors requires careful and systematic documentation of need. The supply of transportation space in urban communities is nearly static while the demands on the space increase each year.

The rise in concern about the quality of life in the urban environment is adding significantly to traffic and transportation management problems. Urban communities are seeking ways to increase amenities in their cities, and this requires space. The most apparent space is the public rights-of-way. Increasing amounts of it are being turned over to pedestrian facilities. Making space for pedestrians normally requires taking space from vehicles. I will examine many of the tools that we have available for making these trade-offs. As professionals, we must offer alternatives that our client groups can understand and weigh to make appropriate decisions.

A typical urban street is a multimodal facility and a terminal facility as well. It must, therefore, be managed properly. Some communities do such a poor job of management that the merchants have taken over the total sidewalk area for retailing and the remaining portion is taken over by newsstands. Parking is the next aspect of street space use. According to the Magna Carta, the King's highway was primarily for the movement of troops and not the stabling of horses. Guidelines clearly indicate that, if hundreds or thousands of people can use the same limited street space that can be occupied by a few people parking, then the public is better served by the movement function. Managers frequently find that shared use of this space is most efficient: movement during certain periods and loading or parking during others. When I worked in Phoenix, a parking space was normally a parking space, a loading zone was normally a loading zone, and a bus stop a bus stop. However, I found in Seattle that sometimes a given space was a parking space, sometimes it was a loading space, and sometimes it was a bus stop. Although confusion can occur, we find that with clear signing the system is quite workable.

Flexibility is a key word in traffic system management. If we have no capacity problems, then we are better off to have a consistent traffic control system—one in which a rose is always a rose and does not at 4:00 p.m. become a turnip. We are aware that through conditioning people drive by habit and relate only partially to outside stimulants. A new signal at an intersection where motorists are used to driving through without stopping may not get immediate compliance. People will still stop at a location where a stop sign has been removed until they become conditioned differently. The potential for accidents goes up significantly when such changes are made. The demand, however, for more efficient management requires that we have the flexibility to change.

The task of transportation system management becomes most difficult in those locations where demand is most competitive for the limited street space, particularly at intersections that have capacity less than that of those streets feeding them. One of the most effective tools is the traffic signal system that determines the sharing of the limited street space in equitable time intervals, eliminates the conflict, and makes the flow smoother. However, before appropriate signal control equipment is selected, the questions of most efficient directional flow need to be addressed and the questions regarding one-way, two-way, or reversible flow roadways must be answered.

ONE-WAY SYSTEMS

Nearly all existing urban streets were originally designed for use as two-way streets. One-way streets are usually installed to reduce congestion, but they also have important safety benefits. Because one-way streets handle traffic only in a single direction, they are commonly operated at least in pairs. The two streets should be located parallel and as near to each other as possible to reduce confusion and out-of-direction travel. They essentially operate as a divided highway, with a wide median being the blocks separating the two one-way streets. Capacity of a one-way street system may increase by 20 to 50 percent over the capacity of a two-way street system, primarily because of reduction in conflicts with turning vehicles. Similarly, traffic safety is normally improved 10 to 50 percent. The one-way system acts to platoon vehicles and thereby produces gaps in traffic for safer cross maneuvers by both vehicles and pedestrians. In general, a one-way system reduces travel time from 10 to 50 percent in spite of increases in overall traffic volumes.

Although the economic impact of converting to a one-way system will vary from place to place, the results of a Michigan study revealed that there was no indication of an adverse economic influence on business activity in the one-way corridor and that the number of business failures was reduced substantially after the one-way conversion. Such general improvements in traffic operations must be balanced against the following negative aspects:

1. Some vehicles must travel extra distances to reach their destinations;
2. Strangers may become confused with a one-way pattern;
3. Transit operations may be adversely affected (this factor must be taken into consideration before the one-way street system is implemented); and
4. An emergency vehicle may need to take a more circuitous route to reach its destination (this may be alleviated somewhat by fire preemption equipment or

traffic signal controls that would allow emergency vehicles preferential treatment).

A one-way street system strongly affects traffic signal operations. Traffic signals can always be progressed to provide continuous flow on one-way streets, but this can seldom be done on densely populated two-way streets. If a substantial pattern of alternating one-way streets exists (both north-south and east-west in an urban grid system) it is frequently possible to have a one-quarter cycle signal offset that will allow progressive movement at reasonable speed for all the downtown street system. This is never possible with a two-way downtown grid system.

REVERSIBLE LANES AND ROADWAYS

Seattle began reversible lane operations in 1953 and has as many as four reversible roadway sections in operation at one time. This traffic engineering concept has been applied to arterial streets as well as to freeway facilities. The concept, which is applicable in most urban areas where traffic flow is highly imbalanced, is generally applied only during peak-hour traffic conditions when a heavy flow of traffic volume can be sustained in the reversed roadway making it quite evident to the off-direction traveler that the lane is being used by the predominant traffic flow. Many of the inherent safety hazards of this type of operation can be obviated if such concepts are an integral part of the new design. For example, the 12-lane Seattle Freeway is built in three parallel sections; four lanes are reversed inbound in the morning and outbound in the evening. The system employs separate ramps as well as separated roadway. Consistency of operation is a significant factor so that commuters become accustomed to the operation. Special attention must be given to terminal conditions and access points. Care must also be exercised not to leave the operation in during periods of light traffic if the opportunity for wrong-way entering of the facility exists. Applications of reversible roadways have been successfully installed by using only signs and markings. Wherever possible, the installation should include lane control traffic signals together with physical barriers, traffic cones, barricades, or other similar devices.

CHANNELIZATION

Turbulent flow has less flow capacity than smooth flow. Anything that can be done at an intersection to reduce this turbulence will enhance capacity. The most common obstruction in the stream of traffic is a left-turner waiting for a gap in opposing vehicular and pedestrian traffic. Three primary alternatives exist. The first is to prohibit the turn. Frequently, the street pattern is such that a motorist can reach the same destination by making a left turn at some previous, less-congested intersection and experience little or no time penalty. Peak-hour turn restrictions are the most commonly used and yield flexibility by allowing the turn during off-peak hours for more direct access. Care must be exercised before installation to determine whether prohibition will solve the problem or relocate it at adjacent intersections.

The second alternative is to provide a left-turn lane exclusively for turning vehicles. This may frequently be accomplished by removing parking on approaches to the critical intersection or acquiring minor amounts of right-of-way or reducing the street margin and sidewalk area. Significant reductions of rear-end accidents can be expected. Similarly, capacity improvements can frequently be attained by a continuous two-way left-turn lane on a two-way arterial street. The prevalence of automobile-oriented, strip developments on urban highways frequently makes installation of a left-turn lane a necessity. The probability of head-on accidents on a two-way lane, initially feared by traffic engineers, has never materialized. Seattle, with more than 160 km (100 miles) of two-way lane marking in operation, has in fact experienced significant reduction of accidents in this category. The lanes also provide some degree of pedestrian refuge.

The third method is to provide an exclusive traffic signal interval to accommodate left-turn movements. Careful study must be given to such installations to ensure that ample time can be set aside for the movement without creating undue congestion by taking time away from through traffic movements. Where unbalanced flow exists, frequently a leading or lagging left-turn arrow may be provided. Analysis of street widths, traffic platooning characteristics, pedestrian volumes, and other factors is necessary to determine what is the best application.

Other geometric design and channelization improvements should also be considered. Included in these may be increasing certain curb radii to enhance the flow of transit or commercial vehicles and reviewing the width of driveways to ensure easy access and egress from commercial properties.

SIGNING AND MARKING

Signs that control the use of the street must be continually updated to ensure that they meet current conditions of traffic volume and safety and needs of abutting street property. The first requirement of a good sign is that it fulfill a need. If drivers are not adequately advised, they cannot take appropriate action and then both capacity and safety are diminished.

Similar attention needs to be given to pavement markings. Transit routes change. Vehicles get wider. Traffic volumes increase. Offsetting of the centerline together with restricting parking may be an appropriate action. More appropriate lane widths may help capacity. Even the ability to see the line is sometimes a problem. During rain and night conditions raised pavement markers provide guidance that paint cannot provide.

RAMP METERING

The basic premise of ramp metering is that more capacity and safety can be gained if traffic using a facility is controlled rather than allowed to build until it produces congestion levels that impede traffic flow. Ramp metering raises the question of who shall be served. The ability to give high-occupancy vehicles preference on major highway facilities can easily double their current carrying capacity. The manner in which a system of this nature is implemented is highly critical in that most freeway facilities were designed for free-flow rather than metered operations. If appropriate metering rates are not established, severe impacts can ensue on the feeding arterial system. Inner-city dwellers have difficulty accepting a system that gives preference to long trips. A balance needs to be exercised to ensure that those people who are willing to live closer to their destinations and thereby use less energy and less transportation physical plant are not preempted by those who make longer, less energy-efficient trips. A systematic review of the entire traffic corridor is needed to determine the impacts of a ramp-metering program.

SIGNALIZATION

The mystique that surrounds most traffic signal systems

leads most citizens to believe that, if the engineer were only smart enough, they would always receive a green light. That mystique also leads uninformed administrators to believe a traffic signal system requires a super computer. The task of the transportation system manager is to find the most cost-effective solution.

Traffic signal systems fall into two basic categories: (a) fixed-time traffic systems and (b) traffic-responsive systems. The traffic-responsive system detects and responds to actual traffic movements. One must first ensure that existing signals are warranted and second that potential new installations are warranted. One must then determine traffic flow characteristics. Is there a repetitive daily traffic flow that can be anticipated within reasonable bounds and programmed into a fixed-time traffic system, or does the traffic flow fluctuate sufficiently to require a traffic-responsive control logic?

Advances in computer technology are beginning to allow us to monitor what the traffic signal is doing at each location. In the past, we relied on visual observations by technicians or police personnel. Accurate assessments need to be made of current traffic control equipment. What is the failure rate of current equipment? What are the consequences of failures being experienced? What technology is now available to obviate this type of failure? How much can we afford to pay for the increased level of sophistication? Studies should include not only the increased capital cost of added sophistication but also the increased load to the current maintenance program. How much additional operating programming staff will be needed?

SUMMARY

The transportation system management requirement of the federal planning and funding programs is brought about largely by significant concerns relating to energy, clean air, and the most economic way to manage transportation. Traffic engineering techniques have always been geared to the cost-effective use of existing facilities, and political and funding efforts are now emphasizing those techniques. No time in history has ever been more opportune for implementing traffic engineering programs, which are highly visible and greatly needed.

FREIGHT MOVEMENT: A CRUCIAL COMPONENT OF TRANSPORTATION SYSTEM MANAGEMENT

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This paper points out how important freight movement is to the functioning of the urban economy, how urban development can be encouraged by including freight movement in the urban transportation planning process, and how the inclusion of freight movement is both logically and legally supported. It is appropriate to apply planning funds to freight movement if these activities are included in the unified planning work program. Thus, the types of freight planning activities considered appropriate can be as varied as the cities that apply for those funds as a portion of their unified planning work programs. The important role of freight planning in the transportation system management (TSM) element is explored. Examples are given of TSM actions that can significantly improve the flow of both freight and people by reducing the conflicts between these essential activities.

The crucial role of freight movement in urban areas is aptly pointed out in the advertisement of the American Trucking Associations: "If you've got it, a truck brought it." Although this statement may be an exaggeration, it makes the point that movement of freight in urban areas by trucks is essential to economic functioning—even survival—of urban communities. The movement of freight, therefore, should receive attention in the urban transportation planning process in a degree commensurate with its importance. Yet, some claim that it receives little or no direct attention in the planning process and that the attention it does receive is not adequately directed to the issue of efficiently moving freight.

The most available means for influencing the efficiency of freight movement is to include considerations of freight movement in the transportation planning process. This would bring us closer to the basic purpose of planning: to improve the quality of life. In fact, there are efforts that are expanding the planning process to specifically address the quality of life (2, 3). Unfortunately, many planners shy away from this broad purpose of planning by confining their perspectives to already familiar ones such as planning for passenger movement.

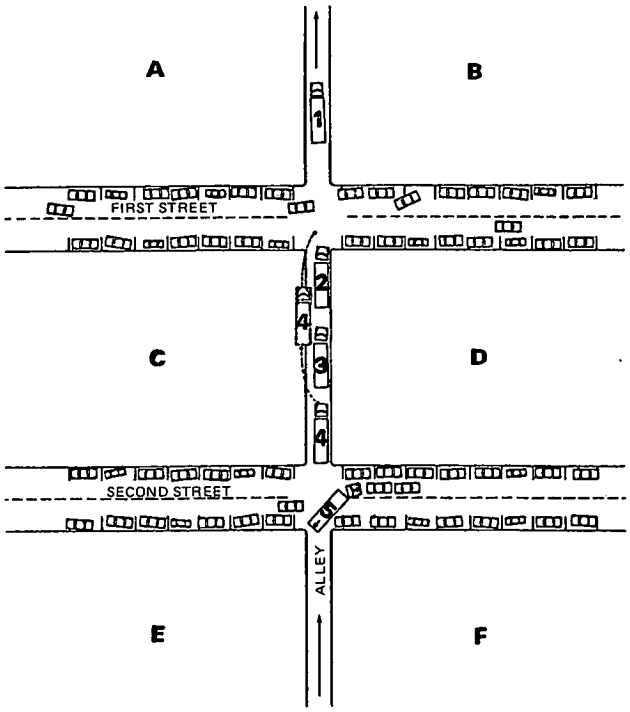
This paper shows that the inclusion of freight movement in the transportation planning process is both a logical and a necessary action. It presents arguments and examples that illustrate how a community's well-being is dependent on the efficient movement of freight. It also points out that this can be done through adjustments to the existing programs with minor redirection of planning funds. Often a significant improvement in transportation system efficiency can be achieved by giving a little extra effort to the impacts of planning recommendations on freight movement.

IMPORTANCE OF EFFICIENT FREIGHT MOVEMENT

The dependence on efficient freight movement is dramatized by occasional short-term breakdowns in the supply of freight transportation services to and from businesses and homes. A severe storm prevents supplying supermarkets with food or homes with heating oil. Truck strikes prevent supplying freight to businesses, causing them to close down and lay off workers. Sanitation workers strike, and the accumulation of refuse causes significant health hazards. These and other dramatic cases of disruptions to the efficient flow of freight attract considerable attention and reinforce its importance.

These are extreme cases in which the supply is cut off or, stated from the demand point of view, in which

Figure 1. Truck 4 wants to make a delivery to building A, but it must wait until all the trucks in front finish their deliveries and move on.



the effective price becomes infinite. But other examples occur daily and are so numerous and seemingly ordinary that they do not appear in the news: A truck is forced to wait before it can make a delivery, delaying or temporarily cutting off subsequent deliveries; businesses waiting for deliveries run out of stock, lose customers, and pay employees for unproductive time; a home delivery is temporarily prevented, keeping someone waiting for it, with possible loss of salary or vacation time, thus increasing the effective price of the delivered item; trucking firms have more vehicles and drivers than would be necessary if delivery trucks were not forced to wait for limited loading dock space or to wait in congested side streets or narrow alleys.

All the temporary but daily interruptions in freight flows increase the cost of transportation and thus reduce our standard of living and quality of life by requiring more resources and income than should be necessary to move this freight efficiently.

1. Businesses that repeatedly run out of stock while waiting for deliveries lose sales and their employees incur unproductive time. To avoid this possibility, many choose to keep larger inventories than would be necessary if freight deliveries were more efficient and reliable. Either of these options raises the costs of doing business. Almost any type of business can be affected, from retail stores to restaurants, wholesalers to home remodelers. Since these businesses are affected by the same increased costs of operation, they all must raise their prices to stay solvent. This invalidates the argument that competition will keep the prices down, and we all wind up needlessly paying extra.
2. Persons who must take time off from work to wait for a delivery can count their lost salary or vacation time directly as an increased price resulting from the delayed delivery.
3. Trucking companies must charge a higher price for each delivery in order to cover the cost of unproductive idle time spent waiting to make deliveries. Since all trucking companies incur these same costs, they have little fear about passing them on; i.e., competition does not prevent these costs from being passed on to the consumers.

The consumer bears the burden of the increasing delays and costs for urban freight distribution. Carriers simply pass the additional costs of servicing the central business district via surcharges and higher rates to the retailers. The retailer, in turn, passes these costs on to the consumer. According to Drake (4), "The problems of goods movement in a metropolitan area are the same for all. . . . These problems are built into the freight rates and therefore are ultimately borne by the general public." More important, consumers are not organized to hold members of the business or planning community accountable (1, p. 12).

The geometric requirements, e.g., for turning and parking, of trucks are strikingly different from those of automobiles. Thus, the omission of truck movement requirements from consideration in the allocation of public curbside parking space can cause major problems. A Teamster official in Saginaw, Michigan, pointed out that parking meter spaces are frequently placed so close to alleys that automobiles parked in those spaces seriously interfere with turning movements of trucks attempting to enter and leave those alleys for pickup and delivery of goods (1, pp. 3-5). Figure 1 (1) shows a particularly troublesome situation in Bay City, Michigan, where trucks are not able to turn into or out of the alley for several blocks. Trucks are forced to enter the alley several blocks away and then travel several blocks farther before they can exit. Any other truck parked in the alley making a delivery blocks all other trucks trying to get in or out. Truck drivers say it is not unusual to spend 2 or 3 hours to enter, service, and exit this alley. Considering the large number of trucks using this alley, with each driver and equipment costing between $18 and $36/h, there would obviously be significant community savings by simply removing a few parking meters at each alley-street intersection.

The recommendations made by public planners often influence the distribution costs a community must bear. Stockton, California, has been actively clearing and rebuilding its central business district (1, p. 5). One phase of this program provides off-street parking by converting the land cleared of old buildings into parking lots. Unfortunately, the adjacent alleys were absorbed into the parking lots to maximize the number of off-street parking places. Thus, much of the once extensive alley system, which effectively separated passenger and freight movement, has been eliminated. Carriers are now forced to make on-street deliveries, which are considerably less efficient than alley deliveries for both passenger and freight movement. The parked trucks, many double-parked, now contribute to the congestion on those streets and increase the conflicts among transit, automobile, and pedestrian modes. This conflict between modes for scarce street space is aggravated by two factors:

1. Several new multistory office buildings were built without proper consideration of their freight-movement needs and consequently have insufficient off-street loading facilities, and
2. The curbside space allocated to the loading and unloading zone was kept small to provide the maximum number of on-street parking spaces for automobiles.

Consequently, the demand for freight movements in this area of town is increasing while the total supply of needed

facilities is drastically reduced and no compensating increases are being made in curbside loading zone space.

This lack of loading and unloading facilities affects everyone. Because of their size, trucks appear to dominate the vehicle flow in the Stockton CBD and, to the sidewalk shopper, the visual impact is overwhelming. The intended purpose of the increased off-street parking was to make the downtown area more attractive. However, because the downtown revitalization plans omitted the crucial component of freight movement, the combination of actions taken may be having just the opposite effect.

Freight movement delays are not the only type of problem. The size and operating characteristics of freight vehicles may create significant safety problems in traffic (1, p. 6). Short, upwardly inclined acceleration lanes create safety problems when trucks enter the traffic stream because they accelerate slowly. Sharp curves in the roadway can cause freight to shift and threaten the stability of the truck unless it slows to speeds well below those of passenger vehicles using the same street. Both of these cause potential conflicts between freight vehicles and passenger vehicles.

URBAN TRANSPORTATION PLANNING PRACTICES

Urban transportation planning traditionally was concerned with providing and maintaining transportation facilities for safe and efficient movement of vehicles within an urban area. These facilities serve different activities vital to the functioning of a metropolitan area, including the movement of its freight. But because the traditional orientation is on vehicle movement, the great bulk of which is passenger vehicles, any benefits that accrue to freight distribution are incidental to the objective of providing adequate capacity for total vehicle movements (1, p. 11).

This orientation is now changing to one of facilitating the movement of people instead of vehicles, by placing the emphasis on high-occupancy passenger vehicles. Currently, few urban transportation planners consciously pursue the complementary objective of facilitating the movement of freight (1, p. 16).

Transportation planners have assumed that the needs of freight-carrying vehicles are essentially the same as those of passenger-carrying vehicles. Therefore in the long-range planning process, freight-carrying vehicles are converted to automobile equivalents and added to automobile trips to get equivalent total vehicle flows. This approach was accepted as reasonably treating the truck flows, or what is now called the stem driving portion of truck movements. [Stem and zone are components into which a route can be divided (15).] Although recent work indicates that this past simplistic conversion of trucks to automobile equivalents did not adequately represent the differential impacts of trucks in the traffic stream, it was a step in the right direction (5). A methodology is currently under development that will more adequately represent the differential impacts of truck types in the traffic stream and may eventually become available as a portion of the urban transportation planning system computer battery.

Although some needs of freight-carrying vehicles are addressed by the current planning process, many local needs are not. Taken individually, the inefficiencies and environmental consequences resulting from not treating each need are generally small; taken collectively their impact is substantial (1, p. 1).

Subsequent sections show that many freight distribution problems can be traced to a lack of consideration for the unique characteristics of different freight distribution practices and a variety of freight-carrying vehicles. Design considerations, operating policies, geometric features of streets, placement of street furniture, number and placement of loading zones, building codes, and land use planning can result in unnecessary delay and expense in a number of instances. In most of these cases the problems can be avoided with a little extra planning effort (1, p. 2). Most important, planners need to consider the implications for freight distribution when they evaluate various future actions.

FUTURE IMPACTS OF INEFFICIENT FREIGHT MOVEMENT

Changing Structures

The highest rate of population growth has shifted from large urban centers to small and medium-sized urban areas (6, 7, 8). Growth in many of these areas will be accompanied by problems, including that of efficiently moving freight. An additional problem that will exaggerate those inefficiencies is that industries currently requiring large amounts of truck travel are the ones forecast to have highest growth rates (21).

A casual observation can detect differences in freight movement efficiency among different metropolitan areas. Regional economists refer to these differences as regional locational advantages or disadvantages. The importance of these locational advantages is easily seen at the metropolitan level where many industries have relocated from the congested downtown to the less congested suburbs. The relative locational advantages of different regions are less commonly acknowledged, although the impact on employment opportunities is often greater. The population shifts now occurring from larger to smaller areas is one illustration of the relative locational advantage of these smaller areas; another is the relocation of many industries from the congested Northeast to the less congested South and Southwest. Although there are many factors other than transportation costs that determine relative locational advantage, an urban area that improves its efficiency of freight transportation relative to other regions will have a better chance of attracting growth in industries particularly sensitive to these transportation costs.

Planners' Perceptions of Impacts

Guidelines are commonly developed for the functional responsibilities of an organization and each of its components. Often these functional statements serve as a constraint on the perceptions and imagination of the people working in these organizations. Transportation planners are no exception, and consequently few acknowledge the many ways they already do or can influence the development or decline of a region. The director of one metropolitan planning organization (MPO) indicated that development and promotion of commercial and industrial districts are and should be the responsibility of the private sector and that the MPO's major role in these planned developments is to ensure reasonable adherence to land use planning guidelines. Such a precise definition of responsibilities does facilitate the management and operation of planning agencies. However, it seriously fails to recognize the major opportunities and public responsibility of the MPO to facilitate development of the community by revitalizing the CBD or by encouraging and controlling the development of well-planned industrial districts (1, p. 9).

Opportunities for Planners to Influence Impacts

1. Many new commercial or industrial parks are developed outside the current urbanized area. The narrow definition of responsibility often practiced excludes those areas from transportation planning consideration until the boundaries of the urbanized area are extended or perhaps until the total vehicle volume (truck and automobile) begins to cause significant impacts on other areas that are already being considered in the transportation plan. As a result of this oversight by public transportation planners and the desire of private developers to keep their costs to a minimum, commercial and industrial tracts are frequently developed without adequate external or internal accessibility. The total community value of these commercial and industrial parks would be increased and the economic base of the community enhanced if the transportation planners considered these developments as a portion of the future urbanized area and planned the required future transportation networks as a portion of the development (1, p. 9).
2. Quite often a city or region desires to attract new economic activity both for the jobs and for the additional tax base associated with it. The most common action taken is to have an advertising campaign. However, some areas grant special tax incentives and provide local government bonds to finance facilities. Sometimes these actions are successful, sometimes they are catastrophic, but generally they are neither. A major reason is that the underlying economic structure and locational advantages of the area are not adequately addressed.

Knowledge of what freight commodities are being shipped into and out of a metropolitan area can be a valuable input to the development of a community (9). An economic base study performed in Modesto, California, found that the primary goods imported into the community were fertilizer, seed, farm machinery, and other farm-supporting products (1, pp. 8-9). The area's exports were largely raw fruits and vegetables, which were processed elsewhere. To expand the economic base, community leaders concluded that a logical course of action would be either to encourage the production of the commodities consumed in farming or to encourage the processing of the fruits and vegetables in Modesto before they were exported from the region.

Having identified the actions that would most significantly reduce Modesto's imports or increase the value of its exports, they were faced with the same problem that others must deal with: What are the chances of success associated with each option? They preferred to attract food processors, but food processing produces large amounts of by-products and would require a substantial capital investment to expand the sewage treatment capacity. The same economic base study that identified the major freight flows also found that no other city within 160 km (100 miles) had the sewage capacity to handle food processing on a large scale and that Modesto had a central location in the food growing region of the San Joaquin Valley, proximity to a major market (San Francisco), and ready access to both highways and major rail lines. Thus, the conclusion was that, if the city were to make a substantial capital investment in a sewage treatment plant, the combination of all its other locational advantages would give it considerable competitive advantage over other communities in the area to attract the food processing industry.

The community built a sewage treatment plant of a capacity that would never have been justified by the previous forecast of population growth. Because of this careful planning, Modesto today is the home of Berberian Haig, the world's largest almond processing plant, Ernest and Julio Gallo Winery, Campbell Soup Company, Del Monte Corporation, and C.V.C. General Foods. A secondary impact resulting from the food processing industry locating in Modesto is that major manufacturers of cans, glass containers, cardboard boxes, and other packaging materials have located in the Modesto area to support the food processing industry.

Transportation planning was included as a significant part in planning the direction, rate, and type of growth desired in various parts of the area. Thus, the community effectively encouraged new development to concentrate in planned commercial and industrial parks. This transportation and zoning planning made it possible to provide efficient locations for the industries, which brought new jobs to the region. At the same time it also provided the means for minimizing the conflicts between the freight movement requirements of the community and the desires of residential and office areas for relative freedom from noisy truck traffic (10). Modesto clearly used an understanding of commodity flow to direct the economic development of the community.

3. Many older cities already have major infrastructures that have developed through the years. Often these areas were developed long ago by the use of design standards for transportation facilities quite different from those used today. Baltimore City has major port and rail facilities located within the city. These are a significant potential resource. However, the surrounding streets are inefficient for a number of reasons. Consequently, there is a continuing exodus of industry from the city to the suburbs or to newer, more efficient cities in other regions. This is an excellent example of the need for transportation system management. Baltimore has valuable capital resources, but needs a major effort to improve the efficiency of these facilities (11). New York City is attempting exactly this type of approach with its garment district. The city is faced with an industry that is relocating both to the suburbs and other regions. New York City has begun a program of transportation system management designed to improve the efficiency of the freight delivery system in the garment district. It is hoped this will slow the exodus of the garment industry from New York City and thus keep employment opportunities there (12).

PLANNING PERSPECTIVES

Planners Must Take Initiative

The people most directly involved with freight movement (shippers, carriers, and receivers) commonly accept the inefficiencies of the transportation system and either feel they cannot influence the efficiency of the system or choose not to spend time influencing it for several reasons (1, pp. 12-13).

1. Many problems inadvertently created by planners and those who operate businesses cause freight distributors relatively minor delays, which, taken individually do not appear to be sufficient cause for complaint.
2. Problems may persist for years but occur only intermittently, and thus the business community simply accepts each one as an unavoidable inconvenience associated with doing business in the community.
3. The shipper or receiver likely faces only a few distribution-related problems in normal operations. When compared to other problems of running a business, a couple of hours or an occasional day's delay in shipping or receiving freight is considered a minor problem.
4. Many people in business are simply not aware that any course of action is available for resolving some

of their districtuion problems.

5. Members of the business community, especially for-hire carriers, are reluctant to complain too vigorously for fear of attracting attention. They recognize that their trucks are not always welcome by the community and do not want unfavorable publicity that could result in further restrictions on their operations.

6. Those in the private sector generally do not find it worthwhile to encourage any major improvements in system efficiency for freight because it would have no real effect on their profit margin. Since freight movement is quite competitive, any reductions in operating expenses would accrue directly to the consumer.

Correcting these inefficiencies would result in large savings that will accrue ultimately to the community, not to those selling transportation services. Conceptually the magnitude of these savings can be calculated by multiplying the time spent at each delay by the hourly costs of each vehicle and occupants encountering these delays. The same could also be done for those kept waiting for the pickups or deliveries. The average person in business only perceives the savings that his or her particular business would make in its operations and thus, unlike the planner, is not concerned with the total economic, environmental, and social costs of freight distribution. Therefore, if the community's freight distribution system is to be improved at the points where it interfaces with other public needs for transportation, the responsibility and initiative lie with the transportation planner (1, p. 13).

Crucial Role of Freight Component in TSM

The change in federal urban transportation planning perspectives resulting from the TSM requirement is particularly relevant to the efficient movement of freight. Even though there is not yet consensus on how freight movement should be included in long-range planning for urban areas, a number of opportunities exist for improving the efficiency of freight movement by considering it explicitly as part of the relatively small system changes that are made quite regularly. The payoff in increased efficiency from these changes is potentially high, even to the point of encouraging some relocation of employment opportunities to more efficient regional areas.

Examples of TSM Freight Considerations

An Urban Mass Transportation Administration (UMTA)-sponsored study of a proposed automobile-restricted zone (ARZ) in Boston found that the present volume of freight movement that must occur even after the proposed time for restricting vehicle movement in the zone (11 a.m.) is far too great to be ignored. The means for making these deliveries must be included in the plan, for any additional freight costs or inconvenience from undelivered freight would be passed directly to the consumer, who would likely respond by avoiding businesses subject to these effects. Such evaluations of the effects of planning alternatives on freight movement are a necessary part of genuinely comprehensive planning.

An earlier study done in the New York City garment district found that practical low-capital improvements had a high payoff in improved efficiency. These changes included installing curb cuts for material-hauling handcarts to separate them from heavy pedestrian flows, restricting parking near intersections to create turn lanes that allow through traffic to proceed, retiming traffic signals during nonpeak times to give more green time to facilitate freight movement vehicles, requiring shorter loading and unloading times, and enforcing traffic regulations. In addition, a type of ARZ was implemented on several cross streets (12, 13).

A study dealing with pedestrian flows in New York City found that the traffic signals were timed only according to automobile performance characteristics. Since sections of many cities have large concentrations of many modes on the same links, it is reasonable to assume that using a proper combination of performance characteristics from these modes would improve the overall efficiency of the system for the total community of users. One possible way to approach these system signal retimings would be to use some of the computer programs being developed for a similar purpose (14). It is just as important to include trucks as one of the modes as it is to include buses, and this would require the computer program to consider multimodal interactions on the traffic system.

The behavior of pickup and delivery trucks is significantly different depending on whether they are performing stem or zone driving (15). An example is a bus service that picks up passengers at many regular stops in the suburbs, makes an express run into town, and discharges passengers at a number of regular stops. The amount of impact on traffic flow is greatly affected by whether the trucks are merely driving through the area (stem driving, which is analogous to the express portion of the bus trip) or whether they are making stops to pick up or deliver freight (zone driving), which can significantly interfere with traffic flow. Fortunately, many low-capital actions can have a significant effect.

1. Loading zones can be located to meet the needs of the freight movers and to maximize the flow of vehicles on the existing streets.
2. Loading zones can be restricted to the actual loading and unloading of freight (e.g., vehicles such as utility trucks can be restricted from parking all day).
3. Vehicles, such as messenger services, not loading or unloading freight can be prohibited from using the space.

POLICY CONSIDERATIONS

Policy Gives Direction

Transportation priorities have evolved through operating policies at both local and federal levels. Many urban transportation policies are set at the local level and consider guidelines set by the federal government. Federal regulations now require as a condition for receiving federal aid that the urban transportation planning process include a multiyear prospectus and an annual unified planning work program (16, section 450.114). An important function of these requirements is that "the plan should set forth the underlying goals and policy objectives and the strategy selected to accomplish them" (16, appendix). Thus, local policy is established by selecting items to be included in the prospectus and work program from these eligible for federal aid.

Local Determination

Only a few planning activities are given a high priority at any given time. But even these priorities are not absolute. A number of suggested actions are listed in the appendix to the planning regulations under the title Advisory Information (16, appendix). Some items in that list are specific because they are required by legislation, but the majority are deliberately stated in a general manner to allow local freedom in developing the prospectus and the unified planning work program. It is reasonable to expect that specific federal suggestions

will change over time to include other important planning activities, but in general most final decisions on what specific activities should be included in the plan are left to the local metropolitan area.

Because local policies or priorities determine what items are included, it is not unusual for some items on the list of federal recommendations to be omitted and other planning activities not on the list to be added. This adjustment is reasonable since local problems can differ widely and local metropolitan agencies are expected to have a better knowledge of their own problems than a federal agency. The unified planning work program establishes planning priorities for what planning activities will receive federal funds. Thus, local policy is established by putting together a series of more pragmatic goals and objectives (16, appendix).

Changing Priorities

Local demands contributing to the determination of priorities are continually changing, causing each year's work plan to change accordingly. In addition, the community may demand changes in the transportation system. Since the community is made up of many diverse groups, the demands of these groups will sometimes require short-range low-capital solutions and in other cases long-range capital-intensive solutions. These changes require the local unified planning work program to adjust in order to meet these needs.

The list of federal suggestions undergoes similar changes. A particularly significant aspect of a recent major shift in federal planning perspectives is its expansion to include short-range planning. Previously, planning was long-range and capital-intensive, whereas traffic engineering was short-range and relatively inexpensive. The urban transportation planning process determined what long-range capital improvements were needed to expand the capacity of the system. The traffic engineering process determined what short-range, relatively inexpensive improvements were needed to improve the efficiency of the existing system. Numerous efforts are now being made to give both short-range and long-range perspectives to urban transportation plans by joining the outputs of these two previously separate functional areas.

The federal planning regulations strongly encourage this unification by requiring a short-term portion called the transportation system management element of the transportation plan (16, section 450.116). TSM is providing an impetus for the traditional urban transportation planning process to look at shorter term, less capital-intensive improvements to the system. It encourages the traffic engineering process to include a look at the overall effects on the system caused or achieved by changes on specific existing links (17).

LEGAL SUPPORT FOR EFFICIENT FREIGHT MOVEMENT PLANNING

There is ample legal support for including efficient freight movement concerns as a portion of the transportation plan. The laws establish the inclusion of freight movement in the planning process. The regulations enable local areas to choose which planning components they will include. The following is the congressional declaration of purpose in establishing the Department of Transportation:

> The Congress hereby declares that the general welfare, the economic growth and stability of the Nation and its security require the development of National transportation policies and programs conducive to the provisions of fast, safe, efficient, and convenient transportation at the lowest cost consistent therewith.

The Urban Mass Transportation Act of 1964 as amended states that

> The welfare and viability of urban areas, the satisfactory movement of people and goods within such an area, and the effectiveness of housing, urban renewal, highways, and other Federally aided programs are being jeopardized by the deterioration or inadequate intensification of traffic congestion, and the lack of coordinated transportation and other development planning on a comprehensive and continuing basis.

The Federal-Aid Highway Act states,

> It is declared to be in the national interest to encourage and promote the development of transportation systems, embracing various modes of transport in a manner that will serve the States and local communities efficiently and effectively. To accomplish this objective the Secretary shall cooperate with the States, as authorized in this title, in the development of long-range highway plans and programs which are properly coordinated with plans for improvements in other affected forms of transportation and which are formulated with due consideration to their probable effect on the future development of urban areas of more than fifty thousand population.
>
> The Secretary may approve as a project on any Federal-Aid system the construction of exclusive or preferential truck lanes.

The Joint Planning Regulations of the Federal Highway and Urban Mass Transportation Administrations state,

> The purpose of this subpart is to implement 23 U.S.C. 134 and sections . . . of the Urban Mass Transportation Act . . . (49 U.S.C. 1602. . .), which require that each urbanized area, as a condition to the receipt of Federal capital or operating assistance, have a continuing, cooperative, and comprehensive transportation planning process that results in plans and programs consistent with the comprehensively planned development of the urbanized area.

UMTA has interpreted its act as applying only to situations involving both people and goods (freight). Since most freight movements do interact with people movements in some definable way, this interpretation merely places a reasonable requirement on the transportation planner to consider such system interactions explicitly.

RECENT RESEARCH

A recent UMTA project on urban goods movement requirements identified a number of problems associated with 44 somewhat homogeneous segments of the economy. This breakdown into segments enables a community to more easily determine what problems they are likely to face depending on their individual economic structure (18).

An UMTA report on several ARZ demonstration areas includes a portion on the importance of considering freight movement in and out of these areas. The transportation costs associated with various alternatives are calculated (19).

A Federal Highway Administration report gives a detailed discussion of various urban planning viewpoints over time, how freight has been included, characteristics of freight movement that are different from passenger movements, and what role policy plays in determining how freight is treated in the urban planning process. This report addresses issues of both short- and long-term planning and methodologies applicable to each (20).

A forthcoming FHWA report (1) includes many TSM considerations that together can make enormous differences in the efficiency of freight movement. This report also includes guidelines on how to include short-range, low-capital freight movement considerations as a part

of the continuing, comprehensive, and cooperative planning process.

CONCLUSIONS

Efficient movement of freight and people is, and will be, a challenging problem for many metropolitan areas now and in the future. If these areas are to avoid or eliminate the tremendous inefficiencies in freight transportation now faced by numerous large older cities, they must begin explicitly to include freight considerations in their planning activities.

Minor considerations given to operating characteristics of distribution firms and freight-carrying vehicles can avoid many unnecessary delays and lower transportation expenses to the general community. In addition, by developing an understanding of commodity flows, planners can take the initiative to positively influence economic growth of the community. Moreover, by improving the overall efficiency of the community's goods distribution system, the planner can alleviate a number of environmental and social problems.

Many things have contributed to the historic lack of interest in this crucial component of urban transportation. The movement of goods is extremely fragmented among a large number of businesses—common carriers, flower shops, liquor stores, office supplies, delivery services, and painters. Many of these businesses are concerned with problems of getting a large amount of sales, and freight movement is considered too small a portion of the business to worry about. They perceive no profit incentive because greater efficiency in freight movement would force the delivered price to be lower because of competition. Therefore, the responsibility for improving the efficiency and reducing the environmental and social impacts of urban freight distribution lies clearly on the public urban transportation planner. There are significant opportunities for improvement by making freight movement a component of the transportation system management element.

A number of urban areas are currently looking at the question of efficient freight movement, trying to establish proper policy for it that will, in turn, be expressed in future unified planning work programs. If the knowledge furnished by these planning efforts were pooled and made available to everyone through channels such as the Transportation Research Board, the Federal Highway Administration, and the Urban Mass Transportation Administration, it could make a significant contribution to the efforts of all those concerned with better planning for the movement of freight in metropolitan areas.

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PREFERENTIAL TREATMENT FOR HIGH-OCCUPANCY VEHICLES

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Preferential treatment for buses and car pools is one of the transportation system management actions that can be applied in many areas to promote shifts by commuters from low-occupancy automobiles to car pools and buses. Although the concept is relatively new, the experience gained from projects undertaken in many cities with diverse conditions has shown that it does work. Dramatic results have been achieved on I-95 in northern Virginia where two bus and car-pool lanes handle 17 000 persons/lane during the peak hour with space capacity. There are many different ways that buses and car pools can be given preferential treatment depending on the type of highway facility. Traffic flow models are available to facilitate the simulation of various alternative strategies, and projects are eligible for Federal Highway Administration and Urban Mass Transportation Administration program funds. With the increased attention on TSM and the expression of it in the transportation improvement programs, traffic engineering, transit operating, and enforcement agencies must work cooperatively with metropolitan planning organizations to develop and implement more preferential treatment projects.

The concept of preferential treatment for high-occupancy vehicles is one of the transportation system management elements that deals directly with the highway portion of the transportation system. It is applicable where highway system capacity is insufficient to accommodate the number of vehicles that compete for the available space. It recognizes that the private automobile, especially the one used for the commuting trip and carrying only the driver, not only demands a disproportionate share of the available highway space, which is in short supply, but at the same time is the most inefficient from the standpoint of moving people, fuel consumption, air pollution, and fiscal resource consumption. For example, vans such as those used in employer-sponsored van-pooling programs occupy the same road space as an automobile but carry 12 people; buses using the road space equivalent to two automobiles transport 50 or so people; and automobiles with one person occupy the same road space as those with five persons.

Most urban highway facilities experience their greatest vehicular demands and consequently are most congested because of insufficient capacity to handle the demand during the commuting periods when the average number of persons per automobile is the lowest. Therefore, the thrust of the preferential treatment concept is to offer an incentive to the 70 to 85 percent of the one-person-per-car highway users to travel in higher occupancy vehicles. The rationale supporting the approach is simply that high-occupancy vehicles—public transit and bus, van, and car pools—move people more efficiently than do low-occupancy vehicles. Further, many preferential treatments can be implemented in a short time at relatively low cost and with minimal institutional obstacles.

The application of this concept is certainly not new. For decades, buses have been given preferential use of curb lanes on many congested streets in numerous downtown areas. Within the last 10 years the practice of also giving buses preferential use of freeway lanes was started on the Shirley Highway in northern Virginia. Although the concept of using a freeway lane exclusively for buses has a great deal of merit from the standpoint of being able to provide tremendous person-moving capacity, only a limited number of freeway corridors have the potential for this level of bus use. Recognition of this led to the concept of using a freeway lane exclusively for buses and other types of high-occupancy vehicles. In essence, this makes it possible to have a preferential freeway lane for the most efficient vehicles that can be expected given the conditions that exist on the freeway, regardless of the existing or potential number of buses. This concept of reserving a freeway lane for high-occupancy vehicles was recognized in 1963 by Nathan Cherniack, former president of the Institute of Transportation Engineers, in advising traffic engineers on what to say to freeway users.

> If you wish to use these high-cost, high-quality facilities in peak periods as superior passenger transport facilities, you must avoid unduly dissipating their inherent passenger carrying capacities; in rush hours, you must avoid occupying a car space with less than two persons when a pooled car in that same space can carry five persons and when a bus in the same car space can carry 50 seated persons. You must agree to forego wasting the passenger capacity of at least one of the expressway lanes in the preponderant direction in peak hours, to give way to those vehicles which will carry a high portion of their passenger carrying facilities. This is only fair.

Despite this urging 14 years ago, the concept has been tried only within the last few years.

TYPES OF PREFERENTIAL TREATMENTS

The types of preferential treatments are many and varied especially when the possibilities include those for all types of high-occupancy vehicles rather than just buses. A logical way to classify them is according to the type of highway facility upon which they can be applied.

Freeway Techniques

The types of treatments that are appropriate for freeways include (a) one or more lanes physically separated and with controlled access from the regular freeway lanes for use by buses or buses and car pools, (b) one lane adjacent to the median but not physically separated from the regular lanes for high-occupancy vehicles, (c) one lane in the contraflow direction adjacent to the median clearly visible to oncoming traffic for contraflow buses and possibly car pools, (d) inside or outside shoulder for buses or car pools or both, (e) separate access ramps to or from freeways for buses or car pools or both, (f) bypass lanes for buses or car pools or both around queues on freeway ramps that are metered to optimize main-line freeway flow, and (g) various types of "queue jumpers" or "head of the line" privileges to high-occupancy vehicles at merging points or lane drops. Examples of all of these types of freeway applications have been implemented on freeways in metropolitan areas such as Los Angeles, San Francisco, Portland, Seattle, Honolulu, Miami, Minneapolis, Washington, D.C., New York, and Boston.

Major Arterial Techniques

Types of treatments that are appropriate for major arterials include (a) one lane in a contraflow direction on a divided arterial for high-occupancy vehicles, (b) one lane in the normal flow direction for high-occupancy vehicles, (c) reversing the direction of a lane for use by high-occupancy vehicles on undivided arterials, and (d) various forms of signal preemption by buses at intersections. Examples of all of these have been implemented on arterials in Miami, Honolulu, and San Juan.

CBD Street Techniques

The types of treatments that have been used and appear to be most appropriate for CBD streets all deal with preferential treatment for buses. These include (a) the curb lane for buses only, (b) the curb lane for buses and right-turning vehicles, (c) reversing the direction of the curb lane for buses on one-way streets, (d) bus-only streets, (e) exempting buses from left-turn restrictions at intersections, (f) various forms of signal preemption by buses, and (g) automobile-restricted zone with bus entry. Examples of the first two types can be found in most any large CBD. Examples of the other types are not so widespread but can be found in San Juan, Seattle, Los Angeles, Miami, Harrisburg, Washington, D.C., Cleveland, Minneapolis, and Portland.

Miscellaneous Techniques

The remaining types of preferential treatments consist of those involving toll facilities and parking facilities. These consist of (a) exclusive lanes through toll plaza areas for buses and car pools, (b) reduced or no toll charges for car pools and buses, (c) assignment of space in parking lots or garages for car pools, (d) special car-pool parking rates, and (e) provision of outlying parking for automobiles to facilitate change of mode to buses and car pools. Examples of the various types of toll facility preference for both buses and car pools exist in San Francisco, Seattle, New York, and Connecticut. A large and growing number of employers are allocating space in their parking facilities for car pools. Seattle has experimented with a reduced rate for car-pool parking, and numerous places provide change-of-mode fringe parking.

RESULTS ACHIEVED

The most dramatic results of any preferential treatment project are those exhibited by the Shirley Highway bus and car-pool lanes in northern Virginia. The highway has been under construction since the early 1960s to upgrade it from a four-lane to an eight-lane freeway consisting of three lanes in each direction separated by a two-lane reversible roadway. Starting in late 1969, buses were given priority use of various portions of the lanes through the construction areas. In December 1973, car pools with four or more persons were also allowed to use the completed sections of the reversible lanes as they were finished. At the start of the project in 1969, 1900 persons in 38 bus trips used the highway during the 2½-h morning peak period. After 3 years, the transit ridership increased by 500 percent to 11 500 persons in 240 buses. In addition, there are more than 1000 persons carried by nontransit intercity and private contract service bus operators. To date, with the inclusion of car pools, these two preferential lanes accommodate 30 550 persons in 2100 car pools and 425 buses during the 2½-h peak period. During the peak hour the two preferential lanes carry 17 000 persons in 250 buses and 1400 car pools at a high level of service with substantial spare capacity, and the three regular lanes carry 8000 persons in 6000 vehicles at a stop-and-go level of service.

The San Bernardino project on I-10 extends from a 1000-automobile fringe parking lot and bus terminal at El Monte to the Los Angeles business district. It is one lane in each direction, is physically separated from the regular freeway lanes, and has two intermediate bus stations. Since its beginning in January 1973 as a bus-only lane, patronage has grown steadily from 1800 to 17 000 daily person trips. In October 1976 it became a high-occupancy vehicle lane by admitting vehicles with three or more persons.

On the Moanolua Freeway in Honolulu, the median lane in each direction was designated as a high-occupancy vehicle lane upon completion of construction work along this newly widened freeway. Initially, the lane was preferential for vehicles with four or more persons during the morning peak period, but it is now a permanent 24-h lane in each direction for vehicles with three or more persons. Initially, about 530 car pools used the lane during the morning peak period, but by February 1975 the lane carried 4650 persons in 1300 car pools and 11 buses.

In Honolulu there is also a high-occupancy vehicle lane on the Kalanianaole Highway. The preferential lane operates as a contraflow exclusive lane on a four-lane undivided section and has a with-flow median lane on a six-lane divided section. The bus-only operation started in August 1973, and an experimental car-pool use was initiated in September 1975. The car-pool experiment resulted in an increase of 1000 car pools to the 15 buses during the morning peak period, and the car-pool use is now considered permanent.

One of the shortest high-occupancy vehicle lanes is on the lower level of a two-level bridge on I-93 leading into the Boston CBD. The left lane is reserved for buses and car pools and also serves as a left exit ramp for traffic not destined for the CBD. The third lane is a barrier lane between the reserved lane and the two congested regular traffic lanes leading to the CBD. A state trooper enforces the head-of-the-line privilege for buses and car pools at the merge of the reserved lane with the regular lanes by directing vehicles with fewer than three persons to the left ramp, which increases the travel time of CBD-destined vehicles by 20 min. The reserved lane provides up to a 10-min saving to 2600 persons in 32 buses and 500 car pools during the morning peak and has increased automobile occupancy from 1.35 to 1.44 persons.

In Los Angeles on three freeways (I-5, I-405, and I-10), car pools and buses are given preferential bypass treatment at metered on-ramps. Average time savings for those vehicles using 13 such ramps range from ½ to 5 min. There has been a 50 percent increase in the number of car pools using these ramps, and the average vehicle occupancy has increased from 1.24 to 1.33 persons.

No description of preferential freeway lanes operations would be complete without a discussion of the Santa Monica Diamond Lanes in Los Angeles since this has generated more newspaper coverage, nationwide as well as locally, than any other highway project. This publicity has been mostly adverse mainly because of a series of unfortunate incidents that occurred on the opening day. The project, which started on March 15, 1976, involved reserving one of the existing lanes next to the median in both directions for buses and car pools during the morning and afternoon commuting periods. Extensive ramp metering was also used to control the volume of traffic attempting to use this freeway. The opening-day

events that caused so much adverse reaction included a multiple rear-end accident, a truck that overturned and spilled its load (both outside the limits of the project), and a malfunction of the ramp-meter signal at the highest volume on-ramp. The extreme congestion resulting from these events was nonetheless attributed to the Diamond Lane. Despite the demands for an abrupt end to the experiment and considerable pressure generated by the press, which encouraged motorists not to accept the lane restriction, the operating conditions rapidly improved. Within weeks the number of car pools was 2½ times and bus riders 3 times the "before" situation, and the average number of persons per automobile on the freeway increased by 10 percent. In addition, the average travel time on the nonpriority lanes became equal in the morning to and only 2 min longer in the afternoon than the before situation, and the average delay to motorists at the metered on-ramps became equal to or lower than the before delays. At the time the project was suspended by a court order for failure to follow correct environmental assessment procedures, about 10 percent fewer vehicles were serving the same number of people on the Santa Monica Freeway with spare capacity available in the preferential lane to serve additional demand.

GENERAL OBSERVATIONS

These projects have demonstrated that they do work. The public will accept them. They do promote shifts of commuters who formerly drove alone to car pools and buses. They are enforceable. They can be implemented quickly, and because of their low-capital nature they are extremely cost effective. The experience gained particularly reinforces the observations contained in a February 1975 report to the Congress by the Department of Transportation.

Experience with preferential highway treatment for carpools, although limited, is very promising. Preferential treatments are practical and effective in inducing more carpooling. Too few urbanized areas are systematically pursuing opportunities to develop preferential highway facilities and traffic control treatments which favor high occupancy vehicles.

Development of preferential highway facilities for high-occupancy vehicles is an important way for highway and transit efforts to be supportive. In most cases there will not be an adequate number of buses to justify reservation of a lane exclusively for transit vehicles. Inclusion of car pools in such a preferential facility can often make an otherwise infeasible transit project a cost-effective and implementable one. On some high-volume bus facilities, car pools should not be included since bus operations would be adversely affected.

Increases in car pooling lead to a greater dependence on public transit for a variety of midday trips made by employees, especially those located in the central areas where convenient transit service exists. Building transit patronage during the off-peak periods when equipment is grossly underused is of particular significance. From a longer range point of view, formation of new car pools is constructive since the habit of always depending on one's own car is broken. Improved attitudes toward ride sharing are thus developed and may evolve into a greater propensity to use transit services as improvements are brought on line.

In many metropolitan areas, active car-pool and transit improvement programs are under way. There is a real danger of being lulled into complacency by these programs in that it may be reasoned that no further action is needed. In most every case, however, these programs only provide commuters who have decided to car pool with information about others who feel the same way or provide them with information on improved transit availability. The main ingredient that is lacking from nearly all of these programs is positive highway-use incentives for making more commuters want to decide to car pool or use transit. When all of the necessary ingredients are applied in concert—incentives on the use of public highways, incentives at the employment site, the ready ability to find others to car pool with, and the availability of transit service—we will be able to see dramatic changes.

The technique that appears to work best is also the most expensive: the physically separated facilities for high-occupancy vehicles such as the Shirley Highway and San Bernardino facilities with express bus service. Despite the high costs associated with the provision of the lanes and the bus service, the public is more accepting of the physically separated facility than of the nonphysically separated facility. The separated facility is recognized as more permanent and more distinct than, say, an adjacent lane, and enforcement is easy and safety is excellent.

Contraflow bus lanes on all types of highways have also been well received and safe. The most significant safety problem has been in the initial weeks following implementation on other than freeways when users may still be unfamiliar with the operation. Contraflow lanes also tend to be self-enforcing.

Concurrent flow lanes without a physical barrier have potentially the widest application. They are inexpensive to implement and have the same capacity and speed of any single lane. However, concurrent flow lanes present several problems. Most concurrent flow lanes require more police enforcement to hold the number of violators down to tolerable level. Motorists just cannot resist the urge to pull into what appears to be an underused, nearly empty lane. Only when the lane is full of buses slowly moving does it become self enforcing.

Allowing buses and car pools to bypass ramp metering seems to have few technical problems. It is easily enforced and can usually be provided by restriping or with minimal widening on the ramp.

Signal preemption has been shown to be an effective technique for providing priority treatment for buses. However, it appears to be more effective in some applications than others. The most effective application appears to be in expediting express buses over long distances on arterials. Signal preemption is less effective in the CBD network and in individual street applications because of greater congestion, more closely spaced intersections, and the high proportion that bus passenger service time is of total delay time. Signal preemption can be effective in special locations such as those requiring difficult merging or weaving maneuvers or at low-volume approaches to major roads.

Bus-only streets in CBDs are relatively new; the first major one began in Minneapolis on Nicollet Street in the late 1960s. Bus-only streets, or transit malls as they are sometimes called, represent a compromise solution to the desires to enhance the environmental qualities of the principal downtown shopping street and to provide priority treatment for buses. The most pleasant environmental characteristics for a downtown street would probably result from complete pedestrianization. Some have provision for automobiles to get to selected places on the bus street such as hotels and parking garages, but do not allow them to use the entire length. Those transit malls that have been implemented have been well received and have aided development and transit service.

The single most important predictor of success of any priority facility is the travel-time savings of a user over those of a nonuser. The accumulated evidence shows that travel-time savings of less than 5 min are barely perceivable and thus generally have little effect in inducing shifts from low-occupancy vehicles. Travel-time savings greater than 10 min generally do bring about shifts in mode, and the greater the savings are the greater the shift will be. The greatest time savings can generally be achieved by operating over a long distance in a preferential manner on a facility in a corridor with severe congestion. Although the possible time savings on any individual facility may appear to be too small to warrant consideration, significant time savings can be attained by adopting a "system" improvement philosophy, i.e., by providing preferential treatment improvement for a number of facilities. In that way, small increments of time savings can be added together to produce a significant overall advantage. If time savings do not appear to be significant, there still is benefit to providing preferential treatment since travel-time reliability is usually improved as a product of preferential treatments. Evidence has shown that the commuter in particular has responded to improvements in reliability.

The provision of preferential fringe or change-of-mode parking facilities outside of congested downtown areas where persons can park their automobiles and use transit for the portion of the trip into the downtown area is well established. These facilities are successful when they are located with easy access for automobiles and for buses, connected by frequent and convenient transit service, and located upstream from a bottleneck area so the transit vehicles can take advantage of the time savings of a priority lane through the bottleneck. A relatively new aspect of this is the provision of fringe car-pool parking facilities in locations that are not served by transit. In many of these, the fringe car-pool parking lot also serves as an impetus for specialized commuter bus clubs. For example, Connecticut's program, which started in 1969, has been expanded to encompass more than 100 car-pool parking lots. Of these, 16 are served by commuter bus runs.

Finally, there is the intangible but critical element of community and media support for preferential treatment projects. The Santa Monica Diamond Lane project certainly showed how adverse media reaction can hinder the ability of a preferential-lane project to remain in operation despite opening-day start-up problems. Had the media heralded the points that after the first 4 weeks bus ridership increased by more than 200 percent, car pools doubled, and 3000 fewer vehicles were on the freeway serving more than 97 percent of the former persons on the freeway rather than heralding the initial problems and thereby encouraging hostility to the project, the diamond lane on the Santa Monica Freeway might still be operating. This is a difficult issue to cope with as evidenced even by the occasional complaints noted by the media in Washington, D.C., on the Shirley Highway. Despite the fact that the reserved lanes during the peak hour serve 8500 persons/lane in only 800 vehicles/lane at over-80-km/h (50-mph) speeds while the regular lanes serve only 2700 persons/lane in 2000 vehicles/lane at stop-and-go speeds, there are occasional comments made by the news media that opening up the "clearly underused" lanes to all traffic would relieve congestion on the Shirley Highway.

ESTABLISHING PROJECTS

With the increased attention to transportation system management and the expression of it in the transportation improvement program, the establishment of preferential treatment for high-occupancy vehicles is more institutionalized. The important consideration, however, is that the successful planning, implementation, and operation of preferential treatment projects involve the close cooperation among a number of agencies and jurisdictions. A typical project may involve all of the following organizations: city traffic engineering department, county traffic engineering department, state highway department, transit operator, city police department, state highway patrol, and metropolitan planning organization.

This cooperation should be established at the outset of initial planning. It should continue throughout the development and assessment of alternative strategy stages, and most important, into the specific project detailed design and implementation activities. This cooperation will also be essential during the early stages of operation to facilitate modifications that are often necessary, to communicate with the media, and to objectively evaluate the effectiveness of the operation in accomplishing the objectives that were intended.

The assistance of federal-aid highway system funding for these types of projects has been available for years and expanded as a result of provisions in the 1973 Federal-Aid Highway Act, the 1974 Emergency Highway Energy Conservation Act, and the Federal-Aid Highway Act of 1976. For example, as an added encouragement to get more of these types of projects operational, federal-aid highway funds, normally available for urban highway construction projects at a 70 percent federal share, can be used for preferential-lane car-pool demonstration projects at a 90 percent federal share. The types of projects that are eligible for this bonus federal share include the work necessary to designate existing highway lanes (whether or not the highway is on a federal-aid system) as preferential car-pool lanes or bus and car-pool lanes, including traffic control devices that are necessary to advise motorists and control the movement of car pools. Eligible costs even include those associated with additional enforcement efforts that might be required as well as public information and promotion expenditures.

Any of the normal federal-aid highway system funds are available for the construction of exclusive or preferential bus lanes, fringe parking, and passenger transfer facilities including shelters. The minimum four-lane requirement for an Interstate Highway project is waived if the project is one for an exclusive or preferential busway.

Various UMTA funding programs are available to support preferential treatment for transit vehicles. UMTA section 3 can support such activities as bus-only streets or transit malls, busways, signal preemption, and transit shelters and stations. On an 80-20 sharing basis, UMTA section 5 can also support the same capital acquisition. UMTA section 6 funds have been used in the past to develop and test new techniques. UMTA continues to be open to demonstrate preferential techniques on an experimental or exemplary basis. UMTA section 9 funds can be used for technical studies for planning and design of preferential treatment techniques.

Despite the existence of traffic flow models that can analyze all combinations of possible reserved lane strategies for any car-pool or bus criterion; feasibility studies that looked at the safety, operational, legal, public information, and enforcement considerations; availability of federal assistance; and actual successful experience with a number of projects that have been implemented, far too many areas have not been willing to give this option serious consideration.

The techniques tried thus far have proved one thing:

They can work. What is needed now is further expansion of these applications to other locales that are confronted with similar pressures: to unclog streets, to comply with air quality standards, to encourage the use of more energy-efficient modes, and at the same time not to impair the mobility and safety of highway users.

The challenge is whether we will take the initiative and use our expertise in employing traffic management techniques to influence the highway user to switch from the most inefficient highway travel mode (one person per automobile) to the much more efficient modes (car pools and buses).

We must be willing to implement techniques that can solve several problems simultaneously. Preferential treatment for high-occupancy vehicles is one of those rare solutions that offers relief from the intricate problems of energy consumption, urban congestion, and air and noise pollution at maximum benefit with minimum harm.

PEDESTRIAN AND BICYCLE PROVISIONS OF TRANSPORTATION SYSTEM MANAGEMENT

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Edwards and Kelcey, Inc.

Walking and bicycle transportation modes can complement the transportation network and yield desirable social, economic, environmental, and health benefits. Among the actions that should be considered to ensure the efficient use of existing street space are the appropriate provisions for bicycle and pedestrian facilities such as bicycle paths and exclusive lanes, pedestrian malls and other means of separating pedestrian and vehicular traffic, and secure and convenient storage areas for bicycles. This paper estimates that potential for travel by walking and bicycle modes and hypothesizes that this potential will continue to increase. The various options for pedestrian and bicycle facilities are described and examples are given. Pedestrian and bicycle provisions included in the transportation system management elements of the Tri-State and Delaware Valley regions are described.

The development of pedestrian and bicycle facilities in this country has traditionally been affected by advances in technology. Historically, walking distances have determined the patterns of human settlements. The development of rail and roadway systems lessened the need to live close to one's work or market area. Transportation networks developed to meet the demands brought about by the segregation of land uses and the desire by many people to live in a suburban or exurban environment. This network, which relied primarily on the automobile and the accompanying highway system, gave minimal attention to alternate transportation modes. Subsequently, the needs of the pedestrian and the bicyclist have been largely ignored. It is interesting to note that in the earlier part of the twentieth century bicyclists were one of the major forces behind the "good roads movement" that eventually benefited the automobile.

In recent years, we have recognized that a single mode of transportation, such as the automobile, cannot solve all urban transportation problems. We have also developed a heightened sensitivity to natural surroundings and increased concern about energy depletion and our dependence on foreign energy sources.

Since our basic transportation systems have been developed and represent a substantial investment, to scrap them and start anew is not feasible. The basic objective then becomes one of making better use of existing facilities. Traditionally, better use has meant an increase in highway capacity by improved signs, signal controls, and other techniques. Recently, there has been an increased effort to improve use of public transportation facilities. The major emphasis is on moving people, not vehicles.

Since the 1960s, the bicycle has been increasingly used as a transportation as well as a recreational vehicle, and facilities for bicyclists and pedestrians are being planned and built in many urban areas. Although biking and walking are not expected to replace the automobile or public transportation as major modes of transportation, they can complement the transportation network and yield desirable social, economic, environmental, and health benefits.

As stated in the September 17, 1975, issue of the Federal Register (1),

> Automobiles, public transit, taxis, pedestrians and bicycles should be considered as elements of one single urban transportation system. The objective of urban transportation system management is to coordinate these individual elements through operating, regulatory, and service policies so as to achieve maximum efficiency and productivity for the system as a whole.

The purpose of this paper is to discuss the options that are available for providing adequate facilities for pedestrians and bicyclists. But, first, the potential for travel by pedestrian and bicycle modes is discussed and considered in the context of the total system.

POTENTIAL FOR TRAVEL BY PEDESTRIAN AND BICYCLE MODES

In 1975, the population of the United States was about 214 million persons. If it is assumed that 10 percent have handicaps that prevent them from walking and another 8 percent are too young to walk, then the total number of persons potentially able to travel by walking is about 176 million. In general, travel by all other modes requires at least one pedestrian link for access to the primary mode, circulation within major activity centers, or modal transfer. Therefore, the potential of travel by a pedestrian mode is great and can be expected to increase.

Estimates are that in 1975 there were 75 million bicycles in use and 100 million users and that there is a potential market of 75 million new customers consisting of 25 million who use but do not own bicycles and 50 million who neither own nor use bicycles (2). The potential for bicycle travel is great and can be expected to increase.

It is important to know the potential for travel by

Table 1. Characteristics of bicycle trips by adults in 1974.

Trip Purpose	Percent of Total Trips	Percent of Total Kilometers	Average Person Trips per Month	Average Round Trip Distance (km)
Work and school	33.1	34.9	13.8	13.0
Recreation and touring	29.3	84.3	7.1	35.7
Utility	17.6	10.3	7.5	7.2
Exercise	16.1	21.4	9.1	16.4
Racing	3.9	9.9	9.3	32.0

Note: 1 km = 0.6 mile.

Figure 1. Average number of months bicycles were ridden in 1974.

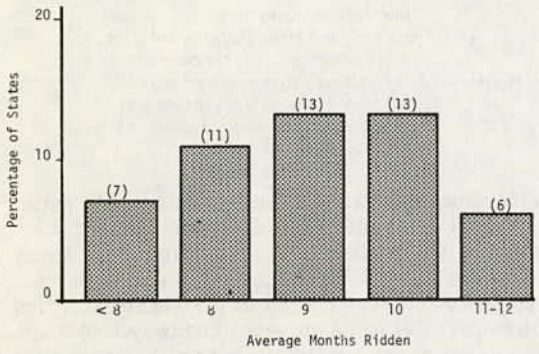
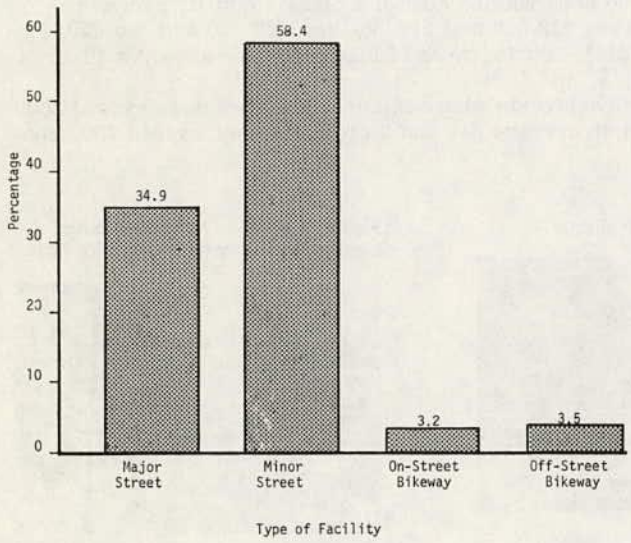


Figure 2. Type of facilities on which bicycles were ridden in 1974.



pedestrian and bicycle modes, but it is also important to know about the characteristics of travel by these modes. Characteristics of pedestrian travel have been widely reported and are fairly well known. For this reason, I will concentrate on some characteristics of bicycle travel.

About 43 percent of all urban work trips are less than 6.5 km (4 miles) in length (3). This is a distance that could easily be traveled by bicycle in a relatively short amount of time. The results of a nationwide survey of regular adult bicycle users are given in Table 1 (4). The average round trip for work and school trips is 13 km (8.1 miles). Work and school trips account for 33.1 percent of total bicycle trips and utility trips for 17.6 percent (i.e., shopping, personal business), indicating that 50.7 percent of total bicycle trips were made for transportation purposes.

Figure 1 (4) shows that the average number of months bicycles are ridden in all states is 9. Even respondents in Alaska reported that they rode an average of 6 months. Respondents reported that their average age was 37.7 years and that the largest percentage of their trips were made on minor streets as shown in Figure 2 (4).

Other studies have found that an average of 35 percent of the population in Pennsylvania, Tennessee, and the District of Columbia are bicycle users (5, 6, 7). In these studies, a bicycle user was defined as a person having ridden a bicycle at least once during the previous year. If it can be assumed that the national percentage of bicycle users is 35 and that all 43 percent of the urban trips under 6.5 km (4 miles) can be made by bicycles, then the potential for the bicycle as a transportation mode is 15 percent of all urban work trips. Of course, this number should be cautiously used since those persons who have never ridden a bicycle are potential users and some of the trips under 6.5 km (4 miles) will be made by walking.

Figure 3. Placement of the bicycle path.

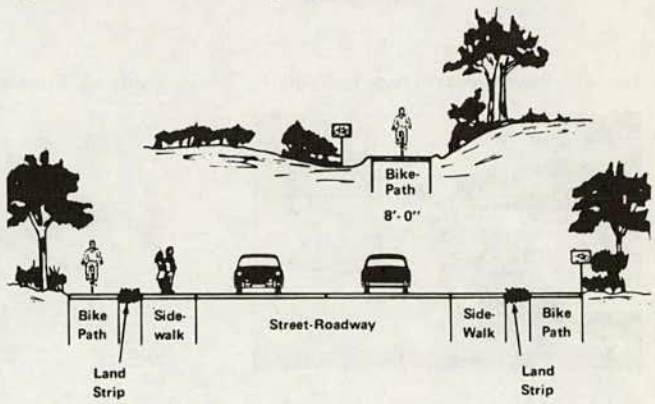


Figure 4. Belt Parkway Bike Path in New York City.

Figure 5. Bicycle path at the University of Colorado in Boulder.

Figure 6. Brooklyn Bridge Bike Path in New York City.

OPTIONS FOR PEDESTRIAN AND BICYCLE FACILITIES

Of the four transportation system management options discussed below for pedestrian and bicycle facilities, three deal with bicyclists and one with pedestrians. In all cases, the use of these options is to promote walking and bicycling as alternatives to using the private automobile for short trips. A major concern is the separation or minimization of conflicts that arise between these modes and the vehicles used for the other modes.

Figure 7. Placement of the bicycle lane.

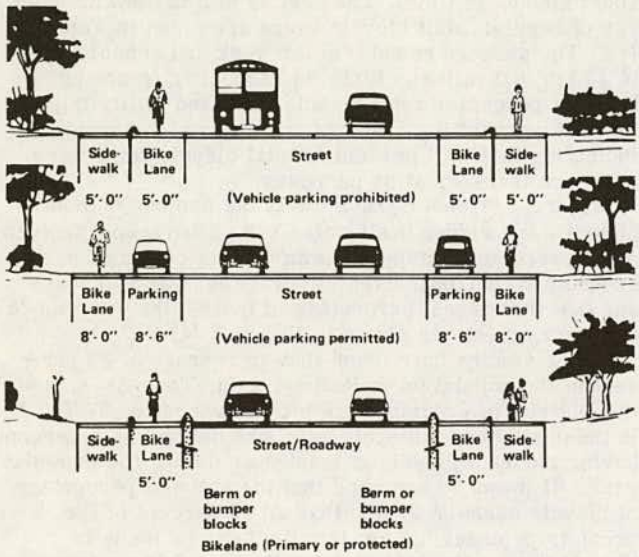
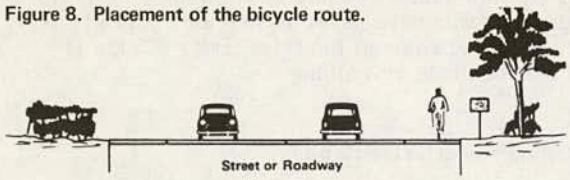


Figure 8. Placement of the bicycle route.



Bicycle Paths and Exclusive Lanes

Bikeways can be divided into three major classes:

Class	Name	Description
1	Path	A facility set aside for the exclusive use of bicycles on a completely separate right-of-way.
2	Lane	A restricted right-of-way for the exclusive or semiexclusive use of bicycles usually within the limits of a vehicular roadway and on which vehicle parking and cross flows by vehicles and pedestrians may be permitted.
3	Route	A right-of-way that is shared with motor vehicles or pedestrians and that may be signed or marked as a bicycle route.

Figure 3 (15) shows the class 1 facility or bicycle path, which is the most desirable type of bikeway from the standpoint of limited conflicts with other modes. It has been the least desirable type of facility in some states where bicyclists have been forced to use these facilities when they are parallel to an adjacent roadway. In most cases, bicycle paths are located in parks, adjacent to controlled access highways, or on abandoned railroad rights-of-way. Because of the intense competition for space, they have limited use in developed urban areas. The construction cost of a class 1 facility ranges between $12 000 and $19 000/km ($20 000 and $30 000/mile). Photographs of bike paths are shown in Figures 4, 5, and 6.

On streets where motor vehicle volumes exceed 2000 on an average day and bicycle volumes exceed 200, con-

Figure 9. Bicycle route in New York City.

Figure 10. Bicycle route in Miami.

Figure 11. Lane in Newark for buses, bicycles, and other vehicles turning right.

Figure 12. Pedestrian facilities on the Avenue of the Americas in New York City.

Figure 13. Nicollet Mall in Minneapolis.

Figure 14. Lexington Mall in Baltimore.

sideration should be given to the creation of class 2 bicycle facilities (8). Figure 7 (15) shows the location of bicycle lanes. These facilities provide a lane for the exclusive use of bicycles except where motor vehicles must cross at intersections, park, or enter driveways. Some experienced bicyclists do not like bicycle lanes, for they feel that they are restricted from mixing with the motor vehicle traffic and are forced to conflict with this traffic at intersections and driveway entrances in a fashion that can create more problems than it solves. Class 2 facilities are best suited for accommodating sizable bicycle demands in areas where there are few intersections and where motor vehicle traffic travels at speeds greater than those attainable by bicyclists. However, in urban areas where traffic speed is in the range of 16 to 40 km/h (10 to 25 mph), the cyclist may be better off riding in the overall traffic stream. The class 2 facility can cost between $1200 and $1900/km ($2000 and $3000/mile) to construct depending on the method selected to delineate the bicycle lane (i.e., paint stripe, physical barrier) from the motor vehicle lanes.

Figure 8 (15) shows the most common form of bicycle facility, which is the signed bicycle route or the class 3 bicycle facility. The major advantage of the bicycle route is that motorists are given formal notice by the use of standard signs that cyclists may be present. Although class 3 facilities are generally located on streets carrying little traffic, many cities have instituted bicycle routes on major avenues, such as Third Avenue in New York City (Figure 9). Such facilities can generally be implemented at a cost of $300 to $650/km ($500 to $1000/mile). Other examples of bicycle routes are shown in Figures 10 and 11.

Signed bicycle routes are not exclusive lanes for bicyclists. Furthermore, most commuter bicyclists will select any route, signed or unsigned, that is most desirable to them (i.e., one that is fastest or has fewest automobiles). Therefore, the class 3 facility is best applied in areas where the street systems are such that most bicyclists in the area tend to use the signed route or where there are points of interest that will attract recreational bicyclists.

In most cases, the creation of a bicycle transportation system requires a combination of the three classes of bikeways in a manner determined by needs, competition for space, and fiscal realities. The true value of a bicycle transportation system is determined by the cost savings that will be accrued by an increase in bicycle commuters and a decrease in automobile commuters. Planners of new residential subdivisions and in-town plazas should consider the bicycle as part of the transportation system and thereby foster the use of this efficient and nonpolluting means of moving people.

Pedestrian Malls and Other Means of Separating Pedestrian and Vehicular Traffic

Pedestrian travel involves a conflict between people and natural or man-made elements. The pedestrian has had to suffer the natural elements of cold, heat, dust, rain, snow, and wind and the man-made elements of vehicular transportation. Means have now been developed that allows the pedestrian to travel within a controlled environment thereby mitigating the effects of the natural elements. Conflicts with man-made elements can be eliminated by a physical or time separation (10).

The physical separations can be either horizontal or vertical. Types of horizontal separation are the sidewalk, partial mall, street closing, or full mall. An example of this type of separation is the redesigned portion of the Avenue of the Americas in New York City (Figure 12). In this project, sidewalks of 3 to 4.6 m (10 to 15 ft) are defined by a double row of trees providing an uncluttered path for pedestrians. Newly created pedestrian spaces were formed by straightening out streets and using the former roadway area for a miniplaza or sidewalk. Other examples are Nicollet Mall in Minneapolis, where sidewalk areas have been widened for pedestrians and only transit vehicles are permitted on the roadway portion of the street (Figure 13), and Lexington Mall in Baltimore (Figure 14), which is currently two blocks long and will be extended to three. Its character was always that of a pedestrian street. When the mall is extended to a length of three blocks, it will tie together Charles Center, another pedestrian area (Figure 15), with major department stores and a station on the new transit system. Other types of horizontal separations include permanent street closings that ban all vehicles or those that may permit truck deliveries. One such example is located in an urban renewal area in Jersey City and is shown in Figure 16. Vertical separation of pedestrian and vehicular systems may be done below or above ground. The pedestrian mall at the Place Ville-Marie in Montreal is below ground (Figure 17). Pedestrian bridges or skyways have been built in San Juan, Minneapolis, Newark, and Denver (Figures 18, 19, 20, and 21). Many skyways, such as the one in Denver, have commercial establishments located within them. Skyways have many times helped to revitalize the business areas of the downtown community, but they should be located where there is heavy pedestrian travel.

Pedestrians and vehicles can also be separated by time either by separate signal phases for vehicles and pedestrians or temporary street closings. Examples of temporary street closings are Nassau Street in New York City and Royal and Bourbon Streets in New Orleans (Figures 22 and 23).

In all cases, the separation of pedestrians and vehicles has increased the safety of pedestrians and improved the pleasantness of walking. Other benefits of carefully planned pedestrian zones include reduced traffic congestion, reduced air and noise pollution, reversed slump in retail sales, and recaptured ambience that only cities have (10).

Secure and Convenient Storage Areas for Bicycles

One of the most difficult problems a bicyclist faces is the lack of secure bicycle parking facilities. Reports submitted from 1723 cities in the United States reveal that more than 0.5 million bicycles are stolen annually (11). Police in California estimate that the value of stolen bicycles during 1971 was $22.3 million. The current resale value of a multispeed bicycle ranges between $40 and $300, which may encourage the professional bicycle thief to take more frequent and higher risks. At the present time, the bicyclist is at a disadvantage to the professional bicycle thief. The thief has available a variety of tools that include metal cutters, hacksaws, pry bars, and hammers. A bicycle is usually secured to a stationary object (Figure 24). The question of how secure the bicycle is or how stationary the object is is usually answered when the bicyclist returns to the parking place. There are three methods of securing a bicycle: chaining and locking the bicycle to a fixed object; locking the bicycle in a rack; and locking the bicycle in a locker.

Table 2 (12) gives the results of tests conducted by prying, smashing, bolt cutting, shear cutting, and hacksawing various locks and chains. Most locks or chains were cut in fewer than 30 s. The most successful type of lock was the Citadel, which required 13 min of hacksawing.

Figure 15. Charles Center in Baltimore.

Figure 16. Restricted Street in Jersey City.

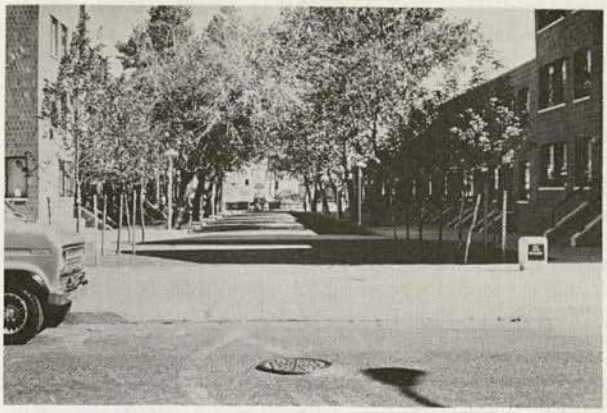


Figure 17. Below-ground pedestrianway in Place Ville-Marie in Montreal.

Figure 18. Pedestrian bridge in San Juan.

Figure 19. Pedestrian bridge in Minneapolis.

Figure 20. Pedestrian bridge in Newark.

Figure 21. Pedestrian bridge in Denver.

Figure 22. Nassau Street closed in New York City.

Figure 23. Royal Street closed in New Orleans.

Figure 24. Bicycle secured to stationary objects.

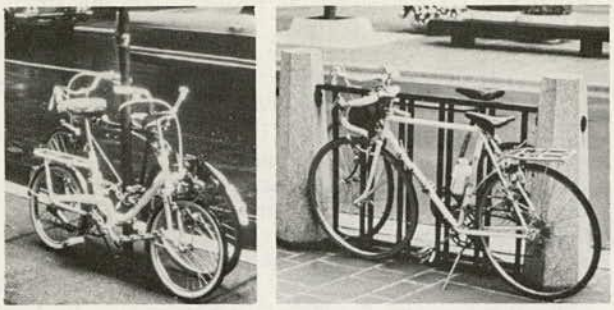


Table 2. Destruction tests of bicycle chains and locks.

Product	Pry Bar	Smashing	Bolt Cutters	Shear Cutters	Hacksaw
Citadel lock	—[a]	—[a]	—[a]	—[a]	780
9.5-mm through-hardened chain	—[a]	—[a]	95	—[a]	—
Kryptonite	—[a]	—[a]	—[a]	16	—
9.5-mm case-hardened chain	—[a]	—[a]	2	—[a]	—
Spoiler lock	—[a]	—[a]	30	1	—
Campbell cable	—[a]	—[a]	12	1	—

Notes: 1 mm = 2.54 in.
The Transportation Research Board does not endorse products or manufacturers. Trade names are given in this report because they are considered essential to its object.
[a]Not cut.

Figure 25. Bicycle secured in racks.

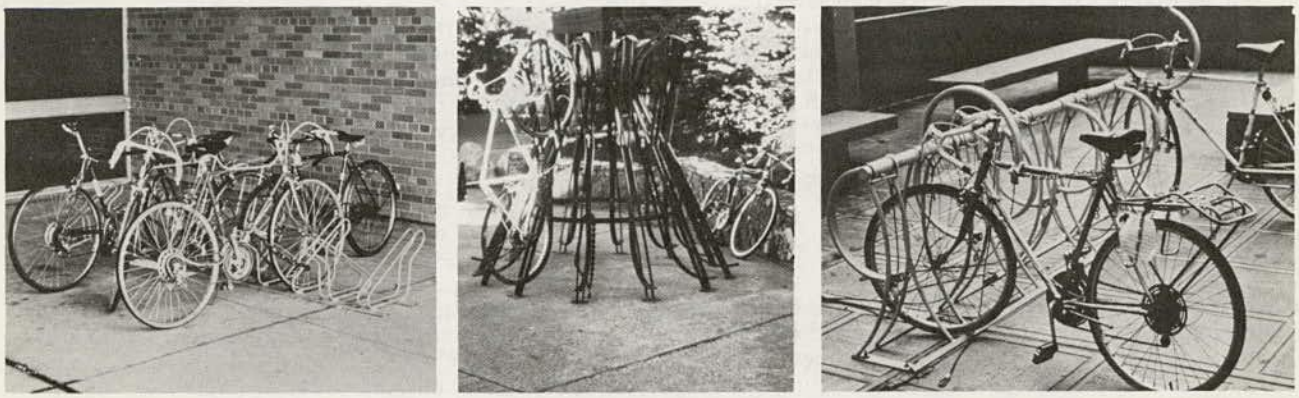


Figure 26. Santa Barbara bike bus.

There are many different types of bicycle parking racks (Figure 25). Some have integral coin-operated locks, and others require that the bicycle be locked and chained to the rack. One system employs a curved steel arm that springs over the bicycle frame and clamps around it. A woven steel aircraft cable both encircles the wheel rim and joins the frame clamp with a padlock. Another type of system is to enclose the bicycle in a cabinet. This method has two advantages: The bicycle is removed from visual temptation, and the bicycle is removed from access. The lockers are coin operated and can be installed in many different arrangements. A single automobile parking space will accommodate as many as eight locker units.

Other Measures to Facilitate Bicycle Use

Other means to facilitate the use of bicycles as a mode of transportation include encouraging persons to use bicycles to go to or from other modes. The Port Authority Trans-Hudson Corporation (PATH) linking Newark, Jersey City, and Hoboken with Lower and Midtown Manhattan permits bicyclists to take their bicycles on the rail rapid system during off-peak hours. This does not help during the commuter rush, but it does provide for a line-haul function between city centers and permits the bicycle to be used as a local distribution vehicle. Many rail systems do not permit bicycles in the transit vehicles.

Other means are being developed to provide a line-haul function by bus to permit the bicycle to be used as a local distribution vehicle. One of these was developed by David Eggleston of San Diego State University. It includes a bicycle trailer that is capable of carrying eight bicycles and is towed by a nine-passenger van (Figure 26).

Another means of encouraging bicycle commuting is to provide park-and-ride facilities at both ends of the trip so that drivers are encouraged to put bicycle racks on their automobiles and use them as a local distribution vehicle.

PEDESTRIAN AND BICYCLE PROVISIONS IN CURRENT TSM ELEMENTS

Provisions for pedestrians and bicycles included in current TSM elements are described below for two regions.

In the Tri-State Metropolitan region, which includes portions of Connecticut, New Jersey, and New York, bikeways are being planned or constructed at four locations in New York State and 40 locations in New Jersey (13). In New York City, plans are being developed for pedestrian facilities on Fulton Street in downtown Brooklyn, underground pedestrian ways in lower Manhattan, and a pedestrian mall in the Times Square area. Studies

are being conducted of pedestrian movement in the Herald-Greeley Square areas, pedestrian street space in Coney Island, pedestrian mobility in the Jamaica Commercial Center, and conflicts between vehicle and pedestrians in the Midtown Manhattan area. In New Jersey, pedestrian facilities being planned include a pedestrian shopping mall in Paterson and a pedestrian mall in Jersey City. Provisions have been or are being made for bicycle parking facilities at many locations in the Tri-State area.

In the Delaware Valley region, most bikeway planning is taking place in New Jersey. Existing Pennsylvania bike paths are confined to state parks, notably the Ridley Creek, Tyler, and Valley Forge areas. Most of the existing facilities devoted to the separation of pedestrians and motor vehicles are concentrated in the Philadelphia central business district including the Underground Concourse System, which connects approximately a 2.6-km^2 (1-$mile^2$) area of downtown Philadelphia. Another prominent and relatively new addition is the Chestnut Street transitway, which was opened in November 1975. Other pedestrian facilities include new highrise commercial buildings and the University of Pennsylvania hospital complex. At the present time, there is no planned program for the provision of bicycle parking facilities.

ACKNOWLEDGMENTS

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PARKING MANAGEMENT STRATEGIES

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Peat, Marwick, Mitchell and Company

This paper provides an overview of the range of parking management strategies. Particular emphasis is placed on describing the strategies and the considerations pertinent to their implementation in specific metropolitan areas. Because of the current interest in transportation system management, the paper is organized around the categories of parking management and control actions identified in the TSM regulations.

Increasing recognition is being given to the important role that the availability and quality of parking can play in shaping the overall service provided by the urban transportation system and in achieving other community objectives. The usefulness of the automobile can be impeded if the driver is unable to find convenient and reasonably priced parking in the vicinity of his or her final destination. Similarly, the ease of access to a transit station and the difficulty of driving and parking near the final destination are important factors influencing a traveler's choice of mode. Consequently, there has been an increased recognition—particularly at the federal level—that public policies influencing the availability and pricing of parking can be used to achieve air quality, energy conservation, and congestion reduction.

FEDERAL PARKING MANAGEMENT INITIATIVES

Environmental Protection Agency

Both the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Transportation (DOT) have undertaken parking management initiatives. In late 1973, EPA promulgated or approved transportation control plans for 30 major urban areas. Some of these included parking management initiatives with respect to both the price and the availability of parking.

Parking surcharges were promulgated by EPA in the

transportation control plans it published in late 1973 for three parts of the country: Boston, Washington, D.C., and five metropolitan areas in California (Los Angeles, San Diego, San Francisco, Fresno, and Sacramento). The transportation control plan that was promulgated for San Diego, for example, required that persons parking automobiles in commercial parking facilities pay a parking surcharge of 25 cents/h plus the commercial rate. The plan also imposed a regulatory fee of $450/year/space on each owner or operator of more than five free parking spaces including free on-street parking spaces outside of residential areas. The plan presupposed that the owner of the space would pass this regulatory fee on to the users in some form. As a result of congressional action, EPA suspended its promulgation of parking surcharges pending a clarification of congressional intent. Local areas may still, however, implement parking surcharges at their initiative.

An important focus of EPA's Parking Management Regulations was the preparation of a plan for the control and management of parking as part of an overall transportation strategy. Potential strategies that might be incorporated into a parking management plan include parking placement strategies, zoning code revisions, park-and-ride lot development, parking freeze areas, pricing policies, on-street parking removal, vehicle travel minimization for new parking facilities, and vehicle travel minimization for existing parking facilities. Proposed new facilities would then be reviewed to determine whether they were in compliance with the pattern for future parking facility development. As an interim step before the development of a parking management plan, the Parking Management Regulations provided for an interim facility-by-facility review of new facilities to assess consistency with the regulations. Implementation of the regulations has been delayed several times by EPA; at this writing, their implementation has been indefinitely postponed while EPA awaits further congressional guidance (1).

U.S. Department of Transportation

The joint rules and regulations of the Federal Highway Administration (FHWA) and the Urban Mass Transportation Administration (UMTA) currently require an urban transportation planning process that includes development of a transportation plan consisting of a transportation system management element and a long-range element (2). The regulations describe a broad range of actions that can be taken to implement TSM; these are summarized below.

1. Actions to ensure the efficient use of existing road space through:
   a. Traffic operations improvements to manage and control the flow of motor vehicles, including channelization of traffic, one-way streets, better signalization and progressive timing of traffic signals, computerized traffic control, metered access to freeways, and reversible traffic lanes
   b. Preferential treatment for transit and other high-occupancy vehicles, including reserved or preferential lanes on freeways and city streets, exclusive lanes to bypass congested points, exclusive lanes at toll plazas with provision for no-stop toll collection, conversion of selected downtown streets to exclusive bus use, exclusive access ramps to freeways, bus preemption of traffic signals, strict enforcement of reserved transit rights-of-way, and special turning lanes or exemption of buses from turning restrictions
   c. Appropriate provision for pedestrians and bicycles, including bicycle paths and exclusive lanes, pedestrian malls and other means of separating pedestrian and vehicular traffic, secure and convenient storage areas for bicycles, and other measures to facilitate bicycle use
   d. Management and control of parking through elimination of on-street parking, especially during peak periods, regulation of the number and price of public and private parking spaces, favoring of parking by short-term users over all-day commuters, provision of fringe and transportation corridor parking to facilitate transfer to transit and other high-occupancy vehicles, and strict enforcement of parking restrictions
   e. Changes in work schedules, fare structure, and automobile tolls to reduce peak-period travel and to encourage off-peak use of transportation facilities and transit services, including staggered workhours, flexible workhours, reduced transit fares for off-peak transit users, and increased peak-hour commuter tolls on bridges and access routes to the city
2. Actions to reduce vehicle use in congested areas through encouragement of car pooling and other forms of ride sharing; diversion, exclusion, and metering of automobile access to specific areas; institution of area licenses, parking surcharges, and other forms of congestion pricing; establishment of automobile-free zones and closure of selected streets to vehicular traffic or to through traffic; and restrictions on downtown truck delivery during peak hours
3. Actions to improve transit service through provision of better collection, distribution, and internal circulation services (including route-deviation and demand-responsive services) within low-density areas; greater flexibility and responsiveness in routing, scheduling, and dispatching of transit vehicles; provision of express bus services in coordination with local collection and distribution services; provision of extensive park-and-ride services from fringe and transportation corridor parking areas; provision of shuttle transit services from CBD fringe parking areas to downtown activity centers; encouragement of jitneys and other flexible paratransit services and their integration in the metropolitan public transportation system; institution of simplified fare collection systems and policies; provision of shelters and other passenger amenities; and improvement in passenger information systems and services.
4. Actions to increase internal transit management efficiency including improvements in marketing, development of cost accounting and other management tools to improve decision making, establishment of maintenance policies that ensure greater equipment reliability, and use of surveillance and communications technology to develop real-time monitoring and control capability

Of particular importance from the perspective of this paper are the actions to accomplish management and control of parking to ensure the efficient use of existing road space; the parking actions identified are

1. Elimination of on-street parking, especially during peak periods;
2. Favoring of parking by short-term users over all-

day commuters;
3. Strict enforcement of parking regulations;
4. Regulation of the supply of parking spaces;
5. Regulation of the price of public and private parking spaces; and
6. Provision of fringe and transportation corridor parking to facilitate transfer to transit and other high-occupancy vehicles.

The mutually reinforcing relations both among the various parking strategies and between various parking strategies and the other categories of strategies identified above should be noted. The effectiveness of a given parking strategy can be enhanced by implementing another strategy. For example, actions to eliminate on-street parking or restrictions to favor parking by short-term rather than long-term users both can be enhanced through strict enforcement of parking regulations. Parking actions that tend to reduce the availability and increase the price of all-day parking for commuters in the central business district tend to encourage the use of fringe and transportation corridor parking facilities. Further, many of the parking management strategies involving regulation of the availability and pricing of public and private parking spaces are closely tied to actions to reduce vehicle use in congested areas through congestion pricing or provision for automobile-restricted areas. Provision of fringe and transportation corridor parking to facilitate transfer to transit vehicles is closely tied to various TSM actions to improve transit service. In assessing parking management strategies, one should therefore consider the effectiveness of various strategies both individually and in combination with other potential TSM actions. An underlying theme of TSM is to develop a program of mutually reinforcing actions designed to achieve a community's objectives.

UMTA and FHWA have created a strong incentive for local areas to implement an acceptable TSM element. A preamble to the joint rules and regulations (2) states that "notice is given that the inclusion in the transportation improvement program (TIP) of projects recommended from the TSM element will be a condition of UMTA program approvals." The joint rules and regulations also suggest, and UMTA and FHWA have indicated in subsequent communications, that all of the major categories should be considered for inclusion in the TSM element. Although UMTA and FHWA do not anticipate that each individual action identified in the regulations necessarily needs to be considered or included in a TSM element, they do indicate that "it is expected that some actions in each category will be appropriate for any urbanized area" (2).

OBJECTIVES OF THIS PAPER

This paper provides an overview description of the range of parking management strategies; particular emphasis is placed on describing the strategies and the considerations pertinent to their implementation in specific metropolitan areas. Because of the current interest in transportation system management, the paper is organized around the categories of parking management and control actions identified in the TSM regulations.

RATIONALE FOR IMPLEMENTING PARKING MANAGEMENT STRATEGIES

The overall goal of urban transportation system management has been described as coordinating the various elements of the urban transportation system through "operating, regulatory and service policies so as to achieve maximum efficiency and productivity of the system as a whole" (2). Within this broad objective, parking management strategies have two principal objectives:

1. To improve transportation service, and
2. To increase the "generalized cost" of using a single-occupant automobile so as to divert these travelers to higher occupancy vehicles.

To the extent that these objectives are contradictory, both would not be pursued in a specific situation. Rather, the determination of which of these objectives is paramount would be based on the particular planning circumstances and objectives of a community.

This second objective is not accepted by all planners and decision makers who have traditionally focused their attentions on improving transportation service. The argument for this approach is that the automobile driver, particularly the peak-hour, home-to-work driver, is not paying the cost of providing him or her with highway facilities (3). Further, it is argued that the peak-hour highway traveler is not charged the full cost of his or her contribution to certain externalities, such as noise, air pollution, energy consumption, and traffic congestion. Currently, the only form of control on single-person automobile use is congestion pricing; a number of economists and planners have suggested that the experienced costs of single-person automobile travel should more closely approach the social costs.

CHARACTERISTICS OF PARKING SUPPLY

An understanding of the characteristics of parking supply in different-sized urban areas is necessary to provide a background for a discussion of parking management strategies. The relation between CBD parking supply and city size is given in Table 1 (4). As the size of the city increases, the supply of CBD parking facilities also increases, but at a decreasing rate. Further, as the city size increases, the proportion of the total parking spaces provided at the curb decreases from about 43 to 14 percent, and the proportion of the spaces provided in garages increases from about 0 to 30 percent. The proportion of spaces provided in off-street lots remains essentially unchanged in the range between 55 and 64 percent.

A further classification of the CBD parking supply is given in Table 2 (4) according to whether the curb spaces are metered or unmetered and whether the off-street spaces are provided in public or private facilities. As the size of the city increases, the proportion of the off-street spaces provided in public facilities increases and the proportion provided in private facilities decreases. These are average data, however, and therefore they mask important differences among cities. The proportions of the total parking spaces in those cities in the country with a population of 500 000 or more for which such data are available are given in Table 3 (23). Spaces provided in commercial facilities range from a low of about 50 percent in Detroit and Pittsburgh to a high of about 94 percent in Atlanta.

CHARACTERISTICS OF PARKING DEMAND

An understanding of selected characteristics of parking demand is also necessary as background for a discussion of parking management strategies. Use of different types of parking facilities as a function of city size is given in Table 4 (4). Use of curb parking spaces tends

Table 1. Supply of CBD parking spaces.

Population Group of Urbanized Area	Curb Spaces		Off-Street Spaces				Avg Number of Total Spaces	Spaces per 1000 Population
			Lot		Garage			
	Number	Percent	Number	Percent	Number	Percent		
10 000 to 25 000	1090	43	1 530	57	10	0	2 630	150
25 000 to 50 000	1430	38	2 420	59	140	3	3 990	120
50 000 to 100 000	1610	35	2 790	60	260	5	4 660	70
100 000 to 250 000	2130	27	4 760	62	820	11	7 710	50
250 000 to 500 000	2450	20	7 910	64	1 940	16	12 300	30
500 000 to 1 000 000	3200	14	12 500	56	6 900	30	22 600	30
Over 1 000 000	8000	14	32 200	55	18 600	31	58 800	20

Table 2. CBD parking spaces classified by type of facility.

Population Group of Urbanized Area	Curb Spaces (%)			Lot Spaces (%)		Garage Spaces (%)	
	Metered	Nonmetered	Special	Public	Private	Public	Private
10 000 to 25 000	47	51	2	18	82	93	7
25 000 to 50 000	55	40	5	27	73	50	50
50 000 to 100 000	55	41	4	42	58	56	44
100 000 to 250 000	47	46	7	52	48	89	11
250 000 to 500 000	49	40	11	66	34	95	5
500 000 to 1 000 000	54	38	8	68	32	87	13
Over 1 000 000	27	46	27	67	33	84	16

Table 3. Total parking spaces and percentage of commercial parking for selected U.S. cities.

City	Total Parking Spaces	Percent Commercial Spaces (%)	1970 Population	SMSA Population Rank
New York	395 973	80	7 895 000	1
Detroit	35 002	50	1 511 000	5
San Francisco	55 950	54	716 000	6
Washington, D.C.	51 995	82	757 000	7
Boston	42 536	59	641 000	8
Pittsburgh	36 439	50	520 000	9
Newark	8 245	61	295 000	14
Dallas	24 354	88	844 000	16
Seattle	24 839	56	531 000	17
Milwaukee	24 710	59	717 000	19
Atlanta	33 280	94	497 000	20

Table 4. Vehicles parked in different types of CBD parking facilities.

Population Group of Urbanized Area	Curb Spaces (%)	Lot Spaces (%)	Garage Spaces (%)
10 000 to 25 000	79	21	0
25 000 to 50 000	74	24	2
50 000 to 100 000	68	31	1
100 000 to 250 000	52	42	6
250 000 to 500 000	54	34	12
500 000 to 1 000 000	33	39	28
Over 1 000 000	30	54	16

Table 5. Purpose of trip and duration of parking.

Population Group of Urbanized Area	Trip Purpose (%)		Parking Duration (h)	
	Work	Shopping and Personal Business	Work Trips	Shopping and Personal Business Trips
10 000 to 25 000	21	61	3.5	0.4 to 0.5
25 000 to 50 000	21	62	3.7	0.5 to 0.6
50 000 to 100 000	20	55	3.3	0.6 to 0.8
100 000 to 250 000	26	55	4.3	0.9 to 1.3
250 000 to 500 000	30	52	5.0	1.0 to 1.3
500 000 to 1 000 000	47	38	5.9	1.5 to 1.7
Over 1 000 000	41	40	5.6	1.1

Table 6. Automobiles used in home-to-work travel and by charge and type of parking facility.

Type of Parking	Parking Charge		Automobiles (%)
	Yes	No	
Commercial facilities	63.1	2.3	6.0
Employer provided spaces	11.3	79.6	75.6
Fringe parking	0.0	0.6	0.5
Other lots	8.5	2.8	3.1
On-street	14.6	12.0	12.1
No all-day parking used	0.5	0.9	0.9
All other	2.0	1.8	1.8
Percent of total	7.3	92.7	100.0

to decrease as city size increases, but use of off-street facilities increases. Irrespective of city size, curb facilities serve a larger proportion of the total demand than they constitute of the total supply. Whereas curb facilities constitute only 43 percent of the total supply in the smallest city size group, they serve over 79 percent of the demand. Similarly, curb facilities constitute only 14 percent of the total supply in the large city size group, but they serve over 30 percent of the demand. In general, curb facilities serve trips of shorter duration and have a higher turnover than off-street facilities.

Trip purpose and duration of parking in different cities are given in Table 5 (4). As the size of the city increases, the proportion of work-trip parkers and the duration of all trips increase. Work trips have an average duration nearly four times that of shopping and personal business parkers in nearly all city sizes. Thus, the larger the size of the city is, the greater the proportion of the parking capacity will be, where capacity is measured in terms of space-hours of usage, which is used for work-trip parking.

ELIMINATION OF ON-STREET PARKING

Elimination of on-street parking, especially during peak periods, is a well-established traffic engineering technique for increasing the capacity of existing highway facilities. Two important reasons for considering the elimination of on-street parking, especially in congested areas and during peak periods, are (a) to increase the traffic-carrying capacity of the streets and thereby reduce traffic congestion and (b) to enhance traffic safety.

The primary purpose of major arterials is to serve moving vehicles, not to serve as a parking facility. The typical arterial street with parking on both sides has only two-thirds of the capacity it would have were parking prohibited; the actual capacity reduction is related, of course, to the number of lanes and whether the location is midblock or at an intersection.

Various studies have suggested that parking activity is directly or indirectly related to approximately one out of five traffic accidents on urban streets. Factors contributing to parking-related accidents include (a) parked vehicles presenting obstacles or constraining the useful roadway, (b) vehicles leaving the parking position, (c) vehicles entering the parking position, (d) automobile occupants entering or leaving the vehicle on the side adjacent to the moving traffic stream, and (e) reduced sight distances resulting from parked vehicles. When conditions of excessive traffic congestion or excessive parking-related accidents occur on arterials with parking, consideration should be given to eliminating on-street parking (4).

The decision regarding whether on-street parking should be prohibited in an area must be responsive to the requirements of both motorists and residents of an area. The following considerations enter into such a decision.

1. Safety. The Model Traffic Ordinance (5) authorizes full-time parking prohibitions on both sides of roadways not exceeding 6.1 m (20 ft) in width and on one side of those not exceeding 9.1 m (30 ft) in width. Parking prohibitions might also be warranted if an unusual number of parking-related accidents were to occur.
2. Capacity. The maximum number of vehicles per hour per lane above which parking prohibitions should be implemented are as follows (24, Table 2):

Prohibition	One Lane	Two or More Lanes
Midblock prohibition for entire street	400	600
Intersection prohibition up to 45.7 m (150 ft) on approach and departure	300	500

3. Functional classification of street system. All other factors being equal, the greater the importance of the facility is, the greater the argument is for prohibiting on-street parking.
4. Special needs of adjacent land uses. In many areas, such as older residential and commercial areas in most cities, where the street provides the only storage area for vehicles, eliminating on-street parking constitutes a severe disservice unless alternative off-street parking facilities are concurrently provided. The importance of on-street parking facilities is emphasized by the parking supply data given in Tables 1 and 4. In all city sizes, on-street facilities serve a much greater proportion of the total vehicles parked than the proportion that they constitute of the total parking spaces. This is a result of the greater turnover and generally greater desirability of on-street spaces.

PARKING RESTRICTIONS TO ENCOURAGE SHORT-TERM USERS

The importance of parking restrictions to encourage short-term users is illustrated by data given in Table 5. The larger the size of the city is, the greater will be the proportion of the total parking spaces used for work-trip parking. Further, since the work-trip parker generally arrives earlier than the shopping-trip or personal-business-trip parker, he or she will generally obtain the most advantageous space unless some form of parking restriction favoring short-term parkers is in effect.

Several arguments are offered for implementing parking restrictions to favor short-term parkers.

1. Parking spaces located closest to commercial and shopping facilities should be reserved for those traveling for personal business and shopping reasons to encourage that kind of travel to the CBD.
2. All-day work commuters generally have low automobile occupancy, travel during peak periods, and are probably the most easily diverted of all of the urban travel market segments to higher occupancy vehicle. They should be provided with parking spaces that are less accessible to their final destinations to encourage them to divert to higher occupancy vehicles.
3. A high turnover of automobiles parked should be obtained from the limited number of parking spaces located closest to commercial and service facilities.

A number of different approaches are available for implementing restrictions on the duration of parking to encourage short-term parking. The approach used is dependent on the specific circumstances of each case including the physical arrangements of the facilities, the availability of alternative facilities for long-term parkers, the method of fee collection, and the enforcement resources available.

1. Place a time limit on the duration of parking. This approach is frequently implemented by using parking meters, although parkers may still put new money into the meters toward the end of the elapsed duration. Another technique is for an enforcement officer to uniquely identify each vehicle, for example, by a chalk mark and to ticket those that have not been moved from their original spaces.
2. Prohibit automobiles from parking before a certain hour. Automobiles can be prohibited from parking until after most all-day workers have arrived at their jobs. This technique is used in Washington, D.C., to constrain employee parking on the Mall and thereby to save the spaces for tourists and in London, England, where many parking facilities in the CBD are closed until after 9:30 a.m. The enforcement costs may be lower with this approach than with placing a restriction on the duration of parking, particularly if meters are not used to enforce the duration restriction. This approach is also effective if the duration restriction is to apply to attendant-operated garages or lots, where it would otherwise be difficult to place duration restraints on parking.
3. Change pricing structure. The parking pricing structure is frequently such that the total cost of parking per hour decreases as the duration of parking increases. Although such a pricing strategy is understandable in terms of profit maximization and the desire to rapidly recover the fixed cost of serving a given vehicle, it does not favoring short-term parkers. An alternative stragegy is for the cost of parking per hour to increase or remain constant as the duration of parking increases. Under this approach, the pricing structure could be designed to serve the needs of a particular market segment. For example, the Air and Space Museum on the Mall in Washington, D.C., has a rate structure designed to reserve the facility for tourists and to discourage all-day parking by employees. Although pricing strategies for encouraging short-term parking have not frequently been employed, they appear to offer potential for application to facilities where the fees are collected by an attendant.

ENFORCEMENT OF PARKING REGULATIONS

Enforcement of parking regulations is an essential condition if the policies on on-street and short-term parking are to be effective. Potential violators must recognize that they have a relatively high probability of receiving a traffic citation and of having to pay the fines for their traffic citations. Enforcement of parking regulations is a specialized area, and consequently transportation planners and traffic engineers have devoted relatively little attention to it and its relation to the effectiveness of parking regulations.

Enforcement of parking regulations requires personnel to patrol the streets, identify violators of parking regulations, and write citations for these violators. This is a labor-intensive function, particularly in areas where there are 2-hour parking limits. The patrol personnel can be reduced to some degree if they patrol in vehicles and have preprinted citations and if the court procedures are streamlined. In addition, patrolling can be tailored to the nature of the potential violations and randomly varied by geography and time so that potential violators cannot predict when they will occur.

In some municipalities, a specialized unit of parking enforcement personnel has been created and the regular police department has been relieved of this responsibility. This approach has two advantages: (a) highly trained and relatively expensive police personnel are freed for law enforcement duties and (b) police morale is improved, for parking regulation enforcement is generally viewed as an undesirable assignment. Creation of a specialized parking enforcement unit has the advantage of relating the enforcement function more closely to the overall parking function. Further, the incremental costs of this unit can frequently be justified by the incremental revenues and increased adherence to parking regulations that result from a more effective enforcement effort. Creation of such a unit is clearly not cost effective in all stiuations. Consequently, each community needs to assess the desirability of creating a special parking regulation enforcement unit in the context of its unique circumstances.

Adequate information systems are necessary to identify violators who have received but not paid parking citations. One approach that has been adopted in a number of municipalities is not to renew the state automobile registration or municipal vehicle identification sticker unless all outstanding parking violations for that vehicle have been paid. In those areas in which a violator parks in one jurisdiction but resides and has an automobile registration in another jurisdiction, interjurisdictional reciprocity agreements must be established.

The possible substitution of administrative hearings for court proceedings with respect to parking violators should also be considered. This approach would free the courts from the burden of adjudicating parking violations, would expedite the administration of sanctions for chronic parking violators, and might be more effectively integrated with the overall parking enforcement system. Such an approach would increase the probability that a chronic parking violator would be apprehended and would receive the sanctions associated with his or her actions.

Finally, the sanctions associated with parking violations should be closely related to the objectives of the parking program and to the anticipated rate at which violators will be apprehended. Suppose, for example, that a parker paid $3/day or $15/week to legally park but that the parking fine, were he or she to illegally park, is only $10 and, further, that the probability of being apprehended is only once per week. Illegally parking would, therefore, be economically advantageous.

REGULATION OF THE SUPPLY OF PARKING SPACES

Historically, governmental regulation of parking supply in the United States has served to increase the overall supply. In many municipalities throughout the country, the local zoning code requires that a minimum number of spaces be provided—this is generally specified as a minimum number of spaces that must be provided per unit of activity (e.g., per dwelling unit for residential facilities or per square foot of floor space for commercial or office facilities).

Recently, the U.S. Environmental Protection Agency has advocated governmental controls to reduce the volume of parking facilities provided by placing constraints on the number of new parking facilities constructed or reducing the total number of facilities currently available (1). The objective of such a program is to (a) make it more difficult for the automobile traveler to find an available parking space and (b) increase the price of parking (insofar as the equilibrium price of parking would be higher if the supply is constrained and the demand curve remains unchanged). As a result, automobile drivers would divert to higher occupancy vehicles.

A strike that closed 80 percent of the parking spaces in downtown Pittsburgh is an example of the potential favorable impacts of constraining the number of parking facilities provided. During the strike, morning peak-period traffic volumes in the CBD declined by about 6000 vehicles (or about 24 percent) and daily systemwide bus patronage increased by about 24 000 riders/day (or about 12 percent) (6). In Marseilles, France, a total ban on parking in the downtown area produced a 40 percent reduction in carbon monoxide concentrations (7).

Constraints on the growth in the supply of available parking have been implemented in Boston and in London. In Boston, the number of off-street parking spaces in the CBD has been frozen at the level of supply that existed in the 1972-73 period. As existing spaces are eliminated for whatever reason, they are placed into a "space bank" and may be allocated to new parking facility development within the freeze area; these new developments are generally oriented to upgrading the existing CBD parking inventory. This freeze is part of an overall program to encourage greater use of public transportation to the CBD; the freeze presupposes that all future increases in travel to the CBD will take place on transit. As part of this program, Boston plans a major increase in parking facilities located along rail rapid transit, commuter rail, and express bus lines (8). In London, zoning regulations place a ceiling on the maximum number of parking spaces that can be provided in new office developments (9).

Techniques for Implementing Regulation of Supply

Five broad strategies for constraining the number of parking facilities provided are discussed below.

Depleting the Existing Inventory

Depleting the existing inventory of parking facilities is the most severe of the supply constraint measures. Approaches to depleting the existing inventory include (a) immediately removing some spaces (e.g., on-street parking), (b) placing a complete moratorium on new construction of parking facilities and thereby allowing the number of parking spaces to decrease as development consumes existing spaces, and (c) removing a specified number of percentage of spaces within a specified time.

Existing on-street facilities within CBDs are generally

metered and provide a valuable service for short-duration trips; on-street facilities are generally not used for long-duration work trips.

Placing a moratorium on the construction of new facilities and allowing shrinkage to take place in the total parking inventory as development consumes existing spaces reduce the existing supply slowly over time. The rate at which the supply is reduced will, of course, be related to the rate at which new development occurs. The impact of a parking facility construction moratorium on new development within the CBD should be carefully assessed inasmuch as this approach could have an adverse impact on CBD development. In many metropolitan areas, organizations that finance new development require the provision of parking facilities in conjunction with a project as a necessary condition for their financial support. In this context, placing a moratorium on new parking facilities might actually discourage redevelopment activities within the parking moratorium area.

Removal of a specified number or percentage of spaces within a specific period of time is the most severe of the parking depletion strategies. In most urban areas, a limited number of spaces could be removed by eliminating on-street parking. If, however, a program were initiated to remove otherwise serviceable public or private sector off-street spaces from operation simply to deplete the inventory of existing parking facilities, there would appear to be a requirement to compensate the owners of the facilities for the resulting reduced value of their facilities. Private owners would be compensated for the reduced revenue that the facility would produce in other than parking uses. Since most public facilities are financed by revenue bonds, some provision would have to be made for meeting the financial obligations on the outstanding bonds.

A systematic program to deplete the existing parking space inventory would require the political support of the local decision-making community. Such a program would appear to be most applicable in mature urban centers in which relatively small growth is taking place, excess parking capacity is currently available, and environmental and energy conservation objectives are of sufficient concern to warrant such a major action.

Freezing the Number of Parking Spaces

Parking supply can be regulated by freezing the inventory of parking spaces. The existing inventory of CBD parking spaces is upgraded over time by replacing obsolete facilities with CBD peripheral garages or underground parking within structures. Spaces removed from service are placed into a parking space bank that may then be allocated to new development according to specified criteria. This is essentially the approach adopted in the Boston metropolitan area.

The freeze approach is clearly a less drastic action than depleting the existing inventory. It would appear most applicable to situations in which the CBD is experiencing some growth in travel; clearly the freeze approach would not have an effect if travel to the CBD were stable. The administrative procedures associated with a freeze, particularly the procedures used to allocate spaces from the space bank to new facilities, need to be carefully established. In this context, the parking development plan for the CBD needs to be carefully coordinated with an overall development plan. This approach may encounter the reluctance of financing organizations to support new projects that do not incorporate parking facilities.

Constraining Normal Growth in Parking Supply

A third approach is to constrain the volume of new facilities provided to less than would be provided under normal market circumstances. This approach would appear to be most applicable to areas experiencing rapid growth in traffic volumes. It recognizes that some new parking facilities should be provided but establishes a ceiling on this number to encourage use of higher occupancy vehicles. This approach requires a carefully formulated set of criteria for establishing the ceiling on the maximum number of parking spaces to be provided. Such criteria might include the availability of alternative transportation services and the environmental and energy implications of the facilities.

Requiring Residential Parking Permits

Residential parking permit programs have been advocated and implemented to reduce parking by commuters on residential streets located adjacent to a congested commercial or employment area in which either insufficient parking is available or available parking is so expensive that commuters are encouraged to park in the residential areas and walk to their final destinations. Heavy commuter parking on residential streets may also occur adjacent to a congested transit transfer point at which insufficient parking facilities are available, particularly a commuter railroad or rail rapid transit station. This situation occurred, for example, at congested fringe parking facilities on both the Lindenwold Hi-Speed Line serving the New Jersey suburbs of Philadelphia and the Bay Area Rapid Transit System serving the San Francisco metropolitan area.

Residential parking permit programs are designed to reserve the available on-street parking in these congested areas for residents. Special permits are issued to residents authorizing them to park on the streets at a time when parking by all others is prohibited. The prohibited period may be from 7 a.m. to 10 a.m. or from 7 a.m. to 6 p.m. Thus, the residential permit program increases the probability that residents of a congested area will be able to find on-street parking in the vicinity of their residences.

Understandably, residential parking permit programs are popular with residents of areas in which congested on-street facilities are being used by all-day commuters. The legality of such programs has been challenged in a number of suits questioning the constitutionality of such measures. Although the matter has not been fully resolved, the courts have permitted several municipalities to implement residential parking permit programs.

Residential permit programs are generally implemented to increase the parking available to residents and not to restrain traffic. If the residential area is located adjacent to the final destination of the all-day work parkers, however, the program will tend to increase the generalized cost of parking and will therefore tend to divert travelers to higher occupancy modes. On the other hand, if the residential area is located adjacent to a transit transfer point, the permit program may have the opposite effect, particularly if alternative transit transfer points with parking are not readily available.

Restricting Facility Use

A final approach to constraining the supply of parking is to place restrictions on the use of existing facilities, such as limiting the duration of parking. Madison, Wisconsin, for example, is converting existing facilities

from long- to short-duration spaces. Another approach is to place restrictions on the hours during which parking facilities can operate. For example, a parking facility might be able to serve only car pools of three or more persons until 9:30 or 10:00 a.m. These approaches tend to discourage the use of single-person automobiles for home-to-work travel.

Considerations Affecting the Regulation of Supply

Placing a ceiling on the maximum number of parking spaces that can be provided involves a relatively new area of governmental regulation, the implications of which are not fully understood. There has been relatively little experience with such an approach in the United States although a number of cities are exploring the use of automobile-free or automobile-restraint zones within their CBDs. The degree to which parking supply constraints can be used to reduce automobile travel and thereby achieve air quality and energy conservation objectives appears to be related to the following factors (10).

1. Placing restrictions on parking supply and thereby inhibiting the use of low-occupancy vehicles must be accompanied by the provision of transit, car pools, and van pools. Therefore, the best time to implement a parking supply constraint program is when a significant improvement occurs in alternative higher occupancy transportation services. This is difficult to achieve, particularly with respect to rail rapid transit systems that are constructed and opened to service over a period of many years. No feasible way has been devised for differentiating the service provided to parkers according to whether they reside in a portion of the region in which the transit service has been improved.
2. Parking supply constraints should be structured to impact those automobile travelers who are most likely to divert to alternative modes, particularly all-day commuters. Further, parking supply constraints should be designed so as not to adversely affect those travelers, such as shoppers, who cannot readily divert. The strategy of not allowing facilities to serve low-occupancy automobiles until after 9:30 or 10:00 a.m. is one approach that effectively focuses the parking supply constraints on commuter parking. This objective might also be achieved by placing restrictions on the duration of parking within specific facilities.
3. A significant proportion of the total parking volume within the CBDs of larger areas is provided by off-street facilities. Consequently, any program to constrain the volume of parking facilities provided must include both off-street and on-street facilities.
4. The objective of parking-restraint measures is to reduce automobile traffic to improve air quality and conserve energy. To achieve this objective, restrictions placed on the supply of parking must be sufficiently stringent to reduce the quantity of parking spaces occupied and not just reduce excess capacity, particularly in CBDs, where the overall level is stable or possibly declining over time. Since the number of automobiles that park in a CBD may vary significantly during the hours of the day, the days of the week, and the weeks of the year, particularly for shopping and personal business and to a lesser extent for work trips, "excess capacity" needs to be carefully defined.
5. Constraining the supply of parking within a portion of a metropolitan area may have long-term urban development implications. If, for example, parking supply were constrained in the CBD but not in the suburbs, new development would likely occur in the suburbs. Under these circumstances, implementation of the parking supply constraint program would appear to require concurrent implementation of development controls throughout a metropolitan area—a situation not currently existing within most U.S. metropolitan areas and one that would be extremely difficult to implement. The parking supply constraint program should be carefully assessed to ensure that it does not significantly impact the overall development patterns within the region in an adverse manner. Concurrent implementation of a parking supply constraint program and a significantly improved transit service (e.g., a regional rail rapid transit system) might have a high probability of achieving the desired objectives without adversely impacting urban development patterns.
6. In many cities, developers clear a site primed for development ahead of time and provide a parking lot until they are ready to begin construction. This allows them greater flexibility in initiating construction and provites an intermediate source of revenue. Parking supply regulations that impede or prohibit this land clearing and holding process might adversely affect CBD development, and their design should consider the role of temporary surface parking lots within the overall land redevelopment cycle.

REGULATION OF THE PRICE OF PARKING FACILITIES

Actions to increase the price of parking are designed to make driving an automobile relatively more expensive and thereby encourage automobile travelers to divert to high-occupancy vehicles. Parking pricing actions that might be taken include parking tax, parking surcharge, increased parking rates, and restructured rate structure.

Techniques for Implementing Regulation of Price

Parking Tax

Although a parking tax is viewed by most municipalities as a revenue-raising device, it also has the effect of increasing the cost of parking and thereby encouraging travelers to divert to high-occupancy modes. Cities that have a parking tax include Pittsburgh, which has a 20 percent tax; Washington, D.C., which has a 12 percent tax; and San Francisco, which levied a 25 percent tax from October 1, 1970, to June 30, 1972, and then lowered it to 10 percent. A further advantage of these taxes is that a significant portion of them are paid by suburban residents. The constitutionality of the Pittsburgh parking tax was upheld by the Supreme Court in Pittsburgh versus Alco Parking Corporation (June 11, 1974):

> By enacting the tax, the city insisted that those providing and utilizing non-residential parking facilities should pay more taxes to compensate the city for the problems incident to off-street parking. The city was constitutionally entitled to put the automobile parker to the choice of using other transportation or paying the increased tax.

Parking Surcharge

A parking surcharge is an additional fee that is added to the existing or regular parking charges as a result of governmental action. Whereas parking taxes can only be applied to situations in which a fee is regularly paid for the use of parking, parking surcharges can also be applied to employer provided parking, free parking at commercial centers, and even free or metered on-street parking. The nature of the surcharge with regard to its

level, the geographical area of application, the hours during which the surcharge applies, the facilities to which the surcharge applies, and the duration of parking to which the surcharge applies can be varied, although the selected approach must be administratively feasible. Consequently, the parking surcharge approach offers the potential for carefully targeting the group that is to be impacted by an increase in parking prices. If this group is, for example, all-day work commuters to the CBD, the group most divertible to transit, then the parking surcharge might be applied only to vehicles having a parking duration greater than 4 h or to vehicles arriving between the hours of 7 and 10 a.m.

Parking Price Increase

A number of actions, other than a parking tax or surcharge, can be taken to increase the overall price of parking. These actions include increasing the rates at municipally owned and operated on-street parking meters, installing meters at additional locations, increasing the parking rates at facilities operated by the city or the municipal parking authority, and placing restrictions on the duration of parking at various facilities. Such actions would indirectly tend to increase commercial parking rates insofar as the municipal or authority operated parking facilities constitute a significant proportion of the total parking supply available within the area. Direct municipal regulation of the rates charged by the commercial parking industry might also be undertaken, although this approach has not yet been implemented anywhere in the country and would probably be subject to a test of its constitutionality.

Parking Rate Structure Revision

The current parking rate structure in many metropolitan areas results in a lower effective rate per hour for long-duration parkers. Although the parking industry practice of charging a higher fee for the first few hours than for subsequent hours is partially related to recovering the incremental costs of serving an additional automobile (irrespective of its parking duration), it also reflects a realistic profit assessment strategy of the parking industry. Revising the parking rate structure so that the parking cost per hour is the same irrespective of the duration of parking or even increases with the duration of parking has the effect of increasing the overall parking cost for all-day work commuters and possibly decreasing the parking costs for short-term shopping and personal business parkers. Such an approach could reduce automobile travel during peak periods by those travelers who are potentially the most divertible to high-occupancy vehicles.

Although revising the parking pricing structure at municipally owned or operated facilities is presumably a matter of municipal policy, revisions at commercially operated or public authority operated facilities require explicit municipal authority. As noted above, regulation of commercial or public authority conditions of parking is a power not currently being exercised by any municipality within the United States, and municipal assertion of such a power would probably be subject to a court test.

Considerations Affecting the Regulation of Price

Potential Desirable Aspects of Price Regulation

Use of parking price regulation to achieve automobile congestion reduction, air quality, and energy conservation has a number of appealing features. If the strategy is implemented in the form of a parking tax, the approach is generally considered to be within the recognized powers of the municipality, its implementation is administratively straightforward, additional revenues are obtained for the municipal treasury, and the incidence of the tax falls on suburban commuters to the CBD and not just the residents of the city (a factor of some importance to elected officials of the central city of a metropolitan area). Further, this approach directly increases the out-of-pocket cost of using an automobile and can be designed to impact those urban travel market segments that are most divertible to high-occupancy vehicles. Some of the limitations of parking price regulation are describe below.

Proportion of Automobile Drivers Who Pay for Parking

Most people who drive to work in the United States pay no parking charges (14). The type of parking facility used and the charge paid by a sample of all U.S. home-to-work commuters are given in Table 6 (14). Only about 7 percent of those who drive an automobile to work pay any parking charge whatsoever; the other 93 percent park for free. Further, only 6 percent park in commercial parking facilities, and nearly 76 percent park in employer-provided spaces. Consequently, on a national basis, a parking price regulation strategy that used parking taxes superimposed on existing parking fees would affect only about 7 percent of the total home-to-work travelers. In some of these cases, parking fees are employer subsidized and consequently any increase in the cost of parking would not directly affect behavior of the home-to-work commuter.

Since the data given in Table 6 represent all automobile commuters within the United States, it might be expected that travelers on radial freeways to the CBD may pay parking fees to a greater extent. A survey of automobile commuters in the Shirley Highway corridor (a major radial freeway from the CBD of Washington, D.C., to the Virginia suburbs) found that 56 percent of the automobile users park for free and that more than 80 percent of the automobile users pay $1/day or less for parking (11). Yet the prevailing commercial parking rates in the Washington CBD were $2/day or greater at the time of the survey. Thus, a majority of the automobile travelers on a major freeway radial to the CBD were either parking for free in employer provided spaces, obtaining reduced rate parking, or obtaining employer subsidized parking. This suggests that the effectiveness of a parking price regulation program would be significantly enhanced if the program could be designed to impact employer provided and subsidized parking in such a manner that travelers perceive an increase in the out-of-pocket parking costs they must pay.

Proportion of Automobile Drivers Destined to the CBD

Most of the parking facilities in the United States in which the user must pay a fee are located in the CBDs of metropolitan areas. Many of the proposals for implementation of a parking price regulation strategy have

therefore focused on increasing parking prices within the CBD. The CBDs of most urban regions within the United States generally attract less than 5 percent of the total travel undertaken in metropolitan areas. Thus, a CBD parking price strategy implemented to achieve energy conservation or regional air quality objectives would impact a relatively small proportion of the regional travel. Such a policy might, however, beneficially affect local air quality (CO concentrations) at key locations within the CBD.

Inelasticity of Parking Demand

Empirical studies suggest that parking usage is suprisingly insensitive to increases in parking prices and that parking revenues are relatively sensitive. A study of the impacts of the San Francisco parking tax on parking demand, gross revenues, and overall traffic levels (12) found that the demand elasticity for parking for all trip purposes was about -0.3. There was some evidence that all-day commuters were more likely to discontinue parking than were shoppers. Gross parking revenues, on the other hand, were found to be quite elastic, that is, the increase in price was more than offset by the decrease in dollar sales volume. A revenue elasticity of about -1.6 was estimated on the basis of the revenue change. Thus, the parking tax caused both a reduction in the number of automobiles parked and a reduction in the net revenues per automobiles parked. This latter change was caused by (a) a tendency to continue using parking but for shorter durations than before the tax and (b) a relatively greater reduction in commuter parking than in shopping and other short-term parking.

The parking tax had relatively little impact on traffic in the city as a whole, causing perhaps a 2 percent reduction in the number of vehicles using the streets of San Francisco—equivalent to about 3 months of secular growth. Further, the tax had a relatively nominal impact on the level of downtown retail activity. Finally, the tax had a major impact on the gross revenues and profits of the parking industry; gross revenues were estimated to be 36 percent below the level projected under normal growth and 31 percent under those observed the year before the tax. These losses exceeded somewhat the revenues that the city and county government collected from the tax. To the extent that the San Francisco tax appears to have affected all-day work commuters to a greater extent than shoppers, it did contribute to reducing peak-period traffic congestion.

Proportion of Traffic Traversing the CBD

If the area in which the parking rate increase is applied is defined as the CBD plus immediately adjacent areas, the available empirical evidence suggests that through travel probably accounts for about 15 to 30 percent of all of the automobile trips currently made into the area (13). If parking restraints were implemented within the area, changes in travel might occur that would increase the proportion of through travel: (a) As congestion is reduced by parking controls, trips formerly routed around the CBD might now be routed through it; and (b) if parking restraints were severe enough, travelers might divert to other modes such as taxi and serve-passenger trips.

Urban Development Implications

If a parking price regulation strategy is implemented in selected portions of a metropolitan areas, such as the CBD, a greater amount of development might occur outside the area in which the parking rate (or supply) regulations are applied. As a practical matter, it would be extremely difficult to control such development through development controls currently available within the United States. Further, competition for development exists at a subregional level in most metropolitan areas within the United States, and the development controls available are generally applied at a subregional level. Consequently, potential development effects need to be considered as part of the overall process of planning a parking price regulation strategy.

Reference was previously made to the role of surface parking lots as an important intermediate stage in the land redevelopment cycle. To the extent that such facilities enable developers to maintain a readily available land bank for new projects, they may facilitate urban redevelopment. Parking price regulation strategy should ensure that the land redevelopment process is not significantly adversely affected.

FRINGE AND TRANSPORTATION CORRIDOR PARKING

The provision of fringe and transportation corridor parking offers a particularly attractive parking management strategy because it focuses on providing improved transportation service and not on increasing the generalized cost of travel. Although fringe and transportation corridor parking currently only provides 0.5 percent of the total parking used in the country (14), this parking management strategy appears to offer some potential for further development. Fringe and transportation corridor parking facilities allow each of the transportation modes to be used to its best advantage; low-occupancy automobiles are used to travel between dispersed residential sites (particularly in low-density areas) and fringe parking facilities, and high-occupancy vehicles (e.g., public transit bus, van pools, and car pools) are used to travel between the fringe parking facilities and the final destinations. To date, fringe parking facilities exist primarily at rail transit and bus routes oriented to the CBDs of large metropolitan areas. Connecticut has, however, been quite successful in developing well-used fringe parking facilities to serve dispersed employment sites and the CBDs of smaller metropolitan areas (15).

An analysis of the cost of operating a 500-vehicle, self-park, surface fringe parking lot is given in Table 7 (16). Turnover is relatively low at fringe parking facilities, and they are not heavily used on weekends. In this sense, the usage of fringe parking facilities is similar to that of public transportation in urban areas. For this reason, it was assumed that each space would be used by 280 vehicles/year and that the facilities would be at capacity each working day (this annualization factor corresponds to the one used for public transportation systems). Thus, the annual cost for the facility must be allocated among 140 000 vehicles/year, yielding a daily cost for a land value of $\$26.90/m^2$ ($\$2.50/ft^2$) or \$0.49/vehicle for a publicly owned facility and \$0.81/vehicle for a privately owned facility. Hence, for the lowest land value considered, the daily cost of operating a publicly owned fringe parking facility is essentially equivalent to the highest daily parking fee for any of the fringe parking facilities considered.

Although exceptions to the above assumptions could be found, these results suggest that in the context of the existing situation the revenues that can reasonably be derived from fringe parking facilities will not meet the fully allocated costs of constructing and operating such facilities even if they are publicly owned. When the facilities are privately owned or the cost of the land is greater than $\$26.90/m^2$ ($\$2.50/ft^2$), the differences be-

tween the potential revenues and the average daily cost are even greater. If this analysis is correct, traditional approaches—such as municipal parking authorities, private enterprise, park-and-shop corporations, and benefit districts—for implementing parking facilities in a CBD will be inappropriate for fringe parking. The organizational and financial structures under which fringe parking programs are sponsored must be such that their fully allocated costs are not borne solely by the users of the facilities.

The experience to date suggests that there are two approaches for implementing fringe parking programs: (a) use of parking facilities constructed as part of other public or private projects and (b) assumption of the investment and, in some cases, operating costs by a public agency. Fringe parking facilities have been implemented at suburban shopping centers in a number of metropolitan areas; such sites are available in most metropolitan areas. A fringe parking facility should be provided with good transit service to the CBD, if possible by an express bus service. This implies a parking facility with a minimum capacity of 500 automobiles. Such facilities could only be located at relatively large regional shopping centers where use of about 500 spaces for commuters during regular work days would not adversely affect the overall parking capacity of the shopping center. Civic centers and stadiums also have a substantial amount of parking that is generally not heavily used during normal working hours and could be made available for a fringe parking program.

Many fringe parking facilities are currently being constructed and operated by public transit operators, particularly rail rapid transit systems. The Lindenwold Hi-Speed Line has approximately 8000 parking spaces, and the Bay Area Rapid Transit (BART) System has approximately 17 000 parking spaces. Significant amounts of fringe parking are being planned for the systems under construction in Washington, D.C., Atlanta, and Baltimore.

Based on recent experiences with fringe and transportation corridor parking (16), several conclusions can be drawn about the usage of fringe parking facilities and planning guidelines for locating, designing, and providing transit service to these facilities. A summary of the important physical and operational characteristics of five selected fringe parking programs is presented in Table 8 (17). The programs in the five cities are described below.

1. In Milwaukee, the Freeway Flyer express bus service is provided between six suburban shopping centers and the CBD;
2. In Seattle, the Blue Streak bus service is provided between a fringe parking lot and the CBD via an exclusive access ramp;
3. In Philadelphia, the Lindenwold Hi-Speed Line provides rail rapid transit service between the Philadelphia CBD and six suburban fringe parking lots located in a New Jersey corridor;
4. In Atlanta the Town Flyer bus provides service between fringe parking facilities located at the Atlanta Stadium and Civic Center on opposite sides of the periphery of the CBD; and
5. In Cleveland, the Cleveland Transit System Loop Bus provides service between the Lakeshore and St. Vincent fringe parking lots located on opposite sides of the periphery of the CBD.

The transportation corridor parking facilities are located between 9.7 and 22.5 km (6 and 14 miles) from the CBD, and the CBD-peripheral parking facilities are located within 1.6 km (1 mile). No parking fee is charged at transportation corridor facilities, except for a low fee charged on the Lindenwold Hi-Speed Line for those spaces that are closest to the stations. Although higher than those charged at corridor facilities, parking rates at CBD-peripheral facilities are significantly lower than in the core of the CBD. On the other hand, transit fares are lower for the CBD peripheral facilities than for the transportation corridor facilities. All of the facilities are self-parking, lighted, paved, and provide shelters (except for Atlanta, where the climate is pleasant for the entire year). Attendants are provided at the Atlanta and Cleveland facilities to ensure the security of the vehicles; such provisions have not proved necessary at the other facilities, where security is provided by transit police, municipal police, or the private security service of the shopping center owner.

Selected travel and socioeconomic characteristics of the fringe parkers in each of these five cities are given in Table 9. Fringe parking facilities are used predominantly by workers, who generally park more than 8 h. Consequently, there is relatively little turnover associated with fringe parking facilities. Automobile occupancy at fringe facilities ranges from 1.1 to 1.3, which is about the national average. Even the Atlanta price structure, designed to attract car pools, appears to have had relatively little impact on automobile occupancy.

Inasmuch as women constitute a significant proportion of the users, fringe parking facilities should be designed so they are attractive to female patrons. Safety factors such as lighting and surveillance appear to be particularly important. Fringe parking facilities attract users from all income categories; most have annual household incomes greater than $10 000, suggesting that fringe parking facilities can, under the proper circumstances, offer a sufficiently high level of service to attract travelers who have a realistic option of using their automobiles. The ability of fringe parking facilities to divert automobile users is also reflected in the fact that about 35 to 80 percent of the respondents at the various facilities surveyed reported that their prior travel mode or the alternative mode they would use was the automobile.

Based on these syntheses of the literature, it is possible to identify the following implications for the location, design, and operation of fringe and transportation corridor parking facilities (16). Further summaries of existing experience and planning guidelines are provided in other research reports (17, 18, 21, 22).

Locational Aspects

1. Fringe parking facilities should be located in transportation corridors so that they intercept home-to-work trips destined to the CBD at a point where there is a sufficient density of transit demand that good transit service may be offered.
2. To the maximum extent feasible, facilities should be located on land that is already devoted to parking or to low-grade nonresidential use. This objective is more achievable for facilities with bus service than it is for those with rail inasmuch as bus is a more ubiquitous mode and the scale of facilities required to serve rail is inherently larger.
3. Fringe parking facilities should be located on sites compatible with the land uses and the activities in the immediately adjacent area.
4. Potential joint-use aspects of a fringe parking facility should be considered during the location process. If planners believe that joint use can occur in the near future, sufficient land should be acquired so that a staged-development program can be implemented.

5. Trade-offs implicit in the scale of the fringe parking facility (namely, the level of transit service as opposed to its neighborhood impacts and the ease of using the facility) should be considered during the planning phase.

Design Considerations

1. To the maximum feasible extent, fringe parking facilities should be designed to minimize potential impacts on the neighborhood. Areas of particular concern are as follows: Available rainfall data should be used to estimate runoff and sufficient drainage should be provided; lighting provided should not intrude on the adjacent land uses; due consideration should be given to the aesthetics of the facility; and walkways should be developed within the facility if it interferes with established patterns of community interaction.

2. Care should be taken to ensure that access traffic to fringe parking does not overwhelm the character of residential neighborhoods. To this end, direct links should be provided, where feasible, from large facilities to high-speed roads.

3. Fringe parking facilities should be paved and lighted. Appropriate shelters should be provided so that patrons may wait comfortably for transit in those areas of the country in which adverse weather conditions may be anticipated for a significant proportion of the year. Other amenities enhancing the utility of even a small facility include telephones and newspaper stands.

4. Fringe lots should be designed to minimize labor costs required to operate these facilities, unless the intensity of use and revenues derived are substantially different from those observed in the case studies. To this end, self-parking and automatic fare-collection equipment should be used.

5. Access and egress facilities and fare-collection procedures should be carefully designed to accommodate peaking.

6. As the scale of surface lots increases, care should be taken to ensure that walking distances do not become excessive. Although the definition of excessive is subjective and related to local conditions, it would appear that parkers having to walk more than 450 to 600 m (1500 to 2000 ft) from their automobiles to the transit boarding point might be discouraged from using the facility. To this end, transit boarding points should

Table 7. Annual operating cost of a 500-vehicle, self-park, surface fringe parking lot.

Cost Category	Land Value ($/m²)	Public Ownership ($)	Private Ownership ($)
Amortization of land	26.9	29 000	41 300
	53.8	58 500	82 500
	80.7	88 500	124 000
	107.6	117 500	165 000
	134.5	145 500	206 000
Amortization of improvements and equipment		17 500	18 100
Operating costs		22 500	22 500
Taxes		–	32 000
Total annual cost	26.9	69 000	113 900
	53.8	98 500	155 100
	80.7	128 500	196 600
	107.6	157 500	237 600
	134.5	185 500	278 600
Daily cost/vehicle parked[a]	26.9	0.49	0.81
	53.8	0.70	1.11
	80.7	0.92	1.40
	107.6	1.13	1.70
	134.5	1.32	1.99

Note: 1 m² = 10.8 ft².
[a]At-capacity operation for 280 days/year.

Table 8. Operational characteristics of typical fringe parking facilities.

Characteristic	Milwaukee	Seattle	Philadelphia	Atlanta	Cleveland
Number of parking spaces	800	475	8200	1250	4100
Number of automobiles parked	400	475	6600	400	4100
Number of facilities	6	1	6	2	2
Distance to CBD, km	16.1 to 22.5	14.5	9.7 to 22.5	1.6	1.6
Daily parking fee, cents	0	0	0 to 25	75[a]	50
One-way transit fare, cents	50 to 55	35	40 to 60		25
Self-parking	Yes	Yes	Yes	Yes	Yes
Attendant on duty	No	No	No	Yes	Yes
Paving	Yes	Yes	Yes	Yes	Yes
Lighting	Yes	Yes	Yes	Yes	Yes
Shelter	Yes	Yes	Yes	No	Yes

Note: 1 km = 0.6 mile.
[a]Parking fee and two-way fare for all automobile occupants.

Table 9. Selected characteristics of fringe parkers.

Characteristic	Milwaukee	Seattle	Philadelphia	Atlanta	Cleveland
Trip purpose, %					
Work	99[a]	85[b]	89[c]	98[a]	95[a]
Other	1	15	11	2	5
Parking duration					
Under 8 h	1[a]	NA	NA	11[a]	2[a]
8 h or more	99	NA	NA	89	98
Occupancy of parked automobiles	1.20[a]	1.06[b]	1.16[c]	1.30[a]	1.35[a]
Sex, %					
Male	52[a]	NA	60[c]	40[a]	68[a]
Female	48	NA	40	60	32
Annual household income, %					
Under $10 000	20[a]	NA	NA	35[a]	53[a]
Over $10 000	80	NA	NA	65	47
Travel alternative or prior mode, %					
Automobile	57[a]	70[b]	36 to 60[c]	81[a]	65[a]
Transit	43	30	64 to 40	19	35

[a]From Peat, Marwick, Mitchell and Company surveys in 1971.
[b]From Seattle Transit System, 1970 data.
[c]From Delaware River Port Authority surveys in 1969-1970.

be located in the center of the fringe parking facility rather than on the periphery. Multiple boarding points should be used, if feasible, and in unusual situations multilevel parking or internal people-mover systems should be considered.

7. Potential joint-use activities should be considered during the design of the facility to ensure effective integration of transportation and other functions. For example, care should be taken so that parking spaces available for transportation and other functions are not preempted by one another and that the access facilities are not overburdened. Joint-use facilities should be designed to ensure that they effectively integrate the transfer location within the neighborhood. Such integration may require that additional local supportive systems be constructed in the neighborhood, e.g., walkways or bikeways.

Service Considerations

1. High-level transit service should be provided from the fringe parking facility to the CBD. For buses, such a quality implies express operations, use of reserved facilities on those segments of the route in which traffic congestion is encountered, and acceptable frequencies during the peak hours. For rail, it implies low travel times and headways during peak hours. Further, careful attention must be given to ensuring that an effective CBD distribution system is developed. Finally, off-peak transit service should be provided to the fringe parking locations.

2. Pricing of the fringe parking-transit service should be carefully considered during the planning phases to ensure its competitiveness. Thus, the trade-off between the community objectives of maximizing patronage of fringe parking and the financial objective of maximizing revenues should be carefully considered.

3. To increase neighborhood compatibility, all-day parking on adjacent streets should be discouraged. Such a policy should be implemented at the inception of fringe parking service.

SOME PLANNING GUIDELINES

This paper emphasizes the diversity of the parking management strategies that are available and the planning considerations that must be taken into account with regard to specific strategies. Because of this diversity, it is neither possible nor desirable to develop a universal parking management program applicable to all metropolitan areas. Rather, each metropolitan area needs to develop its own program responsive to its unique local circumstances. Within this context, there are several broad guidelines for planning a parking management program for a specific local area.

1. Approaches to parking management range widely with regard to the nature, areas of application, levels, and implementation aspects of the actions. Local areas need to explore the full range of alternative strategies available to them.

2. Local areas should place considerable emphasis on developing an integrated parking management strategy that includes the different types of facilities available (metered and nonmetered on-street facilities, off-street lots, and off-street garages); commercial, employer provided and subsidized, and developer provided parking facilities; and the enforcement program needed to ensure the effectiveness of the other elements of the parking management program.

3. The parking management strategy should be carefully designed to serve the needs of the metropolitan area and to achieve its objectives with regard to improving transportation service, reducing traffic congestion and transportation-related accidents, achieving ambient air quality standards, and conserving energy. Further, the planning program needs to carefully integrate consideration of local and metropolitanwide community objectives.

4. Parking management strategies that focus on improving transportation service are generally the most desirable. Strategies that improve service for some but increase the generalized cost for others are next most desirable. Strategies that focus on increasing the generalized cost are less desirable, although these may be necessary in specific instances.

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MANAGING TRANSPORTATION DEMAND BY ALTERNATIVE WORK SCHEDULE TECHNIQUES

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The management of urban transportation demand involves a number of techniques to reduce congestion by altering peak demand patterns. This paper discusses several transportation system management elements and focuses on alternative work schedule techniques such as staggered and flexible work hours and the shortened workweek. Alternative work schedules are deemed to be the most promising approach to managing transportation demand since such techniques are usually highly cost effective, are popularly received, entail nontransportation societal benefits, and can be implemented quickly. The effectiveness and state of practice of various alternative work schedule techniques are discussed, and a recommended approach for studying, implementing, and evaluating such techniques is presented. Brief case studies are given of programs in urban areas.

A primary function of many urban transportation professionals is to determine the demand for transportation and then design and implement systems to serve that demand. The traditional procedure is to analyze the characteristics and quantity of the demand with respect to parameters such as peak-hour flow, trip purpose, directionality, and peaking and to provide a wide variety of facilities to handle the current and forecast demand. Since such facilities usually require high capital and are, in many cases, controversial, increasing emphasis in recent years has been placed on devising ways to alter the demand patterns themselves in order to operate existing systems more efficiently.

TECHNIQUES TO MANAGE DEMAND

A number of techniques are available to alter demand. They vary in their relative effectiveness and ease of implementation. The most common can be classified as alternative work schedules or pricing incentives or disincentives. Each of these is discussed in this paper. Some specific techniques in these areas are contained in the listing of transportation system management (TSM) actions to be considered (1):

Changes in work schedules, fare structures and automobile tolls to reduce peak period travel and to encourage off-peak use of transportation facilities and transit services, such as:
- Staggered Work Hours
- Flexible Work Hours
- Reduced transit fares for off-peak transit users
- Increased peak-hour commuter tolls on bridges and access routes to the city

Alternative Work Schedules

The use of alternative work schedules to manage urban transportation demand is given primary emphasis in this paper. Among the reasons for this are that work schedules are directly correlated with peak-period travel patterns and that a number of feasible concepts can be implemented quickly at little cost, are widely popular, and promise other nontransportation benefits. The fact that the movement away from the rigid 8-h workday is growing in this country behooves the transportation professional to understand and take the lead in directing the acceptance of such concepts so that they are dovetailed with the interests of efficient use of urban transportation systems. In later sections of this paper, a number of alternative work schedule concepts are discussed with respect to their impact on transportation systems and the status of their acceptance. Also discussed is a recommended approach for designing alternative work schedule concepts for an urban area, and a number of case studies of efforts throughout the country are presented.

Pricing Incentives or Disincentives

In a straightforward analogy to the economic theory of demand, the amount of transportation demand varies inversely as the price of the service. Thus, managing demand can be achieved by raising or lowering the price of the service provided. Incentives to use certain public transportation modes or to travel at less-congested off-peak times can take the form of reduced fares or tolls as appropriate. Conversely, disincentives of higher fares or tolls would reduce volumes of certain modes, for example automobiles during the congested peak hour.

Although it is difficult to generalize the wide area of pricing schemes, alternative work schedules are usually more effective than pricing in altering peak transportation demand for work trips. This is because there is a direct impact on such demand when the times that people commute to and from their jobs are changed. In addi-

tion, alternative work schedules are usually more popular and less controversial than pricing schemes and therefore are easier to implement. A common feature of the two concepts though is that the degree of impact on demand increases as the change in work schedule or price increases.

Examples of pricing incentives and disincentives are transit fare reductions, toll increases on many automobile facilities (typically at bridges at CBD cordons), transit fare adjustments for special groups or those riding at specific times of the day or days of the week, and restriction of automobile access to the CBD by charging a stiff entry fee.

ALTERNATIVE WORK SCHEDULE CONCEPTS AND THEIR IMPACT ON TRANSPORTATION DEMAND

Based on the standard 5-day, 40-h workweek in the United States, this section compares and analyzes three alternative work scheduling concepts: staggered work hours, flexible work hours, and shortened workweek (usually to 4 days). The discussion defines each of these concepts and views their impacts on urban transportation systems and their current status of acceptance.

Standard Workweek

The standard 5-day, 40-h workweek had evolved by the end of World War II for most of the western business community. The 8-h day may vary because of time given for lunch, which is an important factor since the actual length of the workday, which defines the commuting trip patterns, may extend over a range of 9 to 9 h. In addition, some shortening of the 8-h day may have been won as a fringe benefit. Further, the pattern of predominant starting and quitting times may vary from city to city, and informally staggered schedules exist to a degree among different industries and within some types of firms. Thus, a standard workday refers to a 5-day work schedule about 40 h long. The problem arises, of course, when there is such a great adherence to a single starting and quitting time that it results in severe transportation congestion.

Staggered Work Hours

Staggered work hours involves shifting fixed standard 5-day work schedules to earlier or later time periods without changing the length of the workday. Under staggered hours, employees must still be at work by a specified time and leave at a specified time. The aim of staggered hours is to spread work schedules to relieve transportation congestion and thereby make commuting to and from work more comfortable. On an individual organization level, staggered hours may be established to relieve elevator congestion, to expand the hours of business coverage, and to improve employee attitudes toward their work.

Staggered hours has a significant impact on reducing peak-period congestion on transportation systems and in elevator operations. It should be understood, however, that all three alternative scheduling concepts will, by their very nature of shifting people out of peak commuting times, lead to reducing peak transportation congestion if that congestion is principally caused by concentrated adherence to a 5-day schedule. Generally speaking, the congestion reduction is directly related to the absolute amount of participation, the degree to which the new schedules are spread, and the degree of peaking that existed with the old schedules.

Staggering work hours has been successful in relieving peak-period congestion on transportation systems in Manhattan, Newark, Philadelphia, Toronto, Madison (Wisconsin), and Riverside (California). Within 2 years after the staggered hours program in Lower Manhattan began, passenger counts showed a one-quarter reduction in the peak at three major downtown New York City subway stations and at the World Trade Center Terminal of the Port Authority Trans-Hudson (PATH) transit system. Two years later, in 1974, transportation crowding was also drastically reduced and peaks flattened in Midtown Manhattan at the Grand Central Station of the IRT Flushing Line subway. The amount of congestion reductions with staggered hours is predictable to a degree since the new work schedules are also fixed, and one can determine how many employees are on different schedules and identify their arrival and departure patterns.

Studies of elevator operations in three office buildings, also in Manhattan, showed staggered hours had a beneficial impact on operations. In particular, waiting times for employees were observed to be reduced substantially. An illustration of this service improvement was at one building where a maximum of 673 persons experienced delays in the elevator lobby on a typical weekday before staggered workhours compared with only 278 persons after a major tenant of the building participated in the program.

The degree of effectiveness of staggered hours in relieving elevator crowding depends on whether a company adopts several different schedules or, as in most cases, merely moves all of its 9 to 5 employees to a new single schedule, such as 8:30 a.m. to 4:30 p.m. Using several different staggered hours schedules is desirable if the organization can be persuaded to do so. Another factor determining the amount of congestion reduction on elevators is the spread of work schedules for all employers on a particular bank of elevators. These factors lead to reduced employee tardiness and increased morale and productivity.

Staggered work hours in a large urban area has had no discernible effect on mode use. If there is good public transit, one may be more inclined to continue using it and to travel in less congested time periods. However, the converse would occur if transit service is not satisfactory in time periods just outside the peak, and this therefore requires effecting service adjustments if necessary as part of a successful program. One saving grace here is the relatively small shift of work schedules required in many instances to achieve the congestion reduction desired on transportation systems. In Manhattan, for example, project staff request only a ½-h change, and this does not shift people too far in time away from peak transit services. In Newark, a 15-min change was recommended. There could be problems, however, if larger schedule changes are recommended.

Some thought that staggered hours would encourage some transit riders to switch to automobiles since they could travel after peak congestion periods. This has not been observed, however, and there are several reasons to suggest that it may not be of great concern. These include the generally longer congestion period occurring for highway facilities and other factors such as the cost of gas, the price and availability of parking, and the travel time on congested roads.

Flexible Work Hours

Flexible work hours, also known as gliding work hours, flextime, and plantime, is a relatively new concept in work-time management; it allows employees a degree of freedom in determining work schedules. Under

flexible hours, employees are permitted to set their own daily starting and quitting times within preestablished limits. They are generally required to be present at work during a fixed or core time and may choose their starting and quitting times in flexible time periods. Thus, they can vary the length of their total working day. An example of a typical flexible work-hour system might allow participating employees to arrive at work anytime between 8 and 9:30 a.m. and depart from work anytime between 4 and 5:30 p.m., with total work hours ranging from 5¾ to 8¾ h (excluding 45 min for lunch). Employees are required to be present during the core hours of 9:30 to 4:30 and must work the required number of weekly hours (36¼).

Several variations of flexible hours are being used by companies. One most often used is called "floating day," which is a bit more restrictive than flexible hours. Employees on a floating day may choose their starting time within a certain flexible period, and this starting time then determines the quitting time based on the length of the workday. For example, employees might have the option to come to work anytime between 7 and 10 a.m., but if they arrive at 8:15 a.m. they are required to work that day until at least 4:15 p.m. (assuming an 8-h workday).

Another variation is called "flexible hours plus four" under which employees can work the total weekly hours requirement in the first 4 days of the week and take the fifth day off. Other options of this include a longer accounting period allowing one to work longer hours in order to build up a reserve and take a day off during the same period. Another basic variation is to allow a flexible lunch period within the flexible day. Workers can then vary the time when they eat lunch as well as the total length of the lunch period. This possibility is often used to reduce cafeteria and elevator congestion at lunch time. In addition, employees may also take longer lunches to run errands or shorter lunch periods to allow them to leave work earlier.

Although staggered hours has proven ability to reduce congestion, it also appears to be able to relieve transportation peaking. This is because commuters, if given a choice, will generally choose to avoid the most congested travel times. In an experiment among staff of the Port Authority of New York and New Jersey, three-quarters of the participants said they adjusted their hours to avoid the most congested traveling periods. Since employees have this choice within limits on flexible hours, it does become, however, more difficult to predict the revised arrival and departure patterns or, indeed, to attempt to design flexible hour systems specifically to reduce congestion at certain spots. However, much insight has been gained from the Port Authority's flexible hours experiment as well as from the experiences of increasing numbers of companies adopting this concept.

The Port Authority experiment showed that arrival patterns on flexible hours on the whole were spread out, and new departure patterns led to reduced afternoon elevator congestion particularly on floors where large units had previously been on a single schedule. This points up another interesting factor: Organizations, like the Port Authority, that were already on staggered work hours usually lead in adopting the flexible system. The shift from staggered to flexible hours is easier to implement since few fixed-schedule organizations are amenable to a flexible hours system at the outset. Flexible hours generally has excellent potential for relieving transportation congestion caused by concentrated arrivals and departures. The concept allows employees to come and go during a broad time span, and that creates a more even flow on all systems. The benefit is usually more pronounced in the afternoon, for arrivals on a single starting time are observed to have a greater time spread than that of departures.

The effect that flexible work hours has on modal switching is also not fully known, although this was examined in the Port Authority's experiment. Given a great degree of schedule flexibility, almost all participants reported they used the same mode of travel as before. Again this must be understood in the context that, before flexible hours, their schedules were mostly staggered away from the height of peak travel periods. But few reported that they shifted from public transit to automobile or car pool, which might have been facilitated with flexible schedules. Some 6 percent did report that they changed mode, but further analysis of the responses to this question indicates that many of them may have meant a revised journey to work by transit rather than, for example, a modal switch from bus to automobile.

Flexible work hours can enhance the formation of car pools when this is the desirable policy and also allows workers to easily adapt to public transit schedules which are more convenient.

Shortened Workweek

The shortened workweek generally involves working the same number of hours but in fewer than 5 days, usually 4 days. The 4-day week in the United States is referred to as the "4-days—40 hours" or "4/40" week, although in some cases the total hours required are somewhat reduced. Under the 4-day week, the extra day off usually is the same for all or most employees, thus allowing the plant or office to close. In a small number of cases, portions of employees have different days off to enable full 5-day business operations.

Three variations of the shorter workweek concept seem to exist: (a) the compressed workweek that consists of the same number of hours worked in fewer and thus longer work days; (b) a reduced workweek that consists of a slight decrease in total weekly hours but still 4 longer days; and (c) a week in which the usual 7 or 8-h day is worked for 4 instead of 5 days. The latter is, understandably, not too popular with management. There seem to be two basic reasons for organizations establishing the new 4-day schedule. One is the attempt to accommodate to employees' life-styles by arranging for another full day of leisure with the understanding that an equal amount of work can be accomplished more efficiently under the new system. Another has been provided by the energy crisis in that a shorter workweek conserves energy. Opponents point out, however, that in colder parts of the nation extended work hours on each end of the regular workday require additional heat. In addition, many modern office buildings cannot shut off heat in parts of the building, and appreciable energy savings can result only if all the heat is completely turned off in the entire building. All tenant organizations in a given building would therefore have to cease operations on either a Monday or a Friday to create a 3-day weekend.

The 4-day week is generally implemented in an organization chiefly to increase morale or productivity or both, but it also has significant implications in reducing transportation congestion. The 4/40 or 4/38 workweek requires the employee to work 9 or 10 h a day, and thus the starting and quitting times are pushed beyond the normal traveling periods. For example, an 8 a.m. to 6 p.m. schedule allows employees to avoid the most crowded travel times and also serves to reduce peak congestion.

If widespread adoption of the 4-day week takes place, however, one long-range implication for peaking of

transportation facilities is that the bands of starting and quitting times for the longer workday would be much narrower. This might lead back to severe peaking in many urban areas, only at earlier and later times with little acceptable margins for change. These effects are especially contingent on whether one has a 3-day or a 4-day schedule and also whether the days off are staggered or whether, as is more common, all employees are off on Friday or Monday.

Depending on the way it is organized, the 4-day workweek may or may not ease any elevator congestion existing in a building. If a staggered day-off schedule is set up for employees on the 4-day week, it could relieve elevator congestion since there would be about 20 percent fewer people working on any given day. If everyone in the same elevator bank works the same 4 days, however, then elevators might still be congested around the nominally scheduled starting and quitting times.

The 4-day week has implications for modal use, although the extent is not known exactly. Where automobile commuting predominates there may be little impact, although car-pool arrangements would be nearly impossible among people mixed between 4-day and regular workweek schedules. In an urban area with heavy transit usage, people adopting the 4-day week would find significantly fewer and less convenient transit services available at the earlier morning and later evening start and quit times. There would then be a tendency to switch to the automobile because roads may be less crowded. A shift from transit may also occur because of reduced fare costs with two less work trips per week (unless a monthly commutation system is used).

Status of Alternative Work Schedules

It is clear that a certain degree of change is at hand for the standard 5-day, 40-h workweek. Alternative schedules are being increasingly used because of the pressures of traffic congestion, energy shortages, additional fringe benefits, and increased part-time employment. Transportation professionals must be aware of these trends since they have such impact on transportation system planning, design, and operation.

The first organized efforts to stagger work hours were made as early as the 1920s, and the attractiveness of the idea has grown in urban areas with greater need for improving public transportation services, higher employment densities, and longer journey-to-work trips. In New York City, for example, because of its high employment density, large working population, and geographical location of the central business district on an island, a number of attempts have been made to implement staggered hours. As early as 1926, the commissioner of the Department of Health established a committee with the aim of preventing "the transmission of respiratory infections which are so common where overcrowding exists."

Work-hour staggering also aroused considerable interest during World War II. The Transportation and Communications Departments of the U.S. Department of Commerce published two pamphlets on work-hour staggering in 1941 and 1942 and, although there are reports that staggered work-hour plans were introduced in a number of large cities, including Washington, D.C., these efforts appear not to have been documented to any large extent. After the war, work schedules generally reverted to prewar habits except for Washington, D.C., as discussed later.

In recent times, staggered hours is becoming more accepted as a low-cost and effective method of reducing congestion on transportation systems and is a suggested strategy in the package of transportation system management elements. In a 1974 international survey by the Port Authority of the state of the practice of staggered work hours, 16 percent of the 131 U.S. cities responding reported that they had used some form of staggered hours to relieve transportation congestion. A higher percentage of foreign cities, 30 percent of those responding, noted experience with staggered hours.

Flexible work hours is also receiving increasing attention and has been implemented by many U.S. companies. It is regarded primarily as an employee benefit to improve morale and reduce turnover, tardiness, and absenteeism. Many companies also use it to reduce congestion by their employees in traveling to and from work. Many of these benefits were realized when the flexible work-hour system was initiated in 1967 by the Messerschmidt Headquarters at Ottobrunn, West Germany. The new hours not only relieved traffic congestion but also had positive effects on employee morale. Flexible hours quickly became popular throughout West Germany, then in many other European countries, and more recently in Canada. This new concept is just beginning to be explored by U.S. companies and the federal government. Again, from the international survey, while only eight responding U.S. cities, or 10 percent, reported experience with flexible hours, 17 foreign cities, or 65 percent of the respondents, reported experience with flexible hour systems.

The status and acceptance of the shortened or 4-day workweek has become increasingly accepted in the United States since 1970, although with considerable controversy. The American Management Association (AMA) in 1972 reported between 700 and 1000 U.S. firms were using the 4-day week with most retaining the 40-h week. A recent newspaper article stated that about 10 000 concerns with a million employees are on some type of 4-day schedule. As noted in the AMA report, in most instances the idea was introduced by management of small manufacturing firms in order to provide a fringe benefit not found in larger competitors. Of the firms surveyed, 85 percent were in the manufacturing sector and the remainder predominantly in service and retail industries. Recently more and more white collar experiments have been made with the 4-day week in spite of the fact that serious questions have arisen regarding fatigue and long-term productivity under the 4-day week.

DESIGNING ALTERNATIVE WORK SCHEDULES FOR AN URBAN AREA

This section presents a framework for designing alternative work schedule programs and a number of brief case studies of North American cities.

Recommended Approach

Since a program to implement alternative work schedules to reduce urban transportation congestion usually involves voluntary participation, the program design is a critical factor in its ultimate success or failure. Unfortunately, however, there are no design procedures that can ensure a successful program.

The overall design strategy of a variable hours program should be to adjust work schedule patterns in such a way that transportation demand is smoothed. This results in more efficient operations, less congestion and delay, and higher use of equipment and facilities. Designing a program includes several basic steps: defining the problem clearly, identifying potential alternate work scheduling methods, evaluating each of these methods by predicting their effectiveness, and deciding on the basic method of approach and implementation. The following are some questions that must be answered.

1. What should be the overall approach of a staggered-hour program for a particular CBD? An answer involves examining available information on transportation, current employment, and work schedules and planning surveys to obtain any additional necessary information.
2. What objectives should be set, and what are the most effective options to be considered? Will the program be directed to a particular transportation mode, geographic location, or peak time (morning or evening) or the entire CBD itself? Which work schedule approaches will be practical and effective in the particular city?
3. How can one predict the effects of a particular work schedule program in a given city? How are the results to be evaluated, what level of participation should be attempted, and how can one anticipate the potential problems of each alternative?
4. How does one "sell" the work schedule program to employers? What strategies would be used? What benefits would be of enough incentive to adjust work schedules? What are the negative aspects to avoid?

Three approaches to designing an alternative work-hour program have been developed: A comprehensive plan and evaluation process that identifies the transportation problems and then estimates the effectiveness of alternative work schedules in alleviating them and two directed plans that are aimed at alleviating specific transportation problems. In the latter, the initial results guide the gradual evolution of the overall program.

The various survey and analysis techniques developed in this paper to identify transportation problems and to aid in the design of a staggered hours program are discussed below in more detail in conjunction with the comprehensive plan. These same methodologies can also be applied on a more limited basis if either of the directed plans are selected.

Comprehensive Plan

The following are the steps in a comprehensive plan for the design of a variable work-hours program.

1. Survey conditions on transportation modes. The first step is to determine the levels of service currently being provided on transportation modes serving the CBD. Where possible, existing data should be used to determine values of demand and service patterns and peaking characteristics, although it may be necessary to conduct some additional surveys.
2. Evaluate current levels of service on transportation modes. Once the surveys have been analyzed, current levels of service on various transportation modes should be reviewed. These include the levels of transit systems, congestion and flow rates on roadways, bus speeds, and conditions on pedestrian facilities. If current levels of service are unsatisfactory during short time durations or if projected service levels indicate future problems, then a feasibility study of alternative work schedule programs should be pursued.
3. Determine the expected need for additional transit facilities. The need for additional transit facilities should be determined. These include those facilities currently being planned or those indicated by deficiencies in the current or projected future levels of service. If new facilities are forecast, then variable hours should be investigated as a means to spread the demand in order to obviate the need for new facilities or to reduce their scope.
4. Conduct a work schedule survey within the CBD. The foundation of the design of a variable hours program is a survey of the starting and quitting times of employees within the CBD. This survey should include as many as possible of the organizations that generate substantial peak-period traffic.
5. Compare projected arrival and departure patterns to those observed on transportation modes. The projected arrival and departure patterns, based on the work schedule survey results, should be compared to demand patterns observed on transportation modes having unsatisfactory levels of service during parts of the peak period. The potential effectiveness of alternative work schedules to improve levels of service is based on (a) the degree of peaking in patterns of arrival to and departure from work, (b) the degree of correlation of these patterns to actual arrival and departure patterns observed on transportation modes, and (c) survey results or estimates of the proportion of journey-to-work trips on transit and roadway systems during peak periods (these are the only trips affected by work schedule adjustments).
6. Develop variable hours alternatives. Alternative work schedule proposals should be developed based on the results of organizational and employee attitude surveys toward changes in work schedules and on the projected impact of the various work-hour schemes in reducing peaking.
7. Project the potential impact of a variable hours program. The design of recommended variable hours alternatives should be based on their acceptability to employers and employees and on the potential impact in improving current or future levels of service. The methods to determine this impact are similar to those discussed in step 2. This procedure may be carried out for several sets of work schedule alternatives to determine which will result in the greatest benefits.
8. Implement the variable hours program. The program should be expeditiously implemented once the recommended approach has been chosen. This involves the broad-based support of business and civic groups and transportation agencies in an energetic promotional and selling effort. Follow-up attitudinal and transportation surveys should be conducted as participation increases, and the results should be compared to similar surveys conducted before the program started. The changes in arrival and departure patterns, transportation demand, crowding, and congestion should be compared to those predicted, and necessary modifications in the program should be made to achieve the benefits originally sought.

Directed Plans

Two directed plans for designing a variable work-hour program are aimed at specific transportation facilities or specific neighborhoods rather than at the entire central business district. The objective of either one is to reduce the time, cost, and effort required to design the program by concentrating efforts on specific transportation problems. A brief description of the two directed plans follows.

1. Physical facilities. The design of the variable hours program is directed or aimed at a specific congested transportation facility or mode rather than at an entire central business district.
2. Neighborhood or special group. The variable hours program evolves initially from a relatively small experiment in a specific neighborhood or industry and evolves on a step-by-step basis until the desired reduction in peak demand for transportation facilities is achieved.

Case Studies

The following are brief case studies of recent or ongoing efforts to adopt alternative work schedules in North American cities. Most encourage the use of only staggered work hours, but several also urge consideration of flexible work hours and label the overall concept as variable work hours.

Manhattan

On April 1, 1970, the Downtown-Lower Manhattan Association in cooperation with the Port Authority of New York and New Jersey initiated a staggered hours program to relieve the severe transportation congestion in the Lower Manhattan business district during the peak hours by persuading business and government to switch away from the predominant 9-to-5 work schedule. In 1972, the program was expanded to include Midtown Manhattan, where it is sponsored by the Midtown Task Force on Staggered Work Hours, a group comprising 26 civic and trade associations and public agencies.

Currently more than 220 000 men and women in more than 400 organizations are participating by staggering their work hours, mainly adopting an 8:30 a.m. to 4:30 p.m. schedule. All levels of government and transportation operators are actively supporting the project. Service or schedule improvements have been made by the metropolitan Transit Authority, PATH, ConRail (Erie-Lackawanna, Jersey Central, and Penn Central railroads), and Transport of New Jersey. Staggered work hours has reduced peaking in the three busiest Downtown Manhattan subway stations by 26 percent in the peak 10 min. Critical peaking at PATH's World Trade Center Terminal relieved about 25 percent in the peak 15 min between 5 and 5:15 p.m.; traffic increased in the more lightly traveled period from 4:30 to 4:45 p.m. by 57 percent. Elevator operations improved in buildings in which staggered hours are in effect.

The overall reaction to staggered hours was positive; attitude surveys indicate that about 85 percent of the men and women sampled had a favorable overall reaction to staggered hours and about 50 percent said their trips to and from work were improved under the new schedules. About 22 percent of the participants report increased effectiveness at work, and only 4 percent report a decrease. Supervisors generally reported an increase in punctuality.

The program in Manhattan continues to urge increased adoption of staggered work hours and to evaluate its impact on transportation systems. Since 1973, it has been aided by technical study funding from the Urban Mass Transportation Administration.

Newark, New Jersey

The staggered hours program began in Newark during the 1973 energy crisis to persuade public and private organizations to change from the predominant 8:30 to 4:30 work schedule. To date, a dozen organizations employing more than 1000 people have shifted their work hours.

During the winter of 1973, the Greater Newark Chamber of Commerce requested the Port Authority to commence a feasibility study of staggered hours in downtown Newark. A work schedule survey conducted in the spring of 1974 found that more than 40 percent of the organizations started work at 8:30 a.m. and quit at 4:30 p.m. and about 20 percent worked from 8 a.m. to 4 p.m.

Transportation surveys were conducted in the spring of 1975 by the city of Newark, Transport of New Jersey, and the Port Authority to determine peak-period transportation patterns on buses, the city subway, and automobiles. The results showed that transportation congestion was correlated with the 8:30 to 4:30 work hours. All companies were urged to shift at least 15 min earlier or later than those times.

Beginning in the spring of 1976, a dozen organizations implemented staggered work hours on an experimental basis, mainly shifting starting 15 min earlier. Several months after the implementation of the new schedules, a work-hours survey was conducted among four of the participating firms to determine the impact of staggered hours on employees. The conclusions in almost every case were positive; 75 percent of the participants expressed a favorable reaction to staggered work hours, and only about 11 percent expressed the desire to return to their old schedule. It was also found that 66 percent said their commuting trip was better than on the previous hours, and only 7 percent reported it was somewhat worse.

Philadelphia

In 1970, the Delaware Valley Regional Planning Commission (DVRPC) received funding from the U.S. Department of Transportation for a study that included a staggered work hours program to lessen the peak-hour congestion on center city transit facilities. Efforts to introduce staggered work hours to Philadelphia began in 1970 as several large Philadelphia firms, aroused by newspaper articles, adopted such plans on their own initiative. About the same time, the major downtown department stores changed their hours to open and close ½ h later than previously. This had dual effects of encouraging people to shop later (thereby making use of transportation facilities at a less critical time) and of having store employees make their trips home at a later, less critical time.

In 1971, a brochure entitled "How to Lose Wait During Rush Hour" was released as the first large effort to implement the concept. Thirty-five of the largest firms in Philadelphia were given this and other materials at a meeeting sponsored by the Greater Philadelphia Chamber of Commerce in June 1971. Efforts to increase the number of persons on staggered work hours continued with a reduced emphasis until late in the summer of 1972. At that time, DVRPC and the Greater Philadelphia Chamber of Commerce cooperated in applying to the federal government for funds for expanded staggered work hours efforts.

In the fall of 1972, a staggered work-hours committee was established under the auspices of the Chamber of Commerce to promote the concept. The first stage in the project was to determine present starting and quitting times within the CBD, the exact nature of the peaking problems, and the types of work-hour staggering that might alleviate them. In late 1972, the Chamber of Commerce conducted a survey of employers to determine numbers, locations, and hours of downtown employees. Other preparatory work included data collection and analysis, review of past efforts, and establishment of a master file of relevant material.

The group was joined in the winter of 1973 by an organization called Alliance of Business, Academe, and Commerce in the United States (ABACUS), which for a time provided valuable business contacts and other assistance. Early in 1973, breakfast meetings were held with top executives of the major banks and insurance companies in Philadelphia. The concept was presented to this group, and its cooperation and participation in the program were requested. Consulting teams were established to work with individual companies. Throughout the program strong efforts were made to obtain

media cooperation in publicizing the program and to alert the public to its benefits.

During and after the period of intense publicity and promotional efforts, surveys and direct contact were used to determine the type and extent of employer participation. Peak-hour loading at the transit stations was monitored to note effects on traffic patterns as a result of the staggered hours programs.

Approximately 160 firms were contacted during the course of the program. Efforts were concentrated on firms with more than 250 employees. Forty-seven firms are known to have participated in the program, involving 42 630 employees on either staggered, flexible, or 4-day work schedules. This level is two-thirds of the goal set by the Staggered Work Hours Committee.

Toronto

The Metropolitan Toronto Council approved the establishment of the Variable Work Hours Project on January 29, 1974, to encourage a wider adoption of variable work hours within Metropolitan Toronto in order to relieve peak-period congestion on the transportation system. The project focused on the downtown area containing about 260 000 employees, which is about one-quarter of Metropolitan Toronto's total employment. A steering committee comprising 15 senior representatives of business and government and a project staff were established to implement and coordinate the project. Each member of the Steering Committee represented one of the following sectors of the business community: banks, education, general insurance, government, hospitals, investments, life insurance, retail, transportation, trust companies, utilities, and communications; there were two members at large.

In May 1974, a report was issued indicating the degree of success attained in encouraging companies in downtown Toronto to adopt variable work hours. At that time a cursory assessment was made of the potential for change to variable work hours within the major industry groups that represent 121 000 employees. No information had been collected or contact made with the member-at-large industries, which represent 42 000 employees. Since February 1974, the project staff through the Steering Committee has worked with companies in downtown Toronto to encourage the adoption of variable work hours. Basically two types of programs were recommended: staggered and flexible hours.

During the months August to October 1974, an extensive survey was conducted among the 490 companies contacted as a result of the project to determine the change in work scheduling that had taken place to that time. Those 490 companies representing 163 000 employees or 63 percent of the 260 000 downtown workers were contacted through the Steering Committee, and 111 representing 68 000 employees have adopted variable work hours and an additional 66 companies representing 29 000 employees are considering variable work hours. At this writing, the project is no longer active.

Riverside, California

In recent years, traffic congestion in the central Riverside area has occurred daily during the morning and evening peak periods because of the 8 a.m. to 5 p.m. workday, causing thousands of people to go the same place at the same time.

A staggered work-hours project was proposed in April 1972 as a means to reduce the peak-period congestion. The city of Riverside and the California Department of Transportation agreed to participate cooperatively in this staggered work hours program. The city was to be the coordinating agency and the city traffic engineer the director. The freeway operations personnel of the department were to assist by preparing questionnaires, correspondence, and surveys and conducting before-and-after congestion and delay studies. The project was scheduled for implementation in April 1973.

Questionnaires requesting pertinent work schedule information were sent to businesses and governmental agencies in August 1972. Replies to questionnaires were received from more than 60 employers of 9500 people, 6300 of whom worked in the downtown area. Of these, 3450 people stated they would voluntarily change work hours if requested. In addition, Riverside City College indicated that it would be possible to stagger morning classes. There were approximately 2000 students and faculty with 8 a.m. classes.

The initial implementation effort was concentrated on the businesses and agencies whose personnel volunteered to cooperate. The survey responses revealed that 1850 of the voluntary group did not begin work or end work during the peak periods. Employers of the remaining 1600 persons were contacted and requested to stagger their schedules. Starting times were shifted mainly to 7:30, 7:45, and 8:15 a.m. The shift ending times were controlled by the starting time and length of lunch hour.

Approximately 900 employees actually changed hours on the April 2 target date. Since then another 300 people have changed, making the total 1200. Of these, 300 are from private businesses, 420 from city agencies, and 480 from county agencies. Riverside City College changed most 8 a.m. classes to 7:45 for the fall semester. As previously stated, this involved 2000 persons. There are an additional 2300 persons whose schedules could be adjusted, and further contact with these employers is warranted to obtain maximum participation in the program. Implementation of public agencies in the staggered work hours program is near maximum. At this writing, the program is inactive.

Madison, Wisconsin

Although the rush-hour traffic in Madison was not deemed critical when compared to that in major metropolitan areas, it was regarded as unsatisfactory particularly for trips at 4:30 p.m. Congestion is more severe during the afternoon peak than the morning peak because more people are making social, recreational, personal business, and shopping trips then.

Recognizing the need for reliable data of employee travel patterns to support the feasibility of a staggered work hour program, early in 1971 the state, county, city, and University of Wisconsin jointly agreed to cooperate in conducting a travel behavior survey of government employees. In 1972, they implemented a staggered hours program involving some 5000 governmental employees in Madison's central business district. Madison planned no initial involvement of the private sector in Wisconsin. Of 17 000 downtown employees, 5000 work for state, city, or county agencies and this group would initially be involved on a recommended work schedule of 7:30 a.m. to 4 p.m.

Chicago

During the fuel crisis in the winter of 1973-74, a consortium of Chicago-area business groups studied the possibility of using staggered working hours as a means to increase the use and productivity of existing transit plant and equipment. The Transit Carriers Coordinating Council (TCCC), the Chicago Association of Commerce

and Industry, the Chicago Central Area Committee, and the Greater North Michigan Avenue were members of the consortium.

TCCC instigated the study, since it was clear that any staggered work-hour plan would have a heavy impact on transit carriers. The main conclusion of its report was that, although staggering of work hours could be handled by the carriers, a large-scale program would cause problems. The most serious drawback to extending the rush hour was the conflict created between commuter trains and freight trains, many of which use the same tracks.

Washington, D.C.

Washington, D.C., has no formal staggered work-hours program, yet 200 000 employees, representing about half of the federal employment in the District of Columbia, are on staggered starting and quitting times. The staggering of hours began during World War II, when it was decided not to have all federal employees arriving and leaving Washington at the same time and thus clogging all the streetcars. The General Services Administration coordinates the staggered system used by the federal government and oversees the spreading of quitting times between 3:30 and 5:30 p.m.

Atlanta

The planning of Atlanta's staggered hours plan was completed in 1970 under the sponsorship of the State Highway Department of Georgia, the city of Atlanta, the countries of Fulton and DeKalb, and the Atlanta Chamber of Commerce. The plan was implemented by the Metropolitan Area Rapid Transit Authority in cooperation with UMTA as part of the Urban Corridor Demonstration Program.

The recommended staggered hours plan for Atlanta involved work-hour changes for employees of a major retail firm and three public agencies, affecting approximately 3000 in the private firm and 8000 in governmental agencies. Although the study criteria allowed as much as a 45-min earlier or later work shift, the optimum plan as recommended envisioned 30-min shifts for the four participants.

The plan called for one public agency to start and quit 30 min earlier, two public agencies to start and quit 30 min later, and the private firm to start 30 min later and quit 15 min later. This variation of work hours for the private firm corresponded to new store hours of opening at 10 a.m. and closing at 6 p.m. On a 15-min basis the plan would reduce peak traffic volumes at the CBD cordon about 5 percent in the morning peak period and almost 6 percent in the afternoon peak.

Unfortunately, the plan was never implemented because the public agencies resisted shifting to later hours. Further efforts to modify the work schedule recommendations were also unsuccessful.

SUMMARY

This paper outlines several TSM techniques to adjust demand patterns to reduce transportation congestion. The focus is on a number of alternative work schedule concepts as being more effective than pricing incentives or disincentives.

Although the potential effectiveness of alternative work hours has been known for a long time, some explanation is needed of the relatively few coordinated efforts that have been undertaken in major cities to date. Several of the case study cities showed a failure to achieve a successful program.

The following reasons (listed in no particular order) can be given:

1. Limited technical knowledge as to the planning, design, and implementation of a variable work hours program;
2. Little desire on the part of government and business institution to undertake, finance, or manage such a program;
3. A reticence, especially by government agencies, in undertaking the considerable "selling" effort to persuade voluntary participation in the program; and
4. Until recently, a limited impetus to seriously consider anything but capital-oriented transportation projects.

Fortunately, it appears that two trends will collectively make alternative work schedule programs more acceptable in urban transportation planning and engineering. The first trend involves the move toward and now the requirement of low-capital programs to solve transportation problems.

This second trend involves the changing work habits throughout the United States and similar change in other western countries. Whether spurred by nontransportation factors or by the several variable work-hour programs in existence, alternative work-hour schemes are increasing steadily. The challenge to the transportation professional is to take advantage of and even direct these trends to complement or enhance the efficient use of urban transportation systems. This is all the more important because some alternatives that employees might adopt could have an extremely unfavorable impact on urban transportation systems.

REFERENCE

1. Federal Register, Vol. 40, No. 181, Sept. 17, 1975, p. 42979.

ACTIONS TO REDUCE VEHICLE USE IN CONGESTED AREAS

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Federal TSM guidelines are used as a basis for four broad groups of measures for reducing vehicle use in congested areas. Within each group, examples of specific measures now in use or planned for implementation are presented. These are classified according to their important opera-

tional features; their advantages and problems are discussed. The four groups are (a) voluntary measures to increase vehicle occupancy, such as single-destination or regionwide car pooling, subscription buses, van pooling, and shared-ride taxi; (b) pricing mechanisms using supplementary or area licenses, parking surcharges, automatic vehicle identification, on-vehicle meters, and manual toll collection; (c) physical and operational restraint of vehicles by means of complete or partial street closures, traffic cells, traffic signals, and intersection modifications; and (d) peak-hour truck restrictions using permits or vehicle-size limitations.

The Federal Highway Administration and the Urban Mass Transportation Administration in their preliminary requirements for TSM planning suggested five groups of actions to reduce vehicle use (34). Although these actions do not necessarily exhaust all options that would reduce vehicle use, we feel they are sufficient for now and have attempted to address each one in this paper. In general we have used this grouping as a basis for organizing this paper; however, two groups have been combined since there is much overlap between them. Within each group we describe specific actions, give examples of where each is being tested, and discuss results and lessons to be drawn from those examples. The three approaches to limiting the number of private vehicles in a congested area are

1. Increase vehicle occupancy by means of voluntary measures or by economic or physical preferential treatment of multiple-occupancy vehicles,
2. Impose economic measures to discourage vehicle use in the congested area, and
3. Apply direct physical or operational restraints to discourage or prohibit vehicles in the congested area.

The fourth approach applies to trucks:

4. Restrict downtown truck delivery during peak hours.

INCREASE VEHICLE OCCUPANCY

Vehicle occupancy may be increased by encouraging ride sharing and car pooling. Preferential treatment of high-occupancy vehicles is discussed in another paper in this report. Here we will concentrate more on positive encouragement measures.

In general, the purpose of a ride-sharing effort is to meet existing travel demands while using fewer vehicles. Most current ride-sharing efforts tend to concentrate on areas of relatively high employment density (e.g., CBDs, large industrial parks), where the probability is highest of finding commuters with compatible travel patterns. Such areas also tend to create much of the traffic congestion and parking problems in any region, and a given reduction in vehicle use produces the greatest benefit. The five major approaches to ride sharing that have been successful in reducing vehicle use are listed in Table 1.

Most single-destination car-pool efforts have been run by large employers matching their own employees by using noncomputerized methods. Employer motivations include reduced employee parking demand, public image enhancement, contingency plan for gasoline shortage, emergency backup for transit strikes, employee fringe benefits, and compliance with federal regulations or community goals or both. These efforts require strong management support to succeed (1).

Most regional car-pool efforts are run by a regionwide government agency and produce match lists by computer. The major advantage is that participation is not limited to large employers. Most such efforts were initiated in response to the energy shortage or federal regulations or both. The most successful matching efforts have been those that operate largely through employers rather than those that attempt to contact and match individual commuters directly. Successful regional systems require strong marketing efforts to get employers involved and to indoctrinate key personnel for the purpose of eventually reaching commuters (2).

Subscription buses are cost effective only for long, line-haul commute trips. Pickup locations can be the commuter's home but generally consist of several prearranged gathering points, such as shopping centers or churches. Vehicles are generally obtained from existing charter bus fleets, and professional drivers are usually required. Fares are normally prepaid and seats guaranteed, but casual riders are sometimes accepted. Subscription buses are almost always under local regulation. A problem of this mode is the difficulty in finding 30 or more commuters with similar origins and destinations and work schedules (3).

Van pools are a more flexible form of bus pools and can be cost effective for trips as short as 16 km (10 miles) one way. Finding the smaller number of compatible commuters is also much easier. The driver is usually an unpaid commuter who rides free, and pickup locations are usually commuters' homes. Vehicles are usually purchased or leased by the employer and are primarily used for commuting purposes. Van pools may or may not be regulated, and these regulations are in flux because of the increasing use of this new commute mode. For the commuters to whom it is applicable, van pooling is the most effective ride-sharing mode for reducing energy consumption and air pollution (4, 5, 6, 7, 8).

Shared-ride taxi service is not widespread since most franchises or government regulations concerning taxi operations do not allow for ride sharing. However, energy considerations and the involvement of the taxi industry in providing solutions to the public transit problem are changing such regulations. The pooling of dispatcher and driver demand-actuated requests is effective to the extent that there is sufficient demand to allow for efficient pooling of the demand. Generally, ride sharing affects level of service by increasing travel time but allows lower fares.

Ride sharing is generally more attractive to the long-distance commuters, who as a group account for a strikingly disproportionate percentage of regional vehicle travel. Although there are many measures of effectiveness for ride-sharing efforts, the single most important one is reduction of vehicle travel per dollar invested in the program. Compared to other traffic management programs, ride-sharing efforts would probably rate high, but few evaluations to date have gone to that level of analysis. When congestion is considered, the major measure of effectiveness should be the reduction in vehicle trips to the congested area. From the evaluations, several things are known:

1. Of every 100 people matched for car pools, from 5 to 20 were found to have formed or joined a car pool;
2. Few, if any, ride-sharing efforts to date have reduced regional vehicle travel by even 1 percent; and
3. The annual cost of regional ride-sharing programs generally falls in the range of $40 000 to $400 000 per year.

There is much conjecture but few facts about the psychological considerations of the decision to share a ride or of the dynamics of ride-sharing groups, but some research is under way. Some general references on ride sharing are included at the end of this report (9, 10, 11, 12).

AREA LICENSES, PARKING SURCHARGES, AND OTHER FORMS OF CONGESTION PRICING

Description of Actions

Several actions to reduce vehicle use in congested areas rely on pricing of travel to discourage automobile traffic, particularly single-occupancy automobiles traveling at peak periods. The actions include parking surcharges and several forms of congestion or road pricing. In the latter category are supplementary or area licenses, automatic vehicle identification (AVI) systems, on-vehicle meters, and manual toll collection. These methods are summarized in Table 2.

Parking charges can be imposed in three locations: city-controlled spaces, privately owned commercial lots, and private lots provided for employees and customers. For municipal facilities, off-street rates may be increased directly or increased indirectly by taxing. Rates can be imposed selectively by location, day of the week, and elapsed parking time. For on-street parking, it is the meter cost per hour that provides the variable. For private lots, surcharges or taxes may be imposed in a flat fashion or with variation by elapsed parking time. Surcharges on employee parking might be varied by single versus multiple passenger vehicles and surcharges applied to businesses providing customer parking.

Congestion pricing or road-pricing techniques differ from parking charges in that these are aimed directly at the travel causing the congestion. Parking charges miss through traffic and are not always specific to the location of congestion or its exact duration. Congestion pricing is location-specific and time-specific. A driver entering a congestion zone must display a prepurchased supplementary or area license (usually in the form of a window sticker) during, say, the morning or afternoon peak or both. In the cordon approach, this traffic plus moving and parked traffic within the cordon must have stickers. Car-pool, emergency, and transit vehicles would probably be exempted. Automatic vehicle identification (AVI) refers to technologies that require a label on vehicles (optional labels such as those used on railroad cars or low-frequency induction systems) that can be read by a scanner at pricing points. Tolls can vary by location and by time of day. Road users are billed periodically. On-vehicle meters tally time within the priced zone, but unlike AVI the time and price register on a vehicle meter. The last pricing technology, manual tolling, simply refers to the familiar toll booth. Here again charges can be varied by time and by location, and through traffic as well as inbound traffic can be charged.

Effectiveness of Actions

Municipalities that impose parking surcharges can expect to have only relatively small impacts on vehicle use in many urban areas. This is because one-third to two-thirds of all traffic in urban areas is through traffic. Also, about 75 percent of persons driving to work in the United States have parking provided by private employers (13). This means raising rates on municipal lots will have relatively little effect on commuter traffic, and it is only through surcharges on private lots that this traffic might be affected. Even in this case, elasticities are such that sizable rate increases are needed to have an effect. Most sources indicate a 3 to 7 percent decrease in CBD vehicle travel might result from a $1/day increase in the average parking charge (14). Another problem with private lot surcharges aimed at commuter congestion is the auditing difficulties that accompany surcharges for long-term versus short-term parkers. San Francisco is studying the audit problems of such a split tax and finding them to be substantial. This is not to say that parking surcharges would not be effective where commuter parking predominates in a congested area or where parking at an activity center (arena, airport) is directly related to congestion. Of course, coupling a good transit alternative with a parking surcharge increases the effect of the charge.

Experience with road-pricing techniques is not great, although evidence is beginning to be gathered on toll roads and supplementary licenses. AVI and vehicle meters are still being tested and developed. An optical AVI system is being used by the Delaware River Port Authority, and induction devices are being tested on vehicles in New York, New Jersey, and San Francisco. Neither AVI nor on-vehicle meters are currently available for widespread application.

Manual tolling with toll booths can be expected to affect traffic to some degree. Studies of bridge and road toll increases in the United States indicate a doubling of tolls (original tolls ranging from 10 to 35 cents) resulted in traffic reduction between 14 and 25 percent for roads with alternate routes and between 8 and 13 percent for roads without alternate routes (15). Clearly, much depends on the travel option. One estimate indicates a 25-cent road toll for commuters traveling a 32-km (20-mile) round-trip to work in Pittsburgh would result in an 11 percent reduction in automobile travel downtown, if a "reasonably good bus exists as an alternative mode" (15).

Supplementary licenses are receiving their first major test in Singapore. The $3/day (U.S. $1.30) window sticker charge for morning peak hours (7:30 to 9:30), combined with improved transit and increased downtown parking charges, has reduced traffic by 46 percent. Trips have been diverted to periods before and after the peak, to transit, and to ring roads (16). London has come close to instituting a supplementary license scheme with fees of £1 to £1.25/day. Projections are that a 45 percent reduction in automobile traffic will result, and transit patronage will be up by 45 percent (17).

Planning for Actions

Of all the techniques discussed, planners and decision makers preparing transportation system management plans should give the most attention to (a) peak pricing on roads where toll booths are already in place; (b) parking surcharges where congestion is a problem at activity centers, where through traffic is not substantial in a congested zone, and where parking rates in the zone are largely within the control of municipalities; and (c) supplementary licenses where through traffic is a problem and where congestion is specific to time and location such that manipulating parking charges would not be effective.

All of the pricing techniques have numerous legal, political, distributional, institutional, and implementation issues associated with them. In areas where tolling authorities are not already established, pricing of travel must entail the most careful planning if implementation is ever to be realized. Fortunately, UMTA can provide consultant assistance to localities seriously interested in road pricing, particularly in the area of supplementary licenses. Berkeley, Madison, and Honolulu have already received road-pricing assistance from UMTA, and one or more of these cities may opt for a demonstration of supplementary licenses. The research to date on these issues is summarized as follows:

1. Road pricing on federally aided roads by means of toll booths is prohibited by U.S. law, except for some

bridges and tunnels. Supplementary licenses for travel on such roads may or may not be illegal. For non-federally aided roads, which make up street systems in most urban areas, supplementary licenses would probably be legal if applied for a reasonable public pur pose (e.g., reducing congestion) and if a good transit alternative were available (18).

2. Revenues from supplementary license schemes set at $1 to $2/day would undoubtedly be sufficient to pay for enforcement and administrative costs and provide funds for transit to serve the priced zone. It may be possible to directly compensate certain adversely affected parties (19), e.g., the poor or businesses in the priced zone, by directing revenues to transit in poor neighborhoods or reducing business taxes in the priced zone. Such considerations are crucial to political feasibility.

3. Institutional and implementation issues of most concern in supplementary licensing are how to design planning and administrative bodies so they are politically feasible and how to manage risks in implementation. Research on these points suggests it is advisable to (a) first institute supplementary licensing as an experiment with a prenegotiated end date; (b) ensure participation of affected parties (commuters, business, the poor, transit) during planning to negotiate on important variables such as price, zone size, compensation mechanisms, and period of experimentation; (c) consider vesting such groups with veto power over changes in the experiment as it proceeds; and (d) provide ample insurance when supplementary licensing is implemented to guard against losses to third parties (e.g., parking business in the priced zone) and the expense of possible litigation.

4. Details on the implementation of supplementary licenses including means of pricing, enforcement, revenue distribution, institutional arrangements, and risk prevention and sharing strategies appear in a recent Urban Institute paper (20), and a recent Transportation Research Board conference paper suggests means for overcoming implementation hurdles (21).

PHYSICAL AND OPERATIONAL VEHICLE RESTRAINT

Most of the discussion on vehicle restraint focuses on downtown areas, where alternatives such as transit and walking are most practical. Vehicle restraint may be applied on the approaches and entry points to downtown or within the downtown area itself. Table 3 gives examples of such measures.

Freeway ramp metering could be described as a method for restraining vehicles on the approaches to downtown. It will not be discussed at length here since it is generally applied with the objective of improving freeway flow rather than reducing total vehicles in the central area.

The best example of an attempt to restrain vehicles on the approaches to a central area is a recently discontinued project in Nottingham, England, called the "zone and collar scheme." The collars consist of signals at intersections along a major arterial approaching central Nottingham from the west. The signals were designed to create queues, thus delaying private vehicles heading into town; special lanes were provided to allow buses to bypass the queues. Park-and-ride lots were provided at which commuters could board buses, specially painted a shocking pink, and dubbed "lilac leopards." In addition, signal timing was set to make entry onto the arterial difficult from neighborhoods along the route. These neighborhoods were the focus of the "zone" part of the plan, which restricted entry or exit from these neighborhoods except at the intersection with the arterial. Thus, the collars could not be bypassed on parallel routes, either by traffic originating in those neighborhoods or by through traffic. The scheme was in effect from the summer of 1975 to July 1976. The scheme was very unpopular and apparently did not cause a significant shift to transit. Two problems with the project were (a) the park-and-ride lots were located too close in to make them attractive to most commuters and (b) too many users of the arterial had destinations not well served by the buses.

In Southampton, England, a major radial arterial is equipped with traffic signals and electronically controlled restrictive signing that are connected to a central control center and programmed to improve vehicle operating speeds, particularly for buses, to the CBD throughout the day (22). Access to the radial is controlled so that, as traffic approaches capacity on the radial, side traffic is restricted from entering until flows are reduced. Some turns are completely curtailed, others are permitted when radial traffic flow is low. At some intersections, only buses are permitted access to the radial. At other intersections, buses can bypass automobiles that are waiting to enter the radial. Thirteen intersections and six pedestrian crossings along a 5.6-km (3.5-mile) section of the radial are involved. The project goals include reducing bus travel time by 5 min along the route and further increasing bus modal split above the previous 50 percent. The cost of the project was $260 000.

In the category of vehicle restraints within the downtown area, traffic cells is a method that has been tried with apparent success in Europe. Key examples are the cities of Gothenburg, Sweden, and Bremen, West Germany. In both cities a central area of the city was divided into quadrants (called traffic cells), and physical barriers were erected between traffic cells. Each traffic cell has only local traffic circulation; all through traffic and traffic going from one cell to another must use a circumferential route that encircles all cells (the exception is public transit, which is permitted to pass through cell boundaries). Entry to and exit from each cell to the circumferential route occur only at designated access points. Motorists are assisted in selecting the shortest routes by traffic cell symbols posted along the streets.

The effects of the traffic cell method are as follows: (a) Through traffic is eliminated from the area and is diverted to the circumferential route, (b) vehicle travel within the area is reduced because direct passage from one cell to another is prohibited, and (c) traffic accidents and pedestrian and vehicle conflicts are reduced because of reduced automobile travel in the cells. In Gothenburg (23) benefits have included a 5 percent reduction in accidents, a reduction in mean concentration of CO from 34.5 to 5.75 mg/m^3 (30 to 5 ppm), and a reduction in noise levels from 75 to 72 dBA. In Bremen (24) the traffic cell implementation was accompanied by the institution of one-way street systems within each cell. The one-way streets were an additional aid in reducing pedestrian and vehicle conflicts. The most significant disadvantage of traffic cells is that traffic increases on the circumferential route and at access points. Also, a well-planned publicity campaign may be necessary to assist drivers in finding their way through the traffic cell system.

The estimated cost of the Gothenburg traffic cell system was $30 000 for advertising and $50 000 for traffic cell barriers and signs (25). The Bremen system had a total cost of about $2 million, which included the cost of parking garage construction within the cells. In both cases, the lead-in time was only about 6 months.

Intersection modification by means of barriers, curb reconstruction, or signing to prevent certain turning or through movements with the purpose of reducing through traffic and restructuring internal traffic circulation has been tried in the United States so far only in residential neighborhoods (26). There is no reason why the technique cannot be used in central areas, as has, in effect, been done in some European cities as part of large central area automobile-restricted zones.

A similar effect may be obtained by using traffic signals. The Greater London Council (GLC) is studying proposals for traffic restraint using traffic-signal imposed delays (27). The key objective of the GLC scheme is to dissuade through traffic from using streets in the central city area in peak periods.

Proposals for pedestrian malls have been popular throughout the United States and Europe for the last 20 years. Until recently these mall proposals have mostly been efforts to make downtown shopping areas competitive with the newer suburban shopping centers by offering much the same physical conveniences and amenities: ample parking; pedestrian access to a variety of businesses, unobstructed by traffic; and clean, modern surroundings. Such proposals have been promoted by downtown business people and civic promoters, and objectives have focused on economics and aesthetics. It is only appropriate, then, that U.S. mall projects are often financed by some form of special assessment district or benefit assessment formula.

Increased concern over traffic congestion and environmental improvement in the 1970s has fueled an explosion in mall building. By 1975 there were malls with permanent, total exclusion of vehicles in 64 U.S. cities of every size, an increase of 30 in 2 years (28). In Europe, more than a hundred cities had complete or selective automobile bans in downtown streets or areas (29).

Reduction of vehicle use is relatively new as an objective for street closings. In the United States, the traffic engineering analysis accompanying a mall proposal has traditionally focused on how to avoid congestion problems on nearby streets. Most U.S. malls are only a few blocks long and are rarely located on streets that are major thoroughfares. The possibility of inducing a significant shift in travel patterns to downtown, away from single-occupancy automobile to transit and multi-occupancy vehicles, is only now receiving serious analytical attention through the automobile-restricted zone program being conducted by the Urban Mass Transportation Administration.

Most of the evidence regarding effects of large-scale street closures in congested areas has been in Europe. In Copenhagen 1.4 km (0.84 mile) of CBD shopping streets have been pedestrianized (30). On the Copenhagen Strøget, which has been closed to automobiles (at first experimentally for limited hours) since 1962, pedestrian volumes increased 35 to 45 percent between 1962 and 1967. Traffic measurements show that 76 percent of the traffic that previously used the Strøget has shifted to nearby parallel streets, although none is as direct a route. Only 35 percent of the former rush-hour Strøget traffic has reappeared on nearby streets; however, it should be noted that 300 time-restricted parking spaces were also eliminated in the pedestrianization. In Norwich, England, 60 percent of the traffic excluded from London Street (one of several streets closed to traffic there) has not been measured to reappear on nearby streets (31).

Despite these statistics, there is no evidence that these street closings have been effective (or necessarily intended) as measures to substantially alter downtown travel patterns or air quality. These projects are best seen as accommodations to the realization that there are places where walking is simply the most appropriate mode of circulation. The closing of the Copenhagen Strøget made no noticeable dent in the dramatic trend of increasing automobile use there. On a nearby downtown street, daily volumes rose from 5500 to 9200 between 1960 and 1967, mostly because of a shift from the traditional modes of bicycle and moped. Downtown public transport use continued its downward trend, dropping by 10 percent immediately after the closing (possibly because of a shift in patronage to outlying points). Environmental benefits have also been observed on the occasion of experimental street closings in New York City (Madison Avenue), in Marseilles, and in Tokyo (29, 32). The air quality measurements, of course, are only for the localized CO problems and not for photochemical pollutants or lead, which are regional in scope.

A recent trend of interest, especially in the United States, is the transit mall, a street that has sidewalks widened, amenities added, and on which only regular city buses, shoppers' shuttles, or rail vehicles operate. Two such malls now exist in the United States: the Nicollet Mall in Minneapolis (completed 1976) and the Chestnut Street Transitway in Philadelphia (completed 1976). A transit mall is under construction in Portland, Oregon. One is planned in Madison, Wisconsin; funding by UMTA already has been approved. At least in Portland the transit mall is part of an overall plan to reorganize, emphasize, and focus metropolitan transit service. Unlike most malls this is not primarily a shopping mall but a major thoroughfare. In most cases, however, a transit mall is a compromise shopping mall, designed to obtain approval from merchants who feel that some vehicular activity is essential to their businesses. In some cases, buses are retained on the mall because removing them would have a serious detrimental effect on transit service. By classifying streets as to mode, the capacity of downtown streets, measured in people per hour, can actually be increased in some cases. Many more transit malls are planned in cities throughout the country.

Elements from all these vehicle-restraint measures may be used to create various types of automobile-restricted zones. These range from reconstruction of a downtown street to reduce its capacity, encouraging through traffic to use parallel streets (a measure that is popular in many small U.S. cities), to combining pedestrian streets, transit streets, and intersection modifications throughout an area.

In Essen, West Germany, the old town center, which was mostly destroyed in World War II, has been rebuilt with an extensive network of pedestrian streets. Work is continuing; so far, a pedestrian area 1 km by 300 m (1.6 miles by 1000 ft) has been created (29). The Hague has 2.4 km (1.5 miles) of pedestrian streets in its center (29). Düsseldorf, faced with an acute downtown congestion problem coupled with declining business, began a project that included improved parking and public transit as well as converting several major streets into pedestrian malls. Although strongly opposed by merchants at first, the closings, which now involve 3.4 km (5.5 miles) of streets, are now considered a great success and are planned to be extended (29).

In Vienna there were plans to create a downtown automobile-free zone 1.3 km (0.8 mile) in diameter; liquid gas-fueled minibuses and delivery vans will be allowed in the zone (33). To date the Karntnerstrasse, Stephansplatz, and the Graben have been turned over to pedestrians and regular city buses. Measurements show a reduction in local noise and CO levels of 40 percent compared to previous levels. The Vienna experiment has suffered from enforcement problems; in addition, lack of a clear parking plan seems to encourage vehicles to travel to the central area, thus

Table 1. Types of ride-sharing efforts.

Method	Description	Example
Single-destination car pooling	Car-pool matching of commuters with the same destination (e.g., single employer, office building, industrial complex)	Aerospace Corporation Burroughs Corporation Pentagon Hallmark Cards
Regionwide car pooling	Car-pool matching of commuters with different destinations	Metropolitan Washington Council of Governments Los Angeles Commuter Computer Portland Metropolitan Area Carpool Project Dallas Carpool
Subscription bus	Prearranged group of 30 to 45 people commuting regularly in a bus to the same destination	Reston Commuter Bus Com-Bus
Van pooling	Prearranged group of 8 to 15 people commuting regularly in a van to the same destination	3M Company Conoco California Department of Transportation Tennessee Valley Authority
Shared-ride taxi	Prearranged tours or dispatcher-driver pooling of demand-actuated requests to serve from 2 to 5 persons, each with different origins and destinations	Danville, Illinois El Cajon Express

Table 2. Parking surcharges and congestion or road pricing.

Method	Description	Example
Parking surcharges	Special parking charges imposed in heavy traffic (downtown) areas directly or indirectly through taxes, covering both off-street and on-street and both private and municipal facilities	
Supplementary or area licenses	Drivers entering a congested zone must display a prepurchased window sticker (license) during certain time periods	Singapore and London
Automatic vehicle identification (AVI) systems	Vehicles traveling in specified areas must display a label that is read by a scanner at pricing point, and charges can vary by location and time of day	Delaware River Port Authority; testing in New York, New Jersey, and San Francisco
On-vehicle meters	Similar to AVI except time and price are registered on a vehicle meter	
Manual toll	Charges are collected at a toll booth and can vary by time and direction	Throughout United States

Table 3. Methods of vehicle restraint.

Control Location	Method	Description	Example
To downtown	Traffic signals	Signals placed on access roads induce delays or encourage use of alternate modes	Nottingham, England Southampton, England
Within downtown	Traffic cells	Area is divided into "cells," borders between cells are closed to traffic except to pedestrians and transit, and automobile travel to and between cells is by circumferential routes	Gothenburg, Sweden Bremen, West Germany
	Intersection modifications	Barriers, curb reconstruction, or signs prevent certain turning or through movements to reduce through traffic and restructure internal traffic circulation	Seattle, Washington[a] Berkeley, California Isla Vista, California
	Traffic signals	Signal timings are set to discourage through traffic	London, England
	Pedestrian or transit malls	One or two streets are closed to all traffic or private vehicles only, pedestrian amenities are added, roadway is narrowed or eliminated, and cross traffic may be allowed	Minneapolis, Minnesota Philadelphia, Pennsylvania Fresno, California
	Automobile restricted zones	Elements may be combined from all of above to eliminate or discourage through traffic by private vehicles and encourage pedestrian uses	Essen, West Germany Nottingham, England

[a]These examples are of applications to residential areas only, but illustrate a method that could be applied to central areas as well.

Table 4. Proposed methods for reducing downtown truck deliveries during peak hours.

Method	Description
Time-shifts in deliveries; night facilities	Require or encourage deliveries at times other than peak hours
Permits	Allow only permit vehicles in area during peak hours
Vehicle-size limitations	Allow only smaller commercial vehicles in area during peak hours
Promotion of fleet efficiency	Encourage fleet operators to reduce redundancy and time-stagger deliveries

creating considerable congestion.

What appears to be a successful automobile-restricted zone is in Nottingham, England. The Nottingham central area scheme covers an area 1 km (1.6 miles) in diameter, around which a ring route has been defined. Within the ring road is the older part of the city, the scene of much shopping and formerly quite congested. Streets that had heavy pedestrian volumes have been converted into pedestrian-only streets; other streets are bus-only or bus-and-taxi-only streets. Private vehicles are prohibited from making certain turns. No on-street parking is allowed anywhere in the central area. One major pedestrian street links two recently completed shopping mall and bus station developments. The net effect of the scheme, which has been in effect since April 1973, is that automobile traffic can drive to most points in the central area, but driving through from one side to the other is difficult. The Nottingham central area scheme appears to be quite popular with the public, business people, and government officials alike.

UMTA's automobile-restricted zone (ARZ) demonstration program may stimulate the first large-scale, areawide traffic closures in U.S. cities, as well as some deeper analysis of their potential as transportation management measures. An objective of this program is to create noticeable shifts in travel patterns. Con-

sultants are now doing preliminary plans and analyses for Boston, Burlington (Vermont), Tucson, Providence, and Memphis. It is expected that UMTA will award two grants for ARZ projects this fiscal year. In Boston, for example, one plan would close off one-third of the CBD streets, others being left open for access to garages and for deliveries, so that driving through the CBD would be difficult or impossible. Of course, much less ambitious projects also could result.

In summary, street closings and vehicle restrictions appear to have most success in areas where pedestrian use is dense, automobile traffic is already congested, and through travel is difficult. In such areas, the benefits from creation of pedestrian areas and improved transit flow clearly outweigh inconvenience to drivers. A comparison of the experiences of Nottingham and Southampton in control of the approaches to a central area also implies that gains must clearly outweigh inconvenience for a project to be successful.

RESTRICTIONS ON DOWNTOWN TRUCK DELIVERIES DURING PEAK HOURS

Any consideration of actions to reduce vehicle use in congested areas should encompass all travel, including goods movement. However, restrictions on truck deliveries are particularly difficult to implement because of the large number of vehicle operators involved; the vast majority of all trucks are single-vehicle operations or trucks from small fleets. In addition, misdirected restrictions can result in either a decline in commercial activity or the raising of prices of consumer goods.

Various proposals have been made for restricting truck traffic in peak hours; the principal ones are summarized in Table 4. However, we find no U.S. examples where these proposals have been successfully applied in any comprehensive fashion, and this area poses a challenge to traffic management.

Time shifts in delivery schedules is one method holding some potential. One approach is to structure goods and services traffic to occur before or after the morning rush period. Because the morning rush period is slightly shorter than the afternoon rush period, the morning period generally has more uncongested time available. Many commercial vehicles already make early deliveries so that this restructuring of delivery times already has some acceptance. Another approach is to encourage more night deliveries. In some cases, the installation of "night drop" facilities (analogous to night maildrops and bank deposits) can facilitate a shift to night deliveries. Night deliveries, however, do cause some problems; for example, drivers may require overtime pay and receiving personnel may be unavailable or may require overtime pay.

Permits can be issued for commercial vehicles so that only commercial vehicles having a need to be in the congested area in the peak period have legal access to the area. Such permit systems may have to be augmented with truck routes and appropriate signing to divert nonpermit commercial vehicles away from or around the congested area.

Vehicle-size restrictions can be imposed. Large trucks and commercial vehicles tend to aggravate traffic congestion during peak periods, but smaller vehicles (such as panel trucks and pickups) have operating characteristics and parking requirements similar to automobiles. Therefore, if the larger vehicles are excluded from traffic in specific areas during peak periods, traffic may flow more freely.

Fleet-dispatching efficiency can be encouraged. Service vehicles for telephone, gas and electric, sewer, and water utilities are often found in groups of two or three at repair or construction sites. More efficient vehicle dispatching could be promoted with the utility companies. In general, fleet dispatchers should be encouraged to time-stagger deliveries and pickups or to use fewer trucks.

Although the techniques discussed above are potential methods for restricting downtown truck deliveries, we were unable to find documented case studies and their application at specific sites. The literature is scarce on this subject because of the many political, labor, and institutional issues that often act to prevent a straightforward exposition of a method of approach.

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MANAGEMENT BY OBJECTIVES APPLIED TO TRANSPORTATION SYSTEM MANAGEMENT

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Management by objectives requires input by all members of the management and supervisory staff of an organization; efforts are aimed at the achievement of stated results or objectives. Transportation system management in urban areas demands that transit and highway interests join forces in developing plans and action programs to make better use of existing facilities. This paper explores both management by objectives and transportation system management and provides suggestions on how the MBO technique can be used to design a TSM action plan.

One of the important recent developments in policy is the requirement that transportation system management (TSM) plans be undertaken and programs implemented in urbanized areas to qualify for federal aid for highways or transit. In other words, rather than purchasing additional transit equipment or building additional lanes of highway, we must now make the use of existing facilities and equipment more productive and more effective.

In part, the notion that lies behind TSM is a reflection of the growing concept of a mature transportation structure in the United States. Up to the present time, this country has been in the process of building transportation facilities and of constructing equipment to use those facilities. In the earliest days of nationhood, there were moves toward the beginning of a public road system; the federally aided National Road from Cumberland, Maryland, into the Northwest Territories is an example of this in the late eighteenth and early nineteenth centuries. A spate of turnpike building in the same time period was followed by the introduction of steamboats on navigable rivers and canal construction in the east and midwest in the 1820s. This was followed immediately—and, indeed, overtaken—by the development of railroads, beginning in the 1830s and going on for more than 70 years. On the heels of railroad development came the beginnings of the building of a national highway system in the twentieth century, culminating most recently in the work on the Interstate highway system. Also, in this century, the improvement of rivers for inland navigation, the forging of a vast pipeline system, and the development of airports and an air traffic control system for air transportation have provided the United States with an unparalleled transportation structure.

The diligence in construction was joined by the provision of equipment in a chicken-and-egg relation. The development of better and larger steamboats brought pressures for river improvements. The twentieth-century push for highways was spurred by the development and growth of the popularly priced private automobile; better highways stimulated the provision of better automobiles, which in turn stimulated a demand for better roads.

One thing that did not occur in the 200 years of growth in transportation was the development of a transportation system. Each mode of transport developed independently and, to a large extent, competitively. Each was treated separately in the policy sense. For example, the Interstate highway system was undertaken with little consideration of its impact on other forms of transportation. The bankruptcy of railroads in the northeastern United States is, in part, due to the intense competition provided by motor carriers enjoying the not insubstantial benefits of the Interstate highways. As a consequence of the lack of concerted transportation policy and programs, there are considerable duplication and overlap in the U.S. transportation picture; at the same time, it is often dif-

ficult to make an intermodal trip or to use more than one transport mode in shipping freight in a reasonably simple and expeditious fashion. The U.S. transportation structure is conspicuous by its cumbersomeness, duplication, and, inescapably, its inefficiency.

The days of building new transport facilities appear to be over. The continent is pretty well filled up, and the transportation structure apparently needs more to be refined and rationalized than to be expanded. Moreover, in many communities there is enormous hostility to the construction of more facilities; a new segment of urban Interstate highway is not usually thought of as a blessing today. Ostensibly the concentration of effort under currently evolving federal policy will be toward making existing facilities function more efficiently rather than adding materially to the stock of capital goods in transportation.

The inspiration behind the TSM policy is also a reflection of rapidly escalating costs due to inflation. Where once tax revenues to build a highway or private capital to expand or improve a railroad were about sufficient to do the required job, rapidly escalating costs of material and labor have meant that expansion of the system demands careful thought and much money. Building additional facilities is, therefore, not likely to take place easily or quickly any more.

Certain types of effort commonly spring into the minds of those involved in trying to figure out what to do about the TSM requirements. For a highway, TSM means, in essence, better traffic engineering. Efforts similar to the old Traffic Operations Program for Increasing Capacity and Safety seem to fit within the TSM rubric. Action programs in TSM involve things such as one-way streets, better traffic signal control, and parking restrictions at certain times of the day. As far as transit is concerned, TSM appears to imply actions such as signal preemption by transit vehicles, reserved lanes for buses and other transit vehicles, and use of express highways by transit vehicles (1).

However, the action programs can be summed up neatly; as Federal Highway Administrator Tiemann indicated, the programs essentially are to improve traffic flow, increase use of high-occupancy vehicles, and maintain system capacity (2). Another way of viewing TSM is that it is aimed at reducing demand and increasing capacity. Because a large proportion of transportation problems occur in urban areas, where increasing capacity by adding more facilities is difficult, reducing demand seems to be the wisest course to follow in such places. Unfortunately, the reduction of demand is closely related to the distribution of population and destinations. The spread-out patterns of growth that developed in American cities in the last half-century and the consequent need to travel long distances will make it difficult or impossible to reduce demand for travel very much in the short run. As a consequence, for the present and the near-term future, better use of existing facilities appears to be the most practical sphere of action.

One important thing that the TSM requirement does is demand that those involved with urban mass transportation and urban highways work together. As simple as that may appear, it is really quite revolutionary, considering the history of separation that has existed in the past. If real coordination of effort can be brought about on the local scene, the outcome should be beneficial, particularly to the taxpayers and to those who must travel in urban areas.

Clearly, transit management has a key role to play in carrying out the transportation system management program. TSM provides a superb opportunity to improve transit performance as well as highway efficiency. This opportunity is also a burden because many transit managers have had little experience in working with other parts of the transportation sector on the local level. Moreover, many transit managers are not particularly apt at managing transit, much less at embarking on a cooperative planning and action effort with highway officials. The lack of professionalism in the transit industry is serious and is only in the early stages of improvement. Forging TSM plans and putting those plans into action will not be an easy chore for transit management in most places.

The concept of management by objectives (MBO) is a tool that may be used by transit managers—and highway and traffic engineers as well—for solving transit problems and for developing the kinds of plans and action that TSM calls for. In this paper, the MBO process is examined as a means of approaching transportation system management, particularly as it is useful for transit managers and planners.

MANAGEMENT BY OBJECTIVES

The idea of management by objectives was first introduced by Drucker in 1954 (3). Management by objectives in the sense in which Drucker used it was aimed at increasing motivation; it allowed lower level managers to set objectives for themselves and thereby to control their own performance. The self-control was supposed to result in a stronger motivation on the part of individuals to do their best rather than just to get by. Higher levels of management would act to coordinate the objectives of the disparate parts of the enterprise under their direction, in keeping with the objectives of the overall enterprise.

The basic philosophy of MBO has been viewed a trifle differently by others (4), who see it as "a process whereby the superior and subordinate managers of an organization jointly identify its common goals, define each individual's major area of responsibility in terms of the results expected of him, and use these measures as guides for operating the unit and assessing the contribution of each of its members."

As thinking on MBO has progressed, it has become a highly useful way of conducting the affairs of an enterprise. The emphasis in management by objectives is on management rather than objectives, because MBO is nothing less than a systematic method of managing; it embraces objectives, plans, managerial direction and action, control, and feedback. All of the component parts must be present for MBO to function properly. Because of its complete and systematic nature, MBO is particularly valuable as a means of achieving results. Being result-oriented, rather than process-oriented, MBO is especially useful for public, nonprofit organizations (5). Such institutions lack the discipline of "the bottom line" as a way (albeit often imperfect) of measuring the quality and success of managers and the success of the enterprise as a whole through the profit mechanism.

MBO techniques in the world of TSM are not aimed primarily at improving motivation or otherwise enriching the job. Rather, the idea of establishing goals and objectives—often foreign concepts in the transportation world—is what MBO can bring to TSM. It will help orient those involved with the mass transportation aspect of TSM as well as those involved in other transportation areas to a means of achieving results.

Very simply, in the public sector, where profit or return on investment does not guide action, there must be some substitute. That substitute is the establishment of broad goals and narrower and more specific objectives, the development of plans to achieve the desired results,

a systematic pursuit, and the achievement of the sought-for end. Goals can be generally defined as broad-scoped conditions that cannot be associated with any single improvement or modification. That is, a goal is a long-run condition considered to be ideal or model. The following example of a goal statement for urban transportation is a derivation and consolidation of several goal statements, including those emanating from UMTA, the Federal Highway Administration, and the American Public Transit Association.

1. Provide mobility for all;
2. Improve the environment by increasing energy efficiency, fostering rational land use, and minimizing air, water, and noise pollution;
3. Sustain and enhance economic growth and vitality;
4. Provide the highest feasible and practicable level of safety for people, goods, and the environment; and
5. Provide for an efficient and cost-effective transportation system.

The broad national goals are typically things about which there are few arguments; they are the sort of ends virtually everyone can agree with. These can be translated into somewhat more specific but still rather general goals on the local level, depending on the problems perceived on the local level. Moreover, depending on perceived local problems, there will be different priorities established for the various goals and the objectives that proceed from them. Priorities are, of course, essential; this is especially so in the use of MBO, whereby a potent means of attaining results is at hand. It is critical that the product of the effort be one that is not only wanted but also needed at a particular time. Local transportation-related goals should, of course, be in line with the needs of the community and should bear a relation to the hierarchy of community needs.

Unlike goals, objectives must be pertinent to a given point. In other words, objectives define a condition more strictly than goals do; they are the means by which broad, desirable goals can be achieved. Objectives have five critical elements that must be included in order to be considered a correctly stated objective.

1. Objectives must be clear, concise, and unambiguous statements of what is to be accomplished;
2. Objectives must be measurable and attainable in a reasonable period of time and with reasonable effort;
3. Objectives must be consistent with goals and priorities;
4. Objectives must be assigned a date of accomplishment; and
5. Objectives must indicate who is accountable for their accomplishment.

The following is an example of an objective: The maintenance manager is responsible for reducing road calls to 1/15 000 revenue vehicle-kilometers by January 1, 1978. Such an objective would help meet the goal for increasing the reliability of transit service.

The main initial task of persons working with TSM on the local level would therefore be to establish transportation (highway and mass transit) goals based on overall community goals and priorities. From that point they would work to develop objectives that fit within the overall framework of TSM. The TSM goals and objectives obviously must be in line with overall community objectives. For the sake of practicality they should be within the spectrum of possibility in a community.

GOALS AND OBJECTIVES DEVELOPED INTO AN ACTION PLAN

There is a great need for planning to be carried out within an action framework. Too often, planners are frustrated because their plans are rarely implemented; Some of the reasons for this are discussed later. For the moment, it is clear that planning cannot be done for the sake of planning alone; there must be an action output from each plan. That is, a plan must go far enough to develop a means by which the plan, be it for TSM or some other purpose, would have a reasonable chance of obtaining some desired results. This is merely another way of saying that all the elements of MBO must be applied if results are to be achieved.

The planning process often lacks closure; that is, it is never brought full circle to completion. It is similar to our nationwide penchant for the distribution of products without sufficient thought given to recycling. A person with an economic bent of mind who dwells on the subject is often appalled by the thought that our highly productive consumer durable goods industry can produce washing machines and refrigerators quickly and efficiently but cannot figure out a way to get used-up washing machines and refrigerators smoothly back into the scrap pile so they can be turned into new consumer durables. Much the same is true of transportation planning, especially TSM-related planning. The process must be designed to include an action plan that, when made operational, produces the desired results.

The aim of action plans is to reach the objectives established. The action plan itself is nothing more than a listing of all the intermediate steps necessary to accomplish a given objective. In the final analysis, the individual actions become subobjectives, as suggested in the following discussion of a model objective and action plan.

Let us assume that a transit operator involved in some aspect of TSM work decides that a prime goal is to increase the reliability of the service in order to make the service more attractive. One objective would be to increase reliability of service, as measured by on-time performance of buses at selected points along each route, by reducing the number of late or early arrivals on any average day by a certain date. (Each goal will probably have more than one objective, but for the sake of example only one will be used.) The objective is not quite complete; who is responsible for achieving the objective is not stated. Before that can be done, some investigation into any causes of delay has to be undertaken. The lack of reliability in service may be due to equipment breakdowns or it may result from delays caused by traffic congestion. Given the objective, the model action plan can then be set out. The first step includes actions to determine the extent of the problem. The initial action consists of spot checks by supervisors of major generator or terminal points and a notation of the number of late or early arrivals.

Actions can then be taken to analyze the problem. For example, route running can be clocked against scheduled running times by given route segments; particular running difficulties can be noted and the location of given difficulties can be isolated. The drivers can also be surveyed regarding the characteristics of each route related to running times. Conclusions can thereby be reached in the attempts to understand the problem fully. The situation may be simply resolved by changing the schedule to reflect realistically the running times at various times of the day. Of course, that type of action—however realistic in the short run—may yield a standard of service that is unattractive to the public.

Given an understanding of the situation, certain actions can then be taken in an effort to resolve the program. Perhaps one of the key issues discovered in the analysis of the problem is that most bus stops are not marked and patrons flag down buses at many places along a route; two stops may be made within a single block, causing delay in maintaining schedules. An action to resolve this particular problem would be to place bus stop signs along the routes in order to help cluster the patrons at fewer points. Other actions might be to begin a customer information program to encourage the use of the bus stops and to speed up the process of boarding by encouraging passengers to have exact change and to use the rear exits when alighting. Still another action might be to impose an exact-fare policy to expedite fare collection.

Another direction of action might be to step up on-the-road supervision in order to monitor on-the-street operations more closely. In somewhat the same vein, a driver-training program might be instituted to help emphasize the importance of reliability and on-schedule performance. A final action would be to continue the analysis of route running times for adherence to schedules on a regular basis in order to make sure that schedules and reliable performance are maintained.

Investigation may reveal that poor schedule adherence is mainly due to traffic congestion at certain times of day. The action to take under such circumstances might be the inauguration of a reserved lane for buses in a few key, bottleneck locations. Signal preemption by buses may be chosen as an attack on the reliability problem, or possibly a combination of the various alternatives sketched out above might be chosen. All of the various efforts mentioned are legitimate TSM approaches. Whatever actions are ultimately decided on must be accompanied by attaching the responsibility to one individual. The individual responsible for an "external"action will truly be furthering the TSM goal of a more integrated transportation system in that his or her efforts will require interaction with those in the highway and traffic engineering arena. Management by objectives provides an orderly means of approaching and resolving a problem.

The following are possible types of actions that could evolve from TSM goals.

1. Actions to ensure the efficient use of existing road space through (a) traffic operation improvements to manage and control the flow of motor vehicles, (b) preferential treatment for transit and other high-occupancy vehicles, (c) appropriate provision for pedestrians and bicycles, (d) management and control of parking, and (e) changes in work schedules, fare structures, and automobile tolls to reduce peak-period travel and to encourage off-peak use of transportation facilities;
2. Actions to reduce vehicle use in congested areas through (a) encouragement of car pooling, (b) restrictions on vehicle use on selected streets, and (c) congestion pricing arrangements;
3. Actions to improve transit service, such as (a) innovative transit services, (b) improvement of routing, scheduling, and dispatching of transit vehicles, (c) provision of shelters and other passenger amenities, (d) better passenger information systems and services, and (e) simplified fare collections systems and policies; and
4. Actions to increase internal transit management efficiency, such as (a) improved marketing, (b) developing cost accounting and other management tools to improve decision making, (c) establishing maintenance policies that ensure greater equipment reliability, and (d) using surveillance and communications technology to develop real-time monitoring and control capability.

The list of possible broad categories of action is a long one, and within each there are possibilities for extensive series of related actions. The items involve actions both internal and external to transit operation.

Nothing can work effectively in MBO without managerial action and direction. Since MBO includes the joint consideration of approaches to meet objectives by all levels of management down to the supervisory level, there is the opportunity for a unified and systematic effort to attain objectives. Management close to each action level is in the best position to act.

Monitoring under MBO, if properly handled, is quick and effective. Because each level of management is in a position to act within its own particular sphere and bears the responsibility for its actions, there is little need for all information to pass completely up and down the chain of command in order for some action or corrective step to be taken. Only absolutely necessary information and questions need be referred to higher levels of management for coordination, concurrence, or correction. As the objectives, target dates, and responsibility for the objectives and actions are established, mileposts of performance are automatically set up and can be used on a regular basis to detect the quality of performance as progress is made. Action and its result are compared with the objective, and further action is taken quickly to get back on track; this takes place at the location closest to the point of action.

After a suitable time period, of course, there must be feedback on the action taken or the problem-solving procedure used. Each of the various actions taken has to be evaluated in light of what happened as a result of the actions. Was the objective attained? If not, why not? At the same time, goals and objectives must be continually evaluated and revisions made in both periodically as experience and the situation demand. Flexibility is necessary to obtain a desired result.

PROBLEMS WITH DEVELOPING GOALS AND OBJECTIVES ON THE LOCAL LEVEL

TSM requires that plans and action be taken on the local level. In accordance with the general thrust of this paper, then, the first step would be the establishment of the overall local goals and objectives. This is much easier said than done.

One would normally look to some national goals and objectives as guidelines for local activity. National goals and objectives on matters such as desirable levels of population density, population distribution, and sprawl could help local governments form goals, objectives, and action plans. However, apart from the list of broad national urban transportation goals given earlier, there is not much else, despite the fact that the majority of the population is urbanized or that the city is the locus of some of the principal social and economic problems of the nation.

There are typically no goals or objectives for transportation or urban areas on the state and local level. For the most part, state and local governments have not set out in any definitive form exactly what they want cities to be or how they want transportation to interrelate with other aspects of urban life.

Adding to the overall difficulty is the fact that urban transportation in general, and mass transportation in particular, are both highly interrelated with everything else on the urban scene. This means that great care has to be taken to choose plans and actions wisely, lest they have some unexpected and unfortunate consequence.

The urban segments of the Interstate highway system may be the best example in recent times of an action thought at one point to be good, but turning out, in fact, to be highly unpopular and destructive in many places at another point.

Overriding all, of course, is the great difficulty in formulating good goals and objectives and action plans, which is much more difficult in the public sector than in the private sector, where profit and return on investment can act as a guide. Members of boards of advisors of planning organizations or directors of transit agencies often have a strong private enterprise background. This is good, except that they tend to think most clearly in terms of profit and loss, not fully recognizing the special mission of nonprofit, public, tax-supported institutions attempting to achieve certain goals and objectives for the community. The consequence of this is the reluctance of highly profit-and-loss-oriented boards of directors to go along with proposals that may increase deficits, but will also actually increase the overall productivity and effectiveness of the system as the movement of people is concerned.

Clearly, the goals that have to be established for TSM, or any other transportation activity on the local level, have to be consistent with local needs, desires, and resources. Goals cannot be conflicting if anything is to work out well. For example, it was not unusual in the 1960s, as privately owned transit firms began to fail or be taken over by public agencies, for local government to make strong statements encouraging the continuance of privately owned mass transportation. At the same time, these same local governments were often involved in the widespread building of highly subsidized public parking garages. Local community leaders and elected and appointed officials, therefore, assured the creation of a situation in which a city would have the dubious but inevitable distinction of possessing publicly owned and subsidized transit as well as publicly owned and subsidized parking.

The objectives that are established in any TSM program on the local level must be consistent with the overall goals established for the urban area. Care must be taken to follow the rules and conditions laid out earlier for setting a good objective. One cannot have an objective to merely "make transit nicer." However, to paint the interiors of all the buses by a given date is a reasonable objective if an overall goal is to improve the general level of hygiene of the transit system.

The greatest difficulty may lie in getting local public officials to state just what it is they really want to have happen. Taking clear stands on issues has the associated problem of providing a standard by which public officials may be held accountable. The more blurred the issues are, the less definite is the expected achievement and the less chance that the public may react unfavorably at the ballot box at some future time.

WORKING ON THE TSM PLAN

In developing a transportation systems management plan, transit managers and highway and traffic officials must work with one another and with local transportation planners. Here the typical management-by-objective procedures would apply. All the various levels involved need to participate in formulating the goals, objectives, and action plans. TSM should not be solely a product of a top planner or top highway or transit official. Throughout all of the organizations that must be involved, there should be genuine attempts to understand one another's problems. It would also be hoped that public officials in a local area would be full participants in the discussions that must go on in developing a TSM program. The local metropolitan planning organization (MPO) is supposed to provide the liaison between government officials and the transportation world, but this role is not always played smoothly.

Early in the game there is, of course, a need to inventory the problems with TSM implications. Traffic bottlenecks, a high level of air pollution, overcrowded buses, underused traffic lanes, impediments to the free flow of traffic, inefficient or dangerous intersections, transit vehicles delayed by other traffic, parking difficulties that might be solved by car pooling, and a host of other things all have to be investigated and considered. The local level participants in this exercise must understand the parameters within which they are working. Low-cost, noncapital projects are in keeping with the concept of TSM. The plans put together must be consistent with overall urban goals, with urban transportation goals and objectives, and with transit goals and objectives.

Conflicts are possible and must be resolved. The highway, traffic, and transit people can find themselves in a fine imbroglio if the transit agency wants to improve the quality of service by spacing its routes more closely together while at the same time the traffic engineers plan to limit the operation of buses to only a few, wide, major streets. Again, traffic management plans of designating certain streets one way to augment traffic flow may make it difficult and time-consuming for transit service to continue to be offered to major traffic generators on that street.

After the TSM notion has been developed according to the goals and objectives set forth and agreed to by everyone, the worth of the action plan needs to be measured. The feedback necessary to measure the effectiveness of TSM operations must have at least three parts: evaluation of the idea, evaluation of the implementation of the idea, and evaluation of the results of the idea. Since TSM and a coordinated approach toward handling and managing transportation in urban areas are new, possibly the implementation will be the most severe problem at the present time. The level of general public awareness and understanding is critical to success, as is the need for support of public officials.

One of the best examples of a TSM type of idea that appears to have been a disaster is the diamond lane program in the Santa Monica Freeway in Los Angeles. The diamond lane (diamond shaped marks are actually painted in the freeway lanes) was set aside for use by buses and car pools only. The Santa Monica Freeway was chosen because it is a metered freeway, and results could be evaluated much more easily on it than on some of the other freeways in Los Angeles or in California. The reduction of one lane caused enormous traffic backups and many accidents. Irate motorists threatened court action, and the Los Angeles press pilloried the California Department of Transportation, the Southern California Rapid Transit District, and any other person or agency that appeared to have something to do with the diamond lane idea. Cries about the inhibition of personal freedom to drivers as a result of the diamond lane project and screams of unconstitutionality were heard in the media.

Apparently, one critical missing element in the whole diamond lane project (and an element that may also be missing in many future TSM undertakings that make changes in the patterns of movements in our streets) was relations with the press and other media early enough in the game so that the public and public officials could be informed about what steps were to be taken and why. Enormous effort must be taken by those responsible for TSM implementation to make sure that the public knows and understands why some action is being undertaken.

Informing the people in the media is essential to that process. The overall goal of the diamond lane project, and all of the TSM projects, is to make existing transportation facilities work better than they do now. This idea has to be put across effectively.

CONCLUSION

To some people involved in local transportation planning and action, the TSM idea may seem an intrusion in their daily activities. However, after a few years of forging goals, objectives, and action plans and seeing successful implementation of those plans, they may wonder why the TSM approach was not required 30 years ago. At the same time there should be no illusion that the process will be easy or the results immediate.

The important thing is that the federal government, in requiring the TSM actions, understand what it has set in motion. UMTA and FHWA must do something substantive with the plans and proposals that are turned in to them; otherwise, the process will be nothing more than a boon to paper manufacturers. Continued support has to be given to local officials. There is an opportunity here to do some small things that may be effective and to do some unusual and large-scale things that may also be effective. The U.S. Department of Transportation has to devote more resources to a quick and knowledgeable evaluation of the TSM plans. The department should also work with Congress and with other federal agencies to establish federal goals and objectives to alleviate some of the difficulties encountered by participants in transportation on the local level.

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IMPROVING SERVICE QUALITY AND EFFICIENCY THROUGH THE USE OF SERVICE STANDARDS

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This paper describes the service policy of the Massachusetts Bay Transportation Authority for surface public transportation and its use in urban transportation system management. The establishment and use of a comprehensive statement of service policy are discussed in the context of TSM objectives. Such a service policy, which contains service goals and objectives, service standards and guidelines, and planning and evaluation procedures, provides the transit manager with a management control framework for monitoring service performance and identifying remedial actions that will improve the quality of service and the efficiency and effectiveness of resource allocation. The paper describes how MBTA uses the control framework embodied in its service policy to identify both general service improvements and some specific TSM service improvements such as reserved bus lanes on arterial streets. The paper concludes by discussing how the MBTA service policy through cooperative planning has begun to make local city and town policy makers more sensitive to transit operations, thereby enhancing the prospects for successful implementation of potentially controversial TSM projects.

The 1976 Transportation System Management Plan for the Boston urbanized area contains the following element:

SERVICE POLICY FOR SURFACE PUBLIC TRANSPORTATION
PROJECT DESCRIPTION: The MBTA has adopted a comprehensive statement of Service Policy for its surface transit operations. The Service Policy provides a management control system for use in guiding the operation and improvement of surface transit services in the MBTA district. The Service Policy has five major components as follows:

1. Service Goals and Objectives—The establishment of generalized goals and specific objectives to guide the management and improvement of transit service.
2. Service Design Guidelines—The establishment of guidelines for use in the design of new surface services and the modification of existing services.
3. Service Performance Standards—The establishment of minimum performance standards in such areas as operating speed, schedule adherence, passenger loading, economic performance and labor productivity.
4. Service Warrants—The establishment of sufficient conditions for the discontinuance of a service and for relationships between the MBTA and private carriers.
5. Service Planning and Evaluation Procedures—The establishment of procedures for decentralization of planning and evaluation of surface services.

The MBTA is currently in the early stages of implementing the Service Policy. Some data collection and processing procedures have been implemented while others are under development. Additional staff resources have been added in the service planning and operations planning areas. Implementation of the service planning and evaluation procedures is near completion.

EVALUATION: The Service Policy will provide information which will be used to determine desired levels of service and the associated optimum allocation of resources. It will identify those services which are a drain on MBTA resources without sufficient offsetting benefits. It also establishes formal mechanisms for developing improvements in service performance and in service quality.

The Massachusetts Bay Transportation Authority (MBTA) service policy for surface public transportation was a logical element of the region's TSM plan. The purposes for which the service policy was established are consistent with the urban transportation system management objective to achieve maximum efficiency and productivity for the (regional transportation) system as a whole. The MBTA service policy uses its various standards, guidelines, and procedures to indicate needed improvements to transit service quality and efficiency.

MBTA SERVICE POLICY

The MBTA service policy for surface public transportation was adopted in January 1976. It pertains only to conventional surface transit including bus, trackless trolley, and surface streetcar operations. Eventually it will be integrated into a comprehensive public transportation service policy for the Boston region and cover rapid transit and commuter rail operations, specialized transport services for the transportation handicapped, and surface operations.

The MBTA service policy was developed to provide a statement of how MBTA intends to manage its surface transit service resources. It provides a uniform basis for evaluating the relative costs, benefits, and overall performance of individual services. It provides a responsive methodology for establishing new services and for developing improvements to existing services. As such, the service policy functions as MBTA's primary management tool for improving the quality and efficiency of its surface transit services and, hence, is a logical element of the region's TSM planning.

MANAGEMENT CONTROL

The transit operator's primary goal is to operate an effective and efficient network of public transportation services for the benefit of all area residents and visitors. The transit operator may have other concerns such as preserving the environment, fostering new jobs either directly or indirectly, minimizing the negative economic effects of the subsidies needed, and improving the overall quality of life in the urban area. Such concerns have heavy political overtones. However, they are secondary and, in fact, are dependent on the operation of an effective and efficient service network.

If the transit manager is to be successful in achieving this principal purpose, he or she must be able to control the resources available. He or she must be able to make decisions on which services should be operated and at what levels and be able to monitor and evaluate service performance to identify inefficient or ineffective resource use. To make these judgments, the transit manager needs a management control system that can measure performance and facilitate analyses of alternatives for improving service quality and efficiency. In short, the management control system must generate information that can be used in making decisions on how resources should be allocated.

The establishment of service standards and guidelines, with attendant procedures for data collection and processing, can help provide the transit manager with the information he or she needs. Service performance standards can provide yardsticks for measuring whether a particular service is an efficient and effective use of resources. Performance standards can also be used to provide quantitative measures of service quality. Service design guidelines can provide a blueprint for planning new services and identifying potential improvements to existing services. As such, service standards and guidelines form the cornerstone for a transit management control system.

Table 1 gives a management control framework for surface transit services based on the MBTA's service policy. Individual standards and guidelines are related to three generalized management objectives: improving service quality, improving service efficiency, and improving service effectiveness. Which standards and guidelines merely serve general management purposes are also indicated. This framework shows which standards and guidelines will generate information that can be used in undertaking specific service management tasks.

The remainder of this paper discusses how MBTA is using the management control framework embodied in its service policy to improve transit service in the Boston region.

IMPROVING SERVICE: MONITORING PERFORMANCE

Identifying Substandard Performance

Quarterly reports are prepared detailing the performance of each service during the subject period based on the operating and economic performance standards contained in the service policy. The completeness of these performance reports is heavily dependent on adequate data. We do not yet have all of the required data collection capabilities so that not all standards are being routinely used.

Table 2 gives some of the data on the operating performance report. Labor productivity, dependability, complaints, load factor, and schedule adherence information will eventually be added to this report.

The performance reports are prepared by the Data Processing Department with assistance and input from the Operations Planning Department. The Operations Planning Department reviews the reports and identifies standard services. For example, for operating speed, the quartile deviation is calculated, and those services having operating speeds below this value are flagged for analysis. Similarly, services having recovery time ratios exceeding the standard values are flagged for analysis.

It is important at this point to discuss further the use of quartile deviation in several of MBTA performance standards. The quartile deviation is one of many rudimentary statistical measures of divergence for a set of data. By flagging any service that is one quartile deviation less than the service average for a particular criterion (such as operating speed) means that over time one will always be reviewing the bottom 25 percent performers on that standard. If ways can be found of improving a service performance on a particular standard, then the long-run effect will be to raise the system average for that criterion, thus improving performance overall.

The concept of using measures of divergency to establish a dynamic performance standard is theoretically appealing. In practice, it may prove difficult to sustain, for there are physical limits to things such as operating speed. Further, constantly reviewing a large percentage of services may prove overly burdensome, given limitations on analytic staff resources. As we gain further experience in using this standard, we will be able to assess the need for adjustments such as reducing the percentage of services under review at any given time.

General Remedial Analysis

Remedial analysis is intended to develop recommendations for improving the performance of a substandard service in a particular area. The procedures used by MBTA in its remedial analysis are outlined below.

1. Substandard services that are identified in the performance evaluation are categorized as follows:

Number	Description
1	First time
2	Previously substandard, improving
3	Previously substandard, no improvement
4	Chronic

It should be anticipated that some services will always

be substandard for at least one criterion. In such cases, no feasible remedy for the substandard performance may exist. However, these chronic substandard services should be reviewed at least once annually for a possible change in conditions.

2. The four categories established are used to establish priorities for analysis and investigation in the development of a remedial improvement plan. The priorities are as follows:

Category	Priority
3	Top
1	Second
2	Third

For services in category 2, if the improvement has been more than an allowance for statistical error, then no further analysis or action need be taken pending further reviews.

3. Typical remedial analyses of substandard performance in recovery time, load factor, labor productivity, and schedule adherence include analyzing the service schedule to determine possible remedies, making additional traffic checks to verify running times, and asking the Transportation Department to observe the operation of the service.

4. Typical remedial analyses of substandard performance in speed include conducting field investigations and discussions with local traffic officials to determine what traffic measures, such as changes in signal phasing or reservation of traffic lanes, could be undertaken to improve speeds; analyzing the service schedule to determine possible remedies; and cataloging the service for possible future use in developing priority treatment projects.

5. Typical remedial analyses of substandard performance in dependability include undertaking an investigation to identify the extent of the equipment or dispatching problem and cataloging the service for possible future use in analyzing programming and budgeting decisions within the operating department.

6. Typical remedial analyses for substandard performance in complaints include undertaking an investigation to identify the source and validity of the complaints and determining the need for disciplinary action or other possible remedies.

7. Typical remedial analysis for substandard economic performance includes undertaking passenger counts and on-board (or platform) surveys to determine the number or characteristics of a service's customers and analyzing the service to determine whether the economic performance can be improved or whether the service should be discontinued.

The undertaking of the remedial analysis procedures outlined above is a time-consuming enterprise. It also requires adequate data collection and processing capabilities to generate accurate and complete information in timely fashion. A great deal of time and effort have been expended at MBTA between the Operations Planning Department and the Data Processing Department to establish proper data linkages, report timing, and formats. Performance reports for the first two quarters of 1976 flagged substandard speed and recovery time on several bus routes, which, in turn, precipitated scheduling actions that enhanced the quality and efficiency of those services.

Remedial Analysis for Economic Performance

If the transit manager is to realize the maximum improvement in service from the resources available, then he or she must be able to allocate resources to those services that are most effective in achieving service objectives. In other words, the transit manager must be able to allocate service resources so that the rate of return from these resources is maximized, measured in terms of the number and characteristics of people being served and in terms of the revenue being generated.

In the private sector, profit is a nearly perfect measure of effectiveness and efficiency in the allocation of resources. For publicly owned transit systems, profit is neither an appropriate nor meaningful measure. Hence, today's transit manager must find surrogate measures for evaluating effectiveness. The set of economic performance standards and their attendent remedial analysis procedures contained in the MBTA service policy provide one example of such surrogate measures.

Under the MBTA service policy, substandard economic performance is systematically identified for bus and trackless trolley services by using quarterly economic performance reports (Table 3). Revenue to direct cost ratios are determined for each service during the subject time period. (Direct cost encompasses only variable costs and does not include fixed or overhead costs. For a specific service, it is derived by using a cost allocation model. Revenue is derived from fare-box readings recorded by operators on special "day" cards.) Services are then ranked according to their revenue to direct cost ratio, from lowest to highest, within each rating station (division). Substandard services are then easily identified by using the appropriate revenue to direct cost standard for each type of service (e.g., regular route, express, school).

For each substandard service so identified, passenger counts are updated and a detailed customer profile is prepared through on-board passenger surveys. This information on customer characteristics and usage patterns is used in two ways.

First, it is used to determine whether the impacted economic standards should apply. The impacted economic standards are one-half the regular economic standard for a particular service type. They are applicable when the subject service is found to exhibit extraordinary social, environmental, or system-related characteristics based on a review of the customer profile. For example, a service that has a performance below the regular economic standard may serve predominantly transit-dependent or elderly persons or may function as a critical link in the overall transportation network. The impacted standard concept recognizes that such services have extra value to the transit system and to the region it serves.

Second, the market information is used to identify and analyze potential remedial actions for improving the economic performance of the subject service. Potential remedial actions include reducing service frequency, discontinuation of portions of the route, schedule adjustments, and special promotional efforts. The remedial analysis process for economically substandard services is undertaken cooperatively with the representatives from the cities and towns served by the subject service. They are informed that the subject service is substandard and are asked for ideas on how the economic performance can be improved. Before any remedial action is taken, the representatives are consulted; the final decision on what is done rests with the MBTA's Operations Planning Department.

IMPROVING SERVICE: COOPERATIVE PLANNING

One of the principles on which the MBTA service policy is based is community involvement. Planning and evaluation of service are conducted in a cooperative environment involving the representatives of the cities and towns within the MBTA district. City and town representatives are kept informed and are consulted during the monitoring of service performance both when substandard conditions are identified and when remedial actions are analyzed. They are also actively involved in the planning of new services and improvements to existing services. In fact, we encourage them to take the initiative in proposing ideas for new services and improvements to existing services.

Since the cities and towns within the MBTA subsidize transit service through property taxes, the service policy recognizes that decisions affecting local bus service should be considered in the same context as the costs and benefits of other municipal services that a city or town provides. Obviously, the MBTA should not independently make value judgments for a community on how to allocate its resources. However, MBTA reserves its management prerogative to make final determinations on the nature and characteristics of surface transit services. This prerogative is derived from its responsibility to manage resources so that both efficiency and effectiveness are maximized by the services provided. This responsibility transcends municipal boundaries requiring MBTA to view individual services in a system context when costs and benefits are evaluated.

The Service Planning Process

The planning process for new or improved services makes use of the Service Design Guidelines given in Table 1. It is a proposal-specific process wherein specific improvement proposals are formulated and run through a management control loop that has the following steps:

1. Initiation or Formulation of a Proposal. A specific service proposal can be initiated in three basic ways: (a) from service reviews in which a comprehensive review of service in a specific city or town is undertaken by using the service design guidelines and performance standards to evaluate the service a community receives; (b) suggestions or requests received from external sources such as a local business, town official, individual citizen, or MBTA employee; and (c) complaints received from external sources.
2. Screening. Proposals for service changes are screened for validity by the MBTA Service Committee, which consists of staff from the Operations Department and Marketing Department. A proposal is either sent on to the next step or is rejected for cause (i.e., it has been tried within the past 12 months or is patently impractical).
3. Investigation and Analysis. Proposals for service changes are investigated and analyzed by the appropriate department or office. During this stage, interaction and discussion occur with the city or town representatives involved and other community representatives. The output of this stage is a service feasibility report, which includes a description of the proposed service plan, economic and qualitative analyses, conclusions, and recommendations.
4. Review. Proposals for service changes and their attendent service feasibility reports are reviewed first by the Service Committee. The Service Committee either recommends the proposed change, rejects it, or requests further analysis and investigation. If the Service Committee recommends a proposed service change, then it is reviewed by the chief operations planning officer, who has the ultimate responsibility for making the decision on whether a service change should be implemented. The service proposals recommended by the Service Committee are cataloged and ranked according to their estimated marginal net cost per passenger as developed in the service feasibility report. In preparing for an upcoming systemwide timetable change, the chief operations planning officer will select proposals from this rank-order list until he has reached the limit of available service improvement resources or until he has reached a level for the marginal net cost per passenger that is too high given current budgetary policy or marketing strategy or both. He may also postpone or reject outright a particular service proposal if there are mitigating circumstances surrounding a particular proposal (e.g., competition with a private carrier service) or if its implementation would be inconsistent with current marketing strategy.
5. Operation and Evaluation. Once a proposal clears the study, review, and decision-making process, it is put into operation at the earliest practicable time. The service is operated for the minimum trial period of 120 days during which time its performance is monitored. During the trial period, a decision is made on whether the service should become a regular feature of the MBTA surface system. This decision is based on an evaluation of the service performance based on the established standards.

Results

The planning process is now fully implemented and functioning. The process has produced two service improvements. One involves an extension and increase in service frequency for a crosstown bus route. It resulted from comments received at a public forum that was held as part of a cooperative service review in the city of Newton. The other resulted from a request made by the city of Boston and involves the addition of Saturday service on another crosstown bus route. Six proposals are in the review stage; they have cleared the Service Committee and are awaiting a decision on implementation.

From our standpoint, the service policy has also produced a subtle yet significant ramification for TSM in the Boston urbanized area. Greater community involvement in service planning matters has forced elected and appointed policy-making officials from the cities and towns served by the MBTA to become more sensitive to what it takes to improve service quality and efficiency. Before the establishment of our service policy, MBTA staff had amicable working relations with traffic and planning officials from the more than 50 cities and towns that receive MBTA service directly. Our relations with policy-making officials in these same cities and towns were strained by ever increasing MBTA tax assessments on their communities and by periodic confrontations over service management actions the MBTA had taken or was about to take.

Local traffic and planning officials understandably have their own set of constituents and their own agenda of concerns, which are often not entirely compatible with the objectives of improving transit service quality and efficiency. Fostering greater sensitivity to transit operations needs among policy-making officials has had the obvious effect of making traffic and planning officials more responsive to our ideas on traffic operational changes and service improvements generated

Table 1. Management control framework for bus service.

Guidelines or Standard	Service Quality	Service Efficiency	Service Effectiveness	General Service Management
Service design guidelines				
Service classifications system				x
Spatial factors	x			
Directness of service	x	x		
Route layout	x	x		
Frequency of service	x	x		
Temporal factors				x
Passenger stops	x	x		
Passenger shelters	x			
Market potential			x	
Trial period				x
Operating performance standards				
Speed	x	x		
Recovery time		x		
Load factors	x			
Labor productivity		x		
Schedule adherence	x			
Service dependability	x			
Complaints	x			
Economic performance standards				
Economic			x	
Social			x	
Environmental			x	
System impact			x	

Table 2. Operating performance report data.

Route No.	Round-Trip Distance (km)	Route Type	Revenue/ Cost Ratio	Day	Time	Avg Speed (km/h) With Layover	Avg Speed (km/h) Without Layover	Avg Layover/ Run Time (min)	Avg Running Time (min)	Avg Allowed Time (min)	Round Trips
80	20.55	B	0.267	Weekday	4-7a	19.2	24.4	27.8	50.5	64.6	9.0
					7-9	16.7	21.4	28.5	57.8	74.2	13.5
					9-4p	17.0	21.4	26.2	57.6	72.7	28.5
					4-6	16.4	19.9	21.5	62.0	75.3	12.0
					6-2a	22.4	25.7	14.7	48.1	55.2	14.0
				Saturday	4-7a	20.4	28.1	37.5	44.0	60.5	6.0
					7-6p	18.9	23.4	23.4	53.0	65.4	38.0
					6-2a	22.9	26.7	16.9	46.2	54.0	11.0
				Sunday	—	21.9	26.7	22.3	46.3	56.6	33.0
87	13.85	B	0.401	Weekday	4-7a	18.0	22.4	24.7	37.2	46.3	6.0
					7-9	18.0	20.5	13.4	40.6	46.0	7.0
					9-4p	16.2	21.4	32.2	39.0	51.1	27.0
					6-2a	17.0	22.5	33.4	36.8	49.1	13.5
				Saturday	4-7a	20.2	24.2	19.3	34.5	41.2	6.0
					7-6p	16.4	18.5	13.8	44.8	51.0	43.0
					6-2a	19.5	22.4	14.7	37.2	42.6	13.0
				Sunday	—	19.0	22.0	15.4	37.9	43.7	34.0

Note: 1 km = 0.6 mile.

Table 3. Economic performance report data.

Route No.	Item	Amount	Route No.	Item	Amount
28	Revenue, $	7000	24	Revenue, $	14 604
	Direct cost, $	23 956		Direct cost, $	48 962
	Revenue per direct cost, $	0.292		Revenue per direct cost, $	0.298
	Net cost, $	16 956		Net cost, $	34 358
	Schedule kilometers	14 273		Schedule kilometers	31 598
	Revenue per kilometer, $	0.49		Revenue per kilometer, $	0.46
	Cost per kilometer, $	1.68		Cost per kilometer, $	1.55

Note: 1 km = 0.6 mile.

during the remedial analysis process.

Hence, we now have an ever-improving climate of cooperation and understanding between ourselves and both the political and technical officials in the communities we serve. This climate is essential to successful TSM planning and project implementation. We feel that our service policy has helped establish this climate by providing a statement of goals, objectives, and criteria that local policy-making officials can relate to.

SUMMARY

The management control and service improvement process embodied in the MBTA service policy has worked well. It has fostered close working relations with cities and towns. Using the service design guidelines and service performance standards, we have begun to make service improvements not only in expanded bus service but also in operating speeds and other efficiency determinants. We have also been able to discontinue 10 separate bus services whose economic performance was substandard and had no chance of improvement. The MBTA had for years attempted to rid itself of many of these ineffective services but had been unable to because of political and community pressure.

There are difficulties of a technical nature with some of the service performance standards. Experience has shown that we need to make some adjustments to eliminate minor inconsistencies and inaccuracies.

Reliable and ongoing data collection and processing procedures and resources are mandatory for the effective use of service standards and guidelines. Progress has been slow and, in many cases, nonexistent where such procedures and resources have been lacking.

Local policy makers are key participants in TSM projects or programs. We could never expect to implement a reserved bus lane on an arterial street if the mayor of the involved community was not willing to withstand the complaints of the merchants who would lose their on-street parking. The MBTA service policy has helped us to establish an improved dialog with local policy makers on operational matters.

DIAL-A-RIDE AS AN ELEMENT IN TRANSPORTATION SYSTEM MANAGEMENT

Thomas Hackley and Karl W. Guenther
Ann Arbor Transportation Authority

The Ann Arbor Transportation Authority has been practicing transportation system management since 1973. The most important program element is the incremental implementation of demand-responsive services that operate in close coordination with the line bus system. Ridership has tripled during the past 3 years. Management of such a system is difficult. Political leaders are not easily satisifed; some want a high-efficiency, high-capacity line bus system; others want a small, stable, unchanging system. Neither side can always accept that constant incremental change is the proper way to achieve the desired end state. The Ann Arbor Transportation Authority must also work with other transportation agencies to ensure coordination and within its own staff to maintain the momentum that has been responsible for its success. This paper describes the Ann Arbor Transportation System and the planning philosophy behind that system as it relates to TSM.

Transportation systems management has been defined as a means of getting the most out of the existing transportation system. In the urbanized area served by the Ann Arbor Transportation Authority, TSM includes the usual traffic operation improvements in the street network plus a coordinated transit and paratransit (dial-a-ride) emphasis in the public bus system. The objective of the Ann Arbor public transit system is to incrementally increase the use of public transit and other high-occupancy vehicles. While dial-a-ride service is a possible supplemental project in some large urban systems, it is the transit system in Ann Arbor.

Ann Arbor has had a dial-a-ride system operating since 1971. Since passage of a special property tax for transit in 1973, dial-a-ride has expanded its role and ridership so that it is now totally integrated with line bus service within the Ann Arbor Transportation Authority operation. Weekday service provides for coordinated transfers between dial-a-ride collector-distributor vehicles and line buses at several points within the system.

Dial-a-ride as a marketing element in Ann Arbor's program has helped the authority secure a dramatic increase in ridership during the past 2 years. Staged incremental implementation of small areas has allowed the introduction of dial-a-ride with a relatively high degree of reliability and minimum disruption. As a planning element, it has opened up a much broader range of service options, which are being applied selectively with changing demand patterns in the city.

Paratransit represents a range of service options, from adding a vehicle to the service with no visible changes to shifting to a different mode of operation. Thus, paratransit, if correctly applied, is TSM without an end point and without need for project definition beforehand. All of our transit improvements thus fit the TSM category. Paratransit is demand responsive in two senses: in the commonly accepted definition of a service mode that has a dynamically routed vehicle and also in a broader definition of a system that itself is dynamically planned to allow changes in service mode based on evolving demand patterns. By continually modifying our system to meet new demands, we are continually practicing TSM.

TSM also emphasizes efficiency in management and intermodal cooperation at a local level. As practiced by Ann Arbor Transportation Authority, this means keeping the professional staff alert to and responsive to new ridership opportunities and higher efficiencies. Externally, the authority must cope with a wide spectrum of local political opinion, must balance the public expectations for dramatic new services with demands for reduced public expenditures, and must work cooperatively with other public agencies to implement TSM projects. These activities and some of the underlying philosophy leading to these activities are described below.

BACKGROUND

The Ann Arbor Transportation Authority was formed as a public authority in 1968, when private carriers became unable to provide the community with acceptable transit service. Its service area includes the city of Ann Arbor, the urbanized area of Washtenaw County, including Ypsilanti, and the rural areas 16 km (10 miles) beyond the Ann Arbor city limits in all directions.

The transit service that operated from 1969 through 1973 consisted of 6 fixed routes, radial to the Ann Arbor central business district, operating on 30-min peak and 60-min off-peak headways. Coverage was limited to the city of Ann Arbor, and weekday-only service operated from 6:30 a.m. to 6:15 p.m. Annual operating budgets during those years were typically $400 000 to $500 000; half of the budget was derived from fares and half from the city's general fund on an annual appropriation basis.

In September 1971, a small dial-a-ride pilot project was undertaken with state of Michigan and local funds to demonstrate the applicability of demand-responsive service in Ann Arbor. The program was successful in increasing transit use and diverting some travelers from private automobiles to transit. The demonstration program cost of $1.74/ride (exclusive of capital) highlighted the fact that a much expanded funding source would be required to undertake additions to the dial-a-ride system.

In April 1973, Ann Arbor voters (city only) approved by a margin of 61 percent a 2.5-mill property tax earmarked for public transit. The tax raises approximately

$1.6 million annually, which is used for the local operating budget. Citizens were extremely active in the millage campaign; no professional public relations firm was used.

The system described to the citizens in the 1973 election campaign consisted of dial-a-ride in neighborhood zones, coordinated with fixed-route service on major arterials. That basic plan has been followed in implementing the present system.

Since 1973, the Ann Arbor Transportation Authority has hired a new management team, expanded from 30 employees to more than 200 employees, added 80 new vehicles to the existing fleet of 20, and embarked on a substantial facility construction program. Ridership has grown from 677 000 in the fiscal year 1972-73 (just before the election) to 1 814 000 in fiscal year 1975-76. Throughout this growth period, the transit system continues to operate within the budget.

DESCRIPTION OF PRESENT SERVICE

The basic format of the Ann Arbor system is a coordinated combination of dial-a-ride and line bus service. The weekday operating system can best be described as having a large circular or "main gear" line route and "satellite gear" dial-a-ride operations restricted to specific zones and coordinated with the line route schedule. Dial-a-ride buses meet every line bus arrival at every transfer point.

Dial-a-ride zones are operated with one, two, or three vehicles on a fixed-schedule tour dictated by the connection with the line bus at a transfer point. Seven such weekday dial-a-ride zones feed this loop route. The loop buses operate in both directions at 15-min peak and 30-min off-peak headways. Central business district routing serves the retail sectors, University of Michigan main campus, and the hospital area.

The weekday system also includes radial routes in Ann Arbor, each slightly different in nature. All operate at 15-min peak headways and 30-min off-peak headways. All serve the CBD activities mentioned above. All fixed-route vehicles travel a common route through the CBD and exit on a paired route from the opposite end.

On the radial routes, some dial-a-ride zones actually feed two transfer points. There are nine outlying zones, whose boundaries and connectivity patterns are based on local trip generators (schools, shopping centers) and geographic constraints.

For neighborhoods close to the CBD, there is dial-a-ride service directly to the major generators in the Ann Arbor CBD, including retail trade, the University of Michigan main campus, and the large medical complex. These same generators are served by the downtown routing of all lines. There are four such close-in zones. Thus, the total number of weekday dial-a-ride zones is 13: 7 on the loop route, 2 on radials, and 4 close in.

The resulting weekday system provides doorstep pickup by dial-a-ride, connections to line buses serving all parts of the community and major generators, and doorstep delivery in neighborhood areas if transfers are made off the line bus at a transfer point. It is thus possible on this system to reach any point inside the city limits.

On weekday evenings, most line route operations cease after 6:15 p.m. The city is then covered by citywide dial-a-ride operations on seven radial zones, all converging on the CBD. Crosstown trips are served by a single transfer at the CBD. Tours are 1 h with two or more vehicles per zone, with effective mean headways of 30 min in each zone and doorstep pickup and delivery. Calls are accepted until 11 p.m. The last trips are dispatched at midnight.

Weekend service is also provided by citywide dial-a-ride operations similar to those on weeknights, except that Saturday line bus service connects the CBD with two major shopping centers on the edge of town. Hours are 8 a.m. to 11 p.m.

The Ann Arbor system also includes specialized service to handicapped persons in vans equipped with wheelchair lifts. These are dispatched as citywide, many-to-many dial-a-ride vehicles.

TRANSPORTATION SYSTEM MANAGEMENT AND INCREMENTAL IMPLEMENTATION

The past emphasis on long-term (15 to 20-year) planning has been helpful in giving information and cost estimates to decision makers, but has been of little help in responding to short-term (2 to 5-year) changes in demand on the system and has even had some negative results. For example, in transit planning, technology and high-capacity systems have received much emphasis, but they often make the improving of existing systems appear undramatic. TSM is now emphasizing these changes in transportation systems. Ann Arbor was an ideal place to launch an incremental program in 1972-73. Significant public opposition to new street thoroughfares had solidified. The Ann Arbor Transportation Authority had formed a far-reaching, ambitious statement of goals that called for a public transit system capable of competing with the private automobile in cost and convenience. And dial-a-ride had, through a small demonstration in one part of the city, captured the imagination of many.

After the 1973 millage vote, Ann Arbor Transportation Authority's implementation of services was deliberately slow. The implementation plan might best be described as programming to meet objectives rather than implementation in the sense of a single major capital project. Each new dial-a-ride zone has been phased in according to a plan originally adopted in 1973. Although the coverage has only been slightly modified, the dates have been continually pushed back to allow for adjustment based on experience so that the full plan described at the time of the April 1973 millage election was not in place until almost 3 years later.

The point of such painstakingly slow implementation is the ability to adjust, correct, and modify each area before proceeding to the next. New staff can only be hired and trained at the rate of three to four persons per week. Equipment deliveries (vehicles, radios, and telephones) have often governed implementation dates, particularly long delays between March 1974 and January 1975. Even at this slow rate, there is criticism from within the organization that we are often not "polished" enough before proceeding to a new area. The operating staff and the union are usually interested in delaying each implementation step as long as possible in the interest of quality control.

Disadvantages of staged implementation include inequitable service delivery (all citizens pay taxes from the outset but do not receive service at the same time) and loss of enthusiasm and momentum. However, we believe that the benefits of staged incremental implementation outweigh the costs. Certainly Ann Arbor services, while not perfect, are operating at a better level of quality than some of the more dramatic "all-at-once" implementations.

INTERNAL MANAGEMENT AND POLITICAL RELATIONS

Technically, incremental changes with a dial-a-ride

system are not difficult to implement. The major problems experienced by the Ann Arbor Transportation Authority have had much more to do with the management of politics and personnel than with the management of the transportation system itself.

The goal of personnel management has been to establish and maintain within the organization a creative and an innovative atmosphere in order to continually change, adjust, and add to our basic services. Management is aware that, if the system stops changing at the end point previously described, then capacity constraints will cause ridership growth to stagnate and policy goals will not be met. Dial-a-ride must, in this case, be viewed as a marketing tool used to encourage patronage sufficient to justify the addition of incrementally higher capacity components of the system.

With the growth of the organization, however, has come bureaucratization and growing resistance to change internally. This resistance is increasing as the original dial-a-ride plan nears full implementation and is especially evident with attempts to initiate small service changes even though they may lead to more significant changes in the long run.

A recent example is the initiation of a daily chartered service for employees of a company that relocated just beyond the Ann Arbor city limits in a corridor that is experiencing great urbanization pressures. Regular fixed-route service was programmed to begin in 3 years in that area, and work subscription service is a paratransit option that is also programmed for the near future. The opportunity was thus taken by the Ann Arbor Transportation Authority management to explore both services with this relatively minor (8 to 10 passengers/day) operation. An added benefit was that the employer covered the marginal operating costs. The operation staff, however, was reluctant to undertake what it saw as a tangential, dead-end project, and much of the planning time was spent convincing operation staff that the project had some value.

The point of this story is that the nature of the organization must parallel the nature of the transit system. In the case of the Ann Arbor Transportation Authority, the desired nature of the transit system is one that will nurture and develop higher and higher demand and then dynamically respond with higher and higher capacity modes. If the organization becomes complacent, the system will stop growing. Ann Arbor Transportation Authority management is, therefore, constantly working to maintain a steady state of change within the organization.

An important part of TSM is a focus on intermodal cooperation at the local level. In the case of the Ann Arbor Transportation Authority, this is accomplished through the local transportation planning agency, the Ann Arbor-Ypsilanti Urban Area Transportation Committee (UATC). This agency is essentially a small metropolitan planning organization, in which representatives of two cities, eight townships, the Ann Arbor Transportation Authority, the county road commission, and the county planning department meet to formulate local transportation plans. In the recently approved 1990 plan for the area, transit is given a major role.

Evidence of local intermodal cooperation is the participation of the Ann Arbor Department of Streets, Traffic, and Parking (STP) in the authority's traffic-signal priority system (STP is installing all on-street equipment and is responsible for setting signal phases) and the new downtown "transit spine" (STP is handling all parking meter removal, signs, and painting). Each of these projects is listed by both the city of Ann Arbor and the Ann Arbor Transportation authority as a current TSM activity. The cooperation is possible only as long as both parties take care to see that traditional roles are preserved, credit is awarded fairly, and no serious disbenefits to either result from implementation.

Two related problems of public opinion have become evident in this community: Having had policies clearly established that heavily emphasize public transit, the public tends to be impatient. The 1990 plan suggests a high-capacity facility, and the people clearly want the benefits to be derived from it. Yet, the system operating today does not seem close to having the capacity or efficiency to achieve the goals, and the ridership growth, although dramatic in relation to previous transit ridership, still has not made the modal-split gains desired. Conservatives see small buses as inefficient and wasteful; liberals want a highly visible, high-capacity system; and neither fully accepts that we must speak in terms of communitywide behavioral change, a slow process, to achieve both efficiency and societal benefit.

The second problem is that many feel that continual change, even though it may be in the right direction, means that the system is never really definable and never really becomes stable. People want change but prefer to experience change from one stable system to another stable system, which then becomes a part of a predictable world. Thus, despite statistical evidence to the contrary, there are those in this politically aware community who feel that the system has failed because it continues to change. From the standpoint of management, maintaining the ability to change is a mark of success since the goal is ever-increasing demand that creates a need for higher capacity transit system elements.

PROCEEDING INTO THE FUTURE

Dial-a-ride service has a definite ongoing role in the program of the Ann Arbor Transportation Authority. Our 1990 plan, completed in 1976, calls for an extension of the coordinated dial-a-ride and line bus concept to all parts of the urbanized area. This, of course, will require additional sources of local funding, either similar to the city of Ann Arbor property tax or perhaps a regionwide replacement of that tax. There is a feeling among those responsible for formulating the 1990 plan, including elected officials, that the doorstep service provided by dial-a-ride is an important part of an increasing emphasis on public transit (and away from private vehicles). There is also a role envisioned for dial-a-ride in providing rural transportation to mobility-deprived persons in the Ann Arbor Transportation Authority's service area. We also intend to add other paratransit programs such as van pooling and "transportation brokering" for specialized transportation needs.

In the matter of relative emphasis, Ann Arbor follows the thesis that, with increased demand density, new fixed-route services are justified and the relative importance of dial-a-ride, in terms of number of riders and number of dollars allocated, decreases compared with line service. There are now plans for adding fixed-route service in established dial-a-ride areas and to add five major regional fixed routes during the next 5 years.

The difficulty in making such a shift in emphasis toward fixed-route operation is primarily one of timing for implementation of a particular route. There is no clear signal for the addition of either fixed-route service in a dial-a-ride area or new service in an urbanized corridor. The first small increment in serving an urbanizing corridor was discussed in the preceding section of this paper. Similarly, the analysis that led to institution of a "flyer" service suggested the need for a small incremental change. That analysis showed a short-term peak of demand density high enough (in theory) to justify a fixed-route addition to the southwest

area. The options were to add more capacity to the area with an additional dial-a-ride vehicle in the peak hour or to add a fixed route with higher incremental capacity but also with the risk of not being able to attract the passengers to fill that capacity. A single fixed run fitted to the demand patterns (established through dispatching records) was added in the morning peak. This decision was shown to be justified by a resultant voluntary diversion of approximately 25 passengers, allowing a reduction in dial-a-ride service hours in the area with no reduction in service quality. Dial-a-ride demand is being watched closely in the southwest area to determine appropriate timing for expansion of the fixed-route service.

PROBLEMS OF PACKAGING TSM ACTIVITIES: DIFFERING OBJECTIVES, CONFLICTS BETWEEN ACTIVITIES, AND INSTITUTIONAL PROBLEMS

Roberta Remak
Remak/Rosenbloom

This paper addresses the problems of selecting effective combinations of TSM activities in light of the broad and sometimes conflicting transportation goals to be achieved and considers some of the institutional implications of programs calling for the cooperation and approval of several public agencies and private organizations. Various federal and state programs and special local concerns represent a number of different social, environmental, and energy-conservation objectives that can be affected by a TSM program. No TSM activity can meet all of these objectives equally well, and local planners must evaluate the proposed program in terms of first one objective and then another to select the combination of activities that offers the best compromise. Both the feasibility and impact of individual TSM activities can be radically changed by being implemented at the same time. Some function more effectively in combination, and others work against each other. The TSM program must be evaluated as a whole to ensure that necessary supportive activities are included and that incompatible combinations are avoided. It is necessary to establish an institutional framework for incorporating all of the concerned agencies and organizations into the TSM planning process and to coordinate the action programs of participating public and private institutions.

In a study of peak-period traffic congestion performed under the National Cooperative Highway Research Program, a number of techniques were identified that could be effective in reducing peak-period congestion, particularly those representing alternatives to capital-intensive solutions such as new rail rapid transit facilities or expansion of urban freeway systems. Techniques operating on both the supply and demand aspects of the congestion problem were included: those that increased the carrying capacity of the existing road system and those that reduced the number of vehicles on that system at peak commuting times. These ranged from technical approaches to improve transit operations and traffic control; social approaches to modify commuting times by staggered and flexible work hours; socioeconomic approaches of road pricing, parking controls, restricting vehicle access, car pooling, and modifying land use patterns; to a sociotechnical approach of substituting communications for travel to work.

During the course of the study, it became apparent that none of the 17 individual techniques had the potential for solving the peak-period congestion problem or for making more than a modest improvement to traffic flow. But it was found that their effectiveness could be improved, substantially in some cases, by implementing them in combination with one another. In fact, some techniques proved to be useless unless accompanied by another. As an example, peripheral parking lots will not attract many users unless some transit shuttle and CBD circulation service is provided.

Out of this recognition of the interdependence of congestion-reducing techniques developed the concept of "packaging" groups of compatible techniques to be implemented within a coordinated program. Although the objectives of the transportation system management (TSM) program are broader than reducing peak-period traffic congestion, many of the optional TSM activities and the congestion-reducing techniques are identical and both types of programs present similar problems of carrying out joint efforts involving a number of different agencies and organizations.

Our current research is focused on the institutional problems of implementing these packages. The project is still in its beginning phase, but we have identified some common types of institutional barriers and have developed some tentative approaches to dealing with them. This paper primarily addresses the problem of selecting effective combinations of TSM activities in light of the broad and sometimes conflicting goals to be achieved, but it concludes with a consideration of some of the institutional implications of programs involving several agencies and organizations.

DIFFERING GOALS

Only within recent years have we come to recognize not only that the several components of an urban transportation system—roads, transit, parking, bikeways, and pedestrian facilities—are interdependent but that transportation resources themselves affect and are affected by local economic and social conditions, land use patterns, physical environment, and national energy resources. Increasing responsibility has been placed on those who provide local transportation facilities and services to consider not only the internal efficiency of their particular operation but its impact on the rest of the transportation system and the community at large.

Various federal and state programs as well as special local concerns represent a number of differing goals to be achieved through improvements to urban transportation. These goals are not always compatible. A goal of mobility for those without access to private automobiles because of age, health, or financial circumstances may be in conflict with a goal of minimizing needs for public subsidy of transit services. Measures that improve traffic flow may encourage people to drive their automobiles to work and thus increase fuel consumption. Localized air pollution problems may be relieved by an automobile-restricted zone but add to traffic congestion on adjacent streets.

No TSM activity or combination of activities can meet all goals equally well. The task facing local designers

of TSM programs is to evaluate proposed actions in terms first of one goal and then another and to select those activities that offer the best compromise among the several goals.

Those responsible for the TSM element of a transportation plan will not necessarily find the concerns of all federal and state agencies and local special-interest groups of equal importance to the particular urban area. The degree to which the several goals are held to be critical will be determined by local conditions. A large city with serious problems of air pollution and traffic congestion will assign a high value to TSM techniques that offer benefits in these areas. A smaller city may give preference to activities that will promote mobility for its citizens that have no automobiles.

Most urban areas will have available to them a regional long-range transportation plan in which regional goals and objectives have been defined. The task of the transportation planning body is to examine these policy statements in light of current local needs and adopt one of two courses of action: (a) accept the goals and objectives as stated and use them to establish the TSM hierarchy of objectives for evaluating proposed activities or (b) propose a new set of regional goals and objectives that better reflect the present needs of the community and the objectives of recent federal and state programs.

TSM activities must be compatible with the long-range transportation plan. For example, if there is a current need for additional downtown parking but the long-range plan calls for restricting private vehicles in the CBD, then any public parking facilities called for in the TSM program should be located outside of the area that will later be restricted, and, if necessary, public transit into and around the CBD should be provided. This TSM action will help to establish travel patterns compatible with the future restricted area. Locating the parking facilities inside the proposed restricted area not only will reinforce habits of driving into the area but also will provide one more economic disincentive to implementing the restrictions.

Although it is possible under the existing UMTA and FHWA joint regulations to draw up a local TSM program independent of the regional, long-range transportation plan and the requirements of other federal and state programs, it is wiser for the community to reconcile its TSM program to these other elements. In the long run the community will be responsible for its performance in each of these areas, and any future conflicts that can be eliminated at this stage will make that task easier.

CONFLICTS BETWEEN TSM ACTIVITIES

Transportation system management as a designated joint UMTA-FHWA program is recent, but many local transportation agencies have long been carrying out such short-term, low-budget improvements as a normal part of their operations. These agencies will have a number of TSM activities to propose. Other TSM actions will be suggested by the list offered by UMTA and FHWA as possible options for local consideration. Still others may be generated by the area's own special-interest groups or unique situation.

The TSM coordinating body or metropolitan planning organization (MPO) will then be called on to evaluate the various proposals with regard to budget constraints and availability of funding assistance, technical and political feasibility, and potential benefits with regard to overall program objectives. Those that meet these criteria are candidates for inclusion in a final program.

Why not simply take all of these practical and desirable actions and say, "Here is our TSM program"? The answer is that both the feasibility and impacts of these individual actions can be radically changed by implementing them in combination with one another.

Some activities, such as feeder systems and long-haul transit, may function more effectively when combined or one may help to reduce the undesirable social and economic side effects of another, such as a transit circulation system in an automobile-restricted shopping area in the CBD.

Certain activities, however, can work against each other. A new demand-responsive feeder service and a car-pooling program directed to the same small residential area can dilute the demand for either mode and leave both without sufficient riders to be successful. A staggered work-hour program may leave express buses underused at one interval but with insufficient time to complete that run and return in time for the next interval.

There may be conflicts in timing the implementation of related actions. Eliminating on-street parking in the CBD can be carried out in a few weeks, but it may be 2 years before the city can acquire the land and complete the construction of peripheral parking facilities or receive delivery of transit vehicles for CBD circulation and access. It may also take several months for the police department to recruit and train the additional personnel necessary to enforce the new parking restrictions.

The compatibility of TSM actions will vary according to the problem setting: size of city, adequacy of existing road systems and transit services, modal split, type and location of employment relative to residences, distribution of population by income and age, access of the population to private transportation, and focus of the actions (CBD, outlying areas, connecting freeway system). Peripheral parking lots with transit service to the CBD may be a good solution for a localized downtown congestion and air pollution problem, but not the most effective means of reducing areawide congestion, pollution, and fuel consumption on the freeway system. Combinations of transit improvements and parking restrictions work well where employment tends to be concentrated, but ride-sharing and parking incentives for car pools may be more effective where major centers of employment are removed from each other.

Unfortunately, there is no formula of optimum transportation improvements to meet different needs. Existing data for this purpose are neither very much nor very good. No universally applicable system of analysis and selection is yet available for local TSM planners, and they must rely largely on their professional experience and knowledge of their communities. Some general rules, however, can be suggested:

1. Activities that improve the carrying capacity of existing roads—left-turn lanes, synchronized traffic signals, elimination of on-street parking—encourage the use of private automobiles and attract new users to the improved route. In smaller cities where the existing road system is nearly adequate to accommodate the limited number of work trips that its economy generates, reasonably long-lasting benefits can be derived from the application of these techniques. In large cities, however, where great numbers of commuters are critically overtaxing existing roads, benefits of increasing the capacity of a particular route can be short-lived. The more drivers whose destinations can be reached by this route and the more severe the congestion on alternative routes, the greater will be the attraction of the improved route and the more quickly it can become saturated again.
2. Packages of TSM activities that work toward reducing demand for transportation resources, either at

peak commuting times or generally, appear to have longer lasting and broader benefits than those that work toward increasing the capacity of the transportation system. Reducing the number of vehicles by increasing occupancy, lessening trip length, changing travel times and routes and eliminating some needs to travel serve the combined objectives of reducing air pollution, automotive fuel consumption and traffic congestion, and may also provide for greater mobility for those without access to cars.

3. Packages of TSM activities that attempt to increase vehicle occupancy must be directed toward areas, routes, and times for which there is a sufficient demand to provide the necessary level of ridership. When these activities are combined with others (changing work hours, dispersing employment, or substituting communications for trips to work) that work toward diluting travel demand, the feasibility of the original package should be reexamined to determine whether an adequate market for them would still exist.

4. Where mobility for private automobiles is to be reduced by parking restraints, road pricing, or restricting entry to certain areas or reserved lanes, sufficient alternative modes of transportation must be immediately available. Packages of TSM activities using such penalties and restrictions must include other actions to improve public transit, bikeways, and pedestrian facilities as necessary to ensure that the former activities do not result in serious economic hardships for those who currently depend on their own automobiles.

INSTITUTIONAL PROBLEMS

Inasmuch as our recognition of the interdependence of the various components of urban transportation systems is relatively new, the authority over existing facilities and services is still dispersed among a number of agencies and organizations that function independently of one another. Transit services are commonly operated by a special transit authority, on-street parking regulations are enforced by the city police department, bridge tolls are usually under the control of a state highway department, and van-pool and car-pool programs may be operated by large private companies.

TSM programs characteristically call for a broad range of improvements throughout the entire transportation system. Although the degree of separation of authority varies from one urban area to another and although many parts of the country have made significant moves toward consolidating certain transportation functions within one agency, it would be the exceptional TSM program that could be implemented entirely by a single existing authority. Rather, the participation of a number of agencies at all levels of government and perhaps some private organizations will be necessary to carry out and support the various activities called for in a TSM program. In addition the program will attract the attention of other public and private institutions concerned with the impacts of proposed changes to the transportation system.

The broader the TSM program is, the greater the number of institutions will be that may become involved. Each additional agency or organization increases the difficulties of coordinating their activities and the potential for conflicts of interest.

Institutional Roles

Institutions become involved in TSM programs in different capacities that can be categorized into three general types of institutional roles.

1. Agencies and organizations will be called on to carry out the designated transportation improvements, such as operating supplementary transit services, enforcing parking and reserved-lane restrictions, or managing ride-sharing programs. Their roles are determined by the specific kinds of activities selected for the TSM program and, for the most part, must be continued over time.

2. Some institutions function primarily in the initial planning and implementation phases to coordinate and select combinations of TSM activities, evaluate and approve proposed programs, provide funds, modify restrictive legislation, or provide the public with information on forthcoming changes in local transportation facilities and services. Their roles are derived largely from the TSM process and the kinds of transportation resources affected rather than from the specific program activities.

3. Many institutions take no active part in carrying out the program, but represent the interests of special groups whose concerns or well-being may be affected by the program. These include welfare-oriented agencies, downtown merchant associations, senior citizen groups, taxpayer associations, and environmental groups. The involvement of such institutions in supporting or opposing the TSM program will be determined by the specific changes proposed: restricting the use of automobiles in parts of the CBD, modifying transit services and fare structures, or establishing bikeways. However, the number and kind of institutions participating in this role also appear to be a function of the political and social characteristics of the particular community.

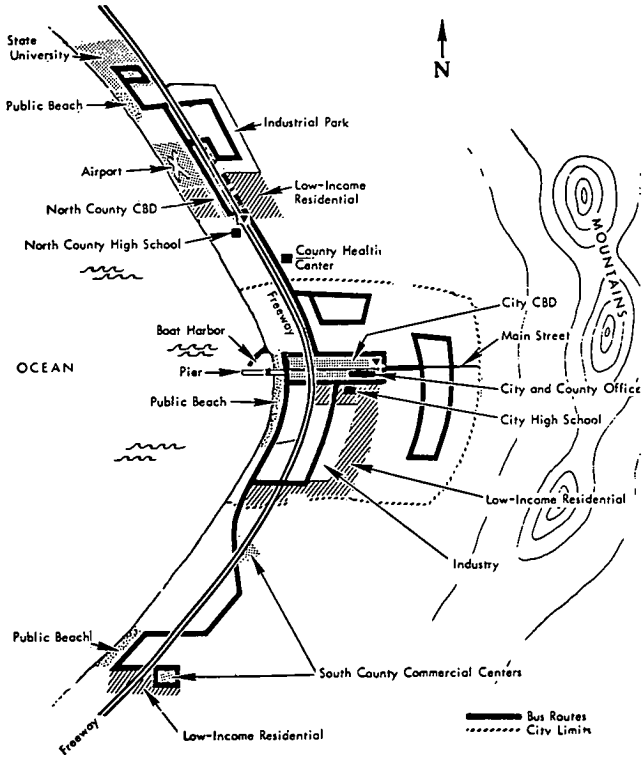
An institution's involvement with the program is not necessarily confined to one of these roles. In fact, it is highly desirable that the agencies or organizations that will in the end perform the activities called for in the program be involved in the planning process. Moreover, it has been observed that any cooperative undertaking that actually succeeds in being carried out can invariably be traced to the strong leadership of an individual representing one of the participating institutions. This institution, then, takes on the responsibility for many of the key functions. It coordinates planning, seeks funding assistance, lobbies for essential changes in existing laws and regulations, and, most important, persuades other public agencies and private organizations to participate in or give their approval to the program.

The participation or approval of the institutions is essential to the successful implementation of the TSM program. However, a variety of practical and attitudinal problems, such as lack of sufficient funds and personnel, legal and regulatory restrictions, or vested interests, may stand in the way of obtaining this support. Some of these problems will be generated by the particular circumstances of a given urban area—its existing transportation resources, environmental problems, and political structure and personalities. Other institutional problems, however, appear to be inherent in the TSM process regardless of the particular setting.

Example of TSM Planning

As a preliminary step to identifying common problems and perhaps some strategies which might be useful in dealing with them, let us look at an example of TSM development in a small city. The planning area and its existing transportation resources, institutional framework, and TSM program presented here are largely

Figure 1. TSM planning area.



drawn from an actual location, but some modifications have been made to simplify and focus the discussion.

Transportation Environment

This urban area of 200 000 population is located on a narrow shelf of land between a mountain range and the ocean. Figure 1 shows the strip configuration of the city and its suburbs. Shown also is the freeway that accommodates its heavy north-south travel but separates the CBD from the waterfront where most of its tourist and recreation facilities are located. In the unincorporated area to the north are a major industrial area and a university campus surrounded by moderate- to low-income residential development. There is another industrial area adjacent to the CBD and another concentration of low-income housing.

The area is strongly automobile oriented; shopping, many community facilities, and residential developments are dispersed. A sizable number in the population, however, have no automobiles. In addition, many of the university students and elderly who have retired in this community also do not have automobiles. A transit district provides fixed-route bus service, although routes are limited and frequency in the outlying areas is low. Like so many other areas, new shopping centers and housing developments beyond the city limits have drawn activity from the CBD, and an urban renewal program is under way to counter this trend.

Institution Structure

The five county supervisors and the mayors of the five incorporated areas in the county have for a number of years formed a regional planning council. In addition to its responsibilities for land use and development planning and federal clearinghouse function, this body has recently been designated as the regional transportation planning agency.

To assist in its transportation activities, the council created a transportation advisory committee, whose 18 voting members are the county and city planning and public works directors, directors of the transit and airport districts, and two regional representatives of the state transportation department. Ex officio members include the U.S. district engineer, the statewide coordinator of transportation planning, and a transportation planning engineer employed directly by the council to supervise the work of the committee's planning staff.

In addition, 216 private concerns, citizens groups, and social service agencies have the opportunity to review and comment on proposed transportation programs. In all, the TSM development process in this small urban area involves 242 public and private institutions.

Transportation Plans

A regional transportation plan has recently been completed that calls for the balanced long-range development of public transit, roads, and bikeways as well as for the development of airport and harbor facilities. Within the context of this plan a TSM program was subsequently drawn up. Not all of the options suggested by the UMTA and FHWA were included, since some were found to be inappropriate to the size of the city and its current needs. Nonetheless, the plan contained 25 potential transportation improvements that call for the active participation of 53 public agencies and 37 nongovernment institutions.

Table 1 gives the activities and indicates the institutions primarily responsible for their implementation. Thirty-nine of the agencies and all but two of the private entities will be involved only in the staggered work hour and car-pooling programs, and major contributions must be made by the transit district to 13 TSM elements, the city's public works department to 8 TSM elements, and the county's road department and the city's parking district to 4 elements each. The chamber of commerce and the citizen planning association, although nongovernment entities, will perform important roles in marketing transit and organizing car pooling.

In addition, implementation of several program elements calls for technical and funding assistance from UMTA, FHWA, HUD, and the Bureau of Outdoor Recreation (BOR) at the federal level and from the departments of transportation and natural resources (state beaches division) at the state level. Activities will also have to meet the approval of federal and state agencies concerned with air quality, energy conservation, and welfare and of the many diverse special-interest groups if the program is to avoid legal or public acceptance problems.

Common Institutional Problems

Even within this relatively simple example of a TSM program we can recognize potential problems that are not necessarily unique to this community. These problems fall into the following categories:

1. Dispersion of transportation authority,
2. Separation of planning and implementation functions,
3. Incompatibility of laws and regulations,
4. Unequal availability of financial resources, and
5. Profusion of special interests.

As an initial step toward identifying barriers to TSM implementation and perhaps suggesting some possible strategies for dealing with them, let us look closer at each of the five problem categories.

Table 1. TSM activities and institutional responsibilities for implementation.

Activities	Primary Implementation Responsibility			
	Government			
	City	County	Other	Nongovernment
Actions to ensure the efficient use of existing road space				
Traffic operations improvements				
Channelize traffic	Public works	Road department	State transportation department	
Install and modify traffic signals	Public works	Road department		
Coordinate traffic signals	Public works			
Preferential treatment for transit and other high-occupancy vehicles				
Create exclusive bus lanes			Transit district	
Construct bus turnouts	Public works		State transportation department	
Exempt buses from selected traffic restrictions	Police	Sheriff		
Provisions for pedestrians and bicycles				
Create bicycle paths and exclusive lanes	Parks			
	Public works	Road department	State beaches division	
Provide storage areas for bicycles	Public works		Transit district	
Initiate other bicycle facilitation measures (bike-bus service in which an express bus tows a bike trailer)			Transit district	
Management and control of parking				
Eliminate selected on-street parking	Public works	Road department		
Establish preferential policies for short-term CBD parking	City council Parking district			
Provide park-and-ride facilities			Transit district	
Enforce parking restrictions	Police	Sheriff		
Changes in work schedules	All	All	Locally based federal and state agencies	Largest private employers
Actions to reduce vehicle use in congested areas				
Car-pool program	All	All	Locally based federal and state agencies	Citizen planning association Large private employers
Automobile-restricted zones				
Close selected CBD streets to private vehicles	Redevelopment City council Police			
Improve peripheral parking facilities	Redevelopment Parking district Public works			
Provide new intrazone transit service	Redevelopment Parking district		Transit district	
Actions to improve transit service				
Bus services				
Improve frequency and accessibility of fixed-route service			Transit district	
Expand express bus service			Transit district	
Establish selected demand-responsive service areas			Transit district	
Provide shuttle service within the CBD	Parking district		Transit district	
Provide bus shelters and benches			Transit district	
Improve passenger information services			Transit district	
Actions to increase internal transit management efficiency				
Increase marketing activity			Transit district	Chamber of commerce
Improve cost accounting and other management tools			Transit district	

Dispersion of Transportation Authority

In many urban areas the current long-range plans and TSM programs represent the initial undertakings of newly created MPOs; in others they represent new functions for a longer established regional planning authority. Transportation planning areas rarely conform to an existing political unit, and these bodies are commonly coalitions of several county and city governments brought together because of requirements of state and federal policies. The ability of these bodies to exert authority over transportation developments depends on the commitment of the representatives to common goals and their political power within their political units.

In some urban areas the MPO will be a well-established, highly effective institution. In others it will be a weak organization, possibly because of serious conflicts of interest among members, lack of technical background in transportation planning, or experience in dealing with the complexities of state and federal transportation assistance programs. There are institutional problems inherent where either of these situations is extreme. The strong MPO may develop a TSM program without sufficient consultation with operating agencies to accurately determine feasibility and probable public response. If the MPO is weak, the operating agencies may develop a TSM program that is insufficiently coordinated and balanced to prevent undersirable economic or social side effects.

Both political skill and technical knowledge are required for successful TSM planning. The institutional structure of the MPO in the example suggests one method of ensuring that both can be drawn upon. The MPO is organized into different levels. At the top are the political representatives of local units of government whose functions are to set transportation goals and policies, evaluate the overall desirability and political feasibility of the several proposed TSM actions, and commit their separate political units to joint courses of action. At the second level are the representatives of local operating agencies, such as the transit district and road and public works departments, who, with the assistance of federal and state transportation advisors, propose specific TSM activities and develop detailed action plans. Continuity of the TSM process is ensured by the appointment of a professional transportation engineer as the program coordinator.

Separation of Planning and Implementation

It is highly desirable that all of the institutions that are to carry out implementation tasks under the TSM program be brought into the planning process. There is the temptation to simplify procedures by confining the planning activity to those public agencies that have direct access to UMTA and FHWA funds. Agencies or private organizations not consulted may later refuse to participate in the TSM program because of funding, staffing, or regulatory problems or simply because they feel threatened by the unexpected interference in their operations. Even the exemplary planning organization discussed in the example failed to include the local redevelopment agency, which will be highly involved with the proposed ARZ, and the county and city enforcement agencies, which will be required to enforce new parking restrictions and exempt buses from certain traffic regulations.

Bringing such agencies into the planning process will bring to light any problems they might face in carrying out their future TSM responsibilities. The plan can be modified to accommodate these problems or steps can be taken to alleviate them. In addition, these institutions can also be excellent sources of information of value to the planning process. Both the redevelopment and enforcement agencies, for example, work closely with the public and can anticipate acceptance or rejection of certain TSM actions while these are still being discussed as options. This advice can be of value in avoiding an unexpected negative public response after the program is under way.

It may not be possible before the TSM element of the transportation plan is conceptualized to identify all of the institutions that will eventually be involved, but provisions can be made for adding them to the planning structure when their roles become apparent.

Incompatibility of Laws and Regulations

Legal and regulatory problems relating to TSM will vary considerably from one urban area to another because most of the activities called for in these relatively modest changes to the transportation system will be affected primarily by existing local and state legislation.

Our hypothetical TSM program calls for closing the main shopping street to private vehicles, revising the rate structure for public parking lots, developing a new one for the new dial-a-ride service, and exempting buses from certain traffic restrictions. All of these fall under local jurisdiction, and it has been observed (with regard to new uses of taxis and jitneys in public transit) that local government is able to move quickly and effectively to remove restrictions and provide enabling legislation. Where the mayors or county supervisors serve in the MPO and have already reached agreement on the need to modify existing local laws and regulations, they can be expected to expedite such changes.

The TSM programs of other urban areas may call for the creation or extension of a state-authorized transit district or may conflict with existing state regulations with regard to licenses and insurance for car pools. Federal regulations and policies may appear as barriers to establishing new demand-responsive or van-pool operations if another transit system is currently providing service. Recent studies of legal and regulatory problems relating to car pools and van pools, road pricing, and parking controls, however, cite instances in which courts and regulatory agencies have supported innovative actions to improve urban transportation, basing their decisions on recognition of critical needs for mobility, air quality, and fuel conservation. The precedents established in these decisions may be helpful in overcoming legal and regulatory barriers to other TSM activities.

Unequal Financial Aid for Participants

The existing system of financing TSM implementation has two undesirable features.

First, it reverses the impetus toward integration of transportation action that has characterized the entire TSM planning process. Each applies directly to its particular sources of implementation funds (public agencies to UMTA, FHWA, HUD, state departments of transportation, local property taxes, or the city's general budget and private organizations to dues and subscriptions from members, donations and private grants, or current operating budgets). Each institution finds itself functioning again as a separate entity, conforming to the particular process through which funds are obtained and dealing with individual problems of restrictions on their use, timing, and amount. Conflicts can occur, e.g., between transit and road agencies as to who will benefit most and whose grant should pay for construction in providing new bus-loading wells along heavily traveled streets.

Second, funding is not equally available to all TSM participants. The scope of activities that can be funded under UMTA and FHWA programs for TSM has been broadened to include diverse needs such as pedestrian facilities in ARZs and enforcement of reserved lanes. However, funds from combined federal and state sources are more readily available in some areas, such as transit, than in others. This cannot help but encourage local TSM planners to weight their plans in favor of activities for which more assistance can be obtained. The resulting plan may not be the optimum balance of activities for the community.

For example, the present UMTA-FHWA list of potential TSM elements does not include actions to promote changes in land use and relocating residences and places of work closer together. Short-term benefits might be achieved at modest cost in come communities by remodeling downtown hotels or underused business properties into apartments for those who work in the CBD. Since such activities are not suggested, and no federal or state transportation assistance is avilable in this area (nor have we as yet identified any other federal program for such small-scale rehabilitation), potential solutions of this nature are omitted from local consideration.

The trend in federal funding, however, has been toward coordinating assistance and extending the scope of eligible activities. Recent directions of UMTA's research program and policy statements indicate a growing interest in the interrelation of land use and urban transportation, and it is possible that the TSM program may be broadened to include all activities that seek to reduce needs to travel as well as those that increase the efficiency of the transportation system.

Profusion of Special Interests

The broad scope of changes to the transportation system called for in a TSM program cannot help but affect the lives of nearly everyone in the community in some degree. Concerns over the impact of these changes will be expressed by a number of private businesses, public agencies responsible for social services, and nonprofit special-interest groups. At first glance, it hardly seems possible that the community of 200 000 population used as our example could produce 216 such institutions. We do not yet know how typical of all urban areas this ratio is, but suspect that the relatively small size of the city, the presence of the university, a large number of retired residents, and a significant minority population may all be contributing to the proliferation of organizations attempting to influence local transportation decisions. Nonetheless, it should be anticipated that the TSM program in any urban area will attract the attention of a number of institutions with special interests.

The concerns of these institutions are highly divergent. Employers will want to ensure that the proposed changes will neither interfere with the ability of their present employees to travel to work nor create internal work-scheduling or parking problems. Schools and serveral agencies will be concerned about access to these facilities for their clientele. Merchant associations will worry about loss of trade if restrictions are placed on driving and parking private automobiles, and taxpayer associations will wory that proposed transit improvements will require higher property taxes.

The problem facing the MPO is how to deal with these institutions so that they will support, or at least not block, the implementation of the TSM program. Citizen participation in the TSM process is required under joint UMTA-FHWA regulations (section 450.120 a3, Code of Federal Regulations, chapter I of Title 23 and chapter VI of Title 49, as amended October 17, 1975), but without specification as to how this is to be accomplished.

Other federal programs, such as urban renewal, have the same requirement. Local redevelopment projects require the appointment of representatives of citizen groups to an advisory board and make use of neghborhood public meetings and newsletters to keep residents and property owners of the redevelopment area informed. Some of these techniques can be applied to TSM, and some of the existing institutional organization might be made use of in communities where citizen groups have already been formed for other purposes.

Another alternative is suggested by our exemplary urban area. Information on program development is distributed and opinions solicited by mail rather than in general meetings. When drafts of proposed transportation plans are completed, each of the 216 public agencies, private firms, and special-interest groups on the mailing list receives a review copy and is asked to comment or raise questions. Their responses are studied, and any modifications to the plans that appear desirable or necessary can be made before the final version is adopted locally and submitted for federal approval.

One final observation about the attitudes of special-interest groups and the segments of the public they represent has been suggested by our initial research. Not only do these various groups view transportation-related problems with different degrees of concern, as one might expect, but many groups and the public at large do not seem to view the problems of traffic congestion, air pollution, and automotive fuel consumption with as much concern as do transportation planners.

This discrepancy in attitude is most apparent with regard to traffic congestion. One has only to observe the numbers of drivers who insist on adding their vehicles to already overcrowded freeways at rush hour rather than change their established travel patterns. Irrationally, such drivers appear to be willing to tolerate intense levels of congestion that they have grown accustomed to and to resist efforts to reduce congestion that interfere with their usual commuting habits.

Many drivers seem to feel their rights threatened by newly imposed user penalties for traveling over a bridge during peak periods or for long-term parking or by the removal of a freeway lane for the exclusive use of buses and car pools. On the other hand, the public seems more willing to accept programs based on exempting high-occupancy vehicles from existing user fees or providing new facilities for their exclusive use.

The Los Angeles diamond lane demonstration is a case in point. Drivers in congested lanes were expected to see traffic flowing freely on the reserved lane and rationally come to the conclusion that they should form car pools or wsitch to transit. Some did, but the majority continued to drive as before, and through their protests the experiment was finally brought to a halt by a court decision. Because the experiment was short-lived and there is some question as to how much the opposition of local news media contributed to the protest movement, we do not know whether it might have proved more successful over time or under different circumstances. But it does suggest that transportation planners should not rely on finding in the community at large a concern with transportation, environmental, or energy goals equal to their own and should, where possible, use positive incentives and new transportation options rather than penalties and restrictions.

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METHODOLOGICAL FRAMEWORK FOR THE TSM PLANNING PROCESS

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This paper describes a systematic TSM planning process that begins with setting objectives and ends with monitoring the effectiveness of implemented projects. The technical requirements for the process are also discussed.

There is a growing awareness that transportation facilities and services and the people and vehicles that use them constitute a system that can be managed. As an increasing proportion of urban America achieves a physically mature transportation infrastructure, system management will gradually become the dominant focus of transportation improvement strategies. This inevitable shift to transportation system management (TSM) represents a radical departure from the historic preoccupation with capital-intensive system additions designed to accommodate increasing demand for transportation service.

TSM encompasses a range of improvement strategies that are nonfacility and low-capital oriented and that use both demand management and supply optimization to capitalize on existing highway and transit facilities to achieve transportation-related goals. Under this broad definition, TSM planning is now the required focus for the short-range transportation element in transportation improvement plans required by DOT of metropolitan areas.

The changes in the transportation planning environment that have been responsible for this shift include the following.

1. Transportation resources are increasingly constrained. Construction costs have risen at rates of from 10 to 15 percent annually. There is competition for funds both among the expanding programs within the transportation sector and between transport and other higher priority social and economic needs. Responsible public institutions must ensure that existing facilities and services are being used in the most cost-effective way before committing additional scarce resources.
2. There is a heightened sensitivity to the mixed blessings of capital-intensive system additions—a recognition that many of the short- and long-run environmental, social, and economic consequences of construction (highway or transit) are neither desirable nor avoidable at reasonable costs. These nontransportation priorities or legal requirements or both imply the need to selectively manage certain types of mode use or even constrain some kinds of mobility to accommodate socially desirable nontransport objectives (clean air, less energy consumption, greater economy). Furthermore, such improvements as have been provided by capital-intensive projects, whether highway or transit, have long lead times that render them unable to respond to short-run environmental imperatives (conservation) or social needs.
3. Substantial transportation infrastructure already exists in the urbanized areas of most of the United States—more than adequate for all but two brief time periods each day. Indications are that only marginal mobility benefits have been achieved by substantial additional expenditures to increase general transport supply in these contexts in the absence of supply or demand management. In a time of scarce fiscal and natural resources, it is becoming increasingly apparent that future transport improvements may have to be targeted on specific socially agreed-upon groups and selected trip purposes or patterns be encouraged or discouraged through both supply and demand management.
4. The unstable and dynamic context for transportation includes possible fuel shortages, inflation, and rapidly changing transportation policy priorities. This implies it may be desirable to develop facilities whose function or use can be modified in whole or part permanently or temporarily in keeping with current policy priorities or in response to future "crises" of any type. System additions must therefore be conceived of and designed as "infrastructure for management," and operations and control features must be designed to enhance existing system flexibility.

A satisfactory programmatic response to the context as described above must capitalize on sunk investment through searching for more cost-effective ways to use existing facilities. On the one hand, this means strategies that, through controls, manage and preserve the levels of service that justify new facilities in the first place. On the other, this suggests dynamic supply operation regimes tailored to variations in demand in real time or to changing policy-based priority purposes. Demand modification involving change in behavior to make better use of the existing transport supply will also become increasingly important. Overall, a management orientation will increasingly augment the facilities-oriented approach in achieving the most efficient satisfaction of a mix of mobility objectives.

In addition to efficiency goals, however, capability to operate transportation systems to accommodate equity and externality objectives must be developed. Non-transportation considerations are placing an ever higher premium on the ability to respond to broader objectives even if this involves a trade-off with the level of mobility per se, through demand as well as supply management.

TSM represents a new focus for metropolitan planning organizations (MPOs) and presents a variety of challenges—technical, institutional, and fiscal—to the continuing transportation planning process. The TSM planning process carried out during the first year under the mandate of the joint FHWA-UMTA planning regulations has been rudimentary:

1. No MPO had or developed a truly systematic process for developing a TSM program;
2. Few cities related their transportation and transport-related objectives to TSM projects;
3. No city developed a complete set of objectives and corresponding measures of effectiveness to permit the testing and modification of TSM programs as part of a continuing and incremental process;
4. Little attention was given to the opportunities for regionwide comprehensive TSM strategies through combining a number of mutually reinforcing actions; and
5. Relations between short-range TSM planning and longer range plans were not identified.

The first-year experience suggests a substantial agenda for improvement in the TSM technical planning process. The reorientation of transportation system management implies a profound change in the focus of both transportation planning and operating institutions and in the day-to-day activities and skills required of planners. Indeed, a systematic approach to a continual process of developing and applying TSM improvements must recognize the unique potential and special characteristics of TSM.

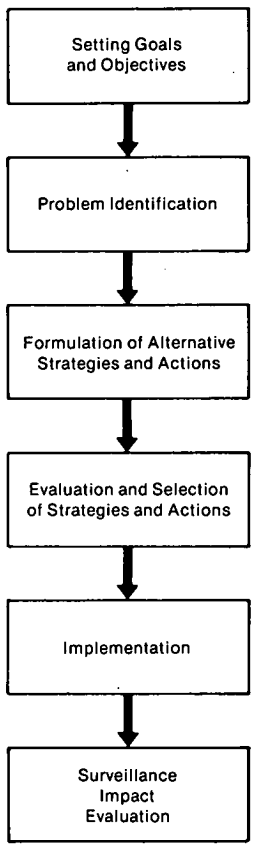
The discussion below is aimed at suggesting the nature of such a systematic TSM planning process. Figure 1 shows the process, which begins with setting objectives and ends with monitoring the effectiveness of implemented projects.

The issues that support the logic of TSM may require a major shift in the planning process to incorporate increased bargaining among institutions involved in implementation. This could result in a hybrid process at the metropolitan level incorporating elements of both "top-down" systematic, goal-based planning and "bottom-up" ad-hoc, negotiation-based planning.

Regardless of the appropriate institutional context, the technical problems remain. For each planning activity—goal formation, problem identification, strategy formulation and evaluation, monitoring, and modification—substantial gaps exist in methodologies and techniques. To the degree to which TSM planning in metropolitan areas is to achieve its full systemwide potential and be more than an uncoordinated "happening," these gaps must be filled. This paper discusses five basic gaps.

1. Although many basic local problems may be easy to identify, more vigorous techniques are needed to locate conditions amenable to TSM solutions on a regionwide basis. The idealized objective-based approach—often characterized as an obsolete appendage to planning—can be valuable in ordering the priorities and trade-offs inherent in the broader purposes of TSM. These trade-offs among transportation objectives as well as between transportation and nontransportation objectives will become especially evident in TSM planning.
2. Program formation requires an understanding of TSM actions and how they work. Accompanying the traditional forward-seeking planning approach that develops programs from objective-based statements can be

Figure 1. Generalized TSM process.



a backward-seeking activity of understanding TSM action characteristics sufficiently to predefine their relevance. The goal of making more efficient use of the existing urban transportation system will require drawing together the fragmented components of traffic engineering, transit operations, and overall transportation management. Within such a framework, the narrow focus of traditional traffic engineering or transit operations is no longer appropriate. The full range of TSM tools including information, restraints, and demand management must be considered in developing comprehensive strategies. Characteristics of a broad range of potential actions must be understood before they can be composed into strategies to meet local objectives and solve local problems.

3. Combining TSM strategies from individual actions requires knowledge of their interactions. Combinations can have synergistic or counterproductive joint effects. Strategy making must consider how objectives or desired impacts can best be accomplished. Here, actual experiment will have to substitute for the relatively undeveloped state of the art.

4. Impact assessment must be carried out at the appropriate level of detail. Although the conventional measures of transportation level of service will remain an important measure, broader measures of effectiveness must be designed to evaluate the ability of TSM strategies to produce positive benefits in the areas beyond transportation service. Safety, air pollution, energy use, environmental and community disruption, and impacts of the public and private economies may be relevant. A comprehensive but efficient set of measures of effectiveness must be developed so that strategies with the highest potential can be quickly identified. Evaluation techniques must be established at the local level for comparing the relative effectiveness of various potential TSM strategies and at the regional level for composing TSM strategies into an overall program and ranking for implementation.

5. A monitoring and surveillance activity is essential to the development of the TSM state of the art. Some indication of the most promising approaches can simplify program development and permit actions to be modified for local circumstances.

6. Methodologies for strategy development, implementation, and assessment must be developed and assembled in a form permitting local planners to develop programs without having to do elaborate, time-consuming research.

The discussion below does not fill all the gaps. However, it suggests the nature of the technical requirements for a systematic TSM planning process. The suggestions made are aimed at a high level of rigor appropriate to the experimental phase in which the profession finds itself with respect to TSM planning. It is not expected nor is it possible that the first rounds of TSM planning at the local level will be undertaken in a rigorous fashion. Technical and institutional problems require a shakedown period. In many cases, research will be necessary to develop planning tools that can incorporate experimental results into easy-to-apply methods for use in regional and local planning. This paper sets an ambitious agenda for action.

OBJECTIVES AND PROBLEMS

Objectives play a central role in both the formation of problem-related TSM strategies and in the development of necessary methodologies for determining strategy effectiveness. The desirability of a particular TSM action can be related to the degree to which it achieves desired transportation or transportation-related objectives. Each specific applications context, however, will exhibit a different mix of objectives. What is more, it is increasingly apparent that certain objectives may conflict with one another. The increased complexity of this goal fabric will place a premium on clear, measurable, objective statements.

The broad range of problems and opportunities encompassed by the TSM concept suggests that no single method for identifying specific primary TSM actions is appropriate. Rather, a collection of techniques can be employed that differ in their rigor, cost, and data requirements. The most rigorous technique of problem identification requires a set of performance standards derived either from local transportation and transportation-related objectives or from performance standards required by an external (federal) program to meet transportation and nontransportation service targets. The existence of a "problem" is detected when system performance data indicate that some aspect of the system is "below standard." The system performance data are derived from field measurements and surveillance (or diagnostic simulation) and presented in terms of performance measures that reflect system conditions for comparison with the performance standard. Such comparisons of actual performance against standards are a highly important first step but one that has been largely missing from early TSM planning efforts.

Statement of Objectives

From a technical point of view, the establishment of an agreed-upon set of objectives is important for three reasons:

1. Objectives provide a point of departure for the

identification of problems—conditions that are contrary to objective-derived standards;

2. Objectives assist in defining the appropriate TSM management concepts, and this determines the appropriate scope of strategies to be included; and,

3. Objectives provide the basis for the development of measures of effectiveness (MOEs) used to evaluate the impact of various strategy combinations.

Consistent with local transportation policies, TSM should have a comprehensive orientation. It should not only concern itself with operating and managing the existing transportation facilities in the most efficient fashion to meet mobility objectives but also consider energy, air quality, environment, economic efficiency, and community quality objectives.

The list below is a comprehensive set of goals and related objectives for TSM strategies. The objectives have been developed within the overall framework of the U.S. Department of Transportation National Transportation Policy goal areas—mobility, health and safety, environmental and community quality, energy conservation, and economic efficiency. The objectives have been stated in terms to permit derivation of quantitative MOEs. Not all objectives themselves can be quantitatively measured, given the state of the art.

Goals	Objectives
Improve personal mobility	Improve level of service of urban travel Improve reliability of travel Provide attractive alternatives to driving Private automobiles Provide good quality, affordable transportation services to elderly, handicapped, poor, and very young Improve facilities for nonmotorized travel modes (pedestrian and bicycle) Improve responsiveness to changing urban transportation needs
Improve public safety	Reduce occurrence of traffic accidents Reduce injuries and deaths resulting from traffic accidents Improve personal security of urban travelers
Enhance environmental and community quality	Reduce automotive emissions and impacts Reduce noise and vibration impacts Minimize adverse impacts on natural environment Minimize community disruption and relocation Enhance aesthetic qualities of urban environment Complement long-range urban land use goals
Conserve energy resources	Reduce fuel consumed in urban travel
Improve the economic efficiency of transportation	Increase person and goods movement capacity of existing transportation facilities Reduce personal costs of urban travel Reduce public costs of urban transportation systems Achieve greater equity in payments for urban transportation Reduce costs of urban goods movement Minimize adverse economic impacts caused by urban transportation Maximize positive economic impacts caused by urban transportation

It is obvious that each goal area must be reflected by several criteria. Mobility, for example, can be achieved in many ways for different groups and circumstances, and each way would have different impacts on objectives related to other goal areas. In fact, objectives within each goal area may, to some degree, conflict. Complete discreteness is not necessary or desirable since this limits local flexibility in goal achievement.

Points of View and Objective Conflicts

Since TSM actions will have varying incidences with respect to impacts, it is also not surprising that any single objective can have a substantially different interpretation. The broad range of potential objectives or problem areas constituting targets for TSM actions suggests that trade-offs will be implicit in any strategy—trade-offs among different types of transportation impacts, between transportation and nontransportation impacts, between users and nonusers, and among geographic areas or groups of persons affected. Therefore, within any given goal area, the objectives can usefully be broken down by point of view indicating in the objective statement the intended incidence-target group. These include:

1. The user—individuals whose travel behavior and level of service are directly affected by TSM strategies;
2. The system manager—institutional operators or policy makers involved in management, resource allocation, and technical decisions; and
3. The public—divided into the system abutters, people or groups who are the most direct and regular recipients of the direct or indirect nonuser impacts of TSM strategies (noise, safety, retail sales changes), and the public at large, the community as taxpayers and indirect recipients of the regional benefits (or costs) of TSM improvements.

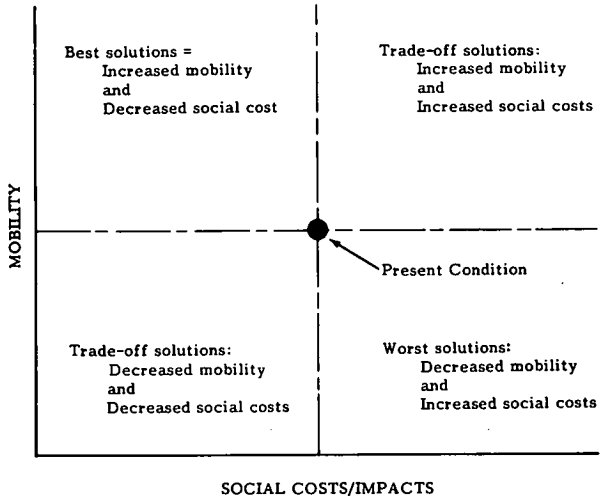
System users are primarily concerned with mobility, economic efficiency, and health and safety. The public at large (in the role of nonusers) is concerned with environmental and conservation objectives and economic efficiency and only indirectly or secondarily with mobility. System abutters are obviously concerned with access, goods movement, and possible negative impacts on their property and activities.

This emphasis on multivalued evaluation requires a systematic approach to goal and objective definition, criteria statements, and derivation of measures of effectiveness. An important aspect of this systematic approach is clear recognition that the difference in values among different groups in society and the wide range of possible improvement actions naturally lead to priority conflicts. Seldom will the objectives of all points of view be simultaneously favorably impacted. The determination of what constitutes a "good" versus "bad" strategy is becoming increasingly complex. Any transportation objective, if narrowly defined, may have counterproductive effects on other transportation objectives. One example is the implicit conflict between the desire to improve flow (and thus increase mobility) without inducing new trips or increasing overall travel (with attendant negative environmental and energy consequences).

Thus, TSM strategies can have a positive impact on mobility and a negative impact on social costs (which include user costs and energy and environmental impacts). Ideal TSM programs simultaneously increase mobility and reduce social costs. However, strategies that involve some slight decrease in mobility to achieve a reduction in social costs may be acceptable. The converse, improved mobility at the cost of a slight increase in social costs, may also be acceptable. There must be increased recognition that these conflicts exist and require conscious trade-offs in the TSM planning process. Figure 2 indicates the four types of potential solution spaces with the implicit trade-offs among objectives indicated.

Members of the community may have one point of view as taxpayers or recipients of negative environmental impacts and a completely different view as system

Figure 2. Potential solution spaces.



users. The potential for trade-offs among conflicting points of view must be built into an overall evaluation process, and such differences in point of view incorporated into specific measures of effectiveness in order to be responsive to the range of public concerns. How such trade-offs are made and their desirability will be determined locally in the light of local objectives. It is clear, therefore, that potential conflicts between objectives must be identified so that TSM strategies can be designed to minimize any negative interactions among programs. Several issues must be dealt with in establishing a final set of objectives.

1. Level of detail. Some goal areas could, in theory, be divided into a variety of subobjectives. "Minimize adverse ecological impacts" could be divided into objectives with respect to water quality, soil conditions, plant life, and so on. However, the nature of TSM strategies suggests that only marginal changes in ecological conditions are likely and, in addition, are difficult to measure. Therefore, such a detailed breakdown is less relevant and not included.
2. Objective redundancy. Often, more than one objective can be stated for a given goal area. However, they may be redundant with respect to measures of effectiveness. For example, "reduce congestion" and "reduce travel time" might both be stated as objectives related to mobility. However, the measures of travel time and reliability are more specifically related to the measures of flow and, being directly measurable, are therefore preferable as objectives.
3. Scale of impact. Are the objectives areawide, for a corridor, or for a subarea? As a practical matter, objective achievement becomes more measurable when it is area specific and targeted at a specific point of view (user group).
4. Data collection. The efficiency of data collection must be addressed in respect to objectives. The objectives can often be stated such that a single measure can serve as an indicator for more than one objective. Given the cost and difficulty of monitoring system performance and impacts, it is important to limit the total number of required measures.

Problem Identification

A clear set of objectives can aid in identifying problem conditions that need attention. Standards derived from the objectives can be used as a guide to assign priorities to locations by preparing measures of effectiveness against which measurements of deteriorating conditions can be compared and evaluated. These standards will reflect a desired level of transportation service or related conditions and can be stratified by peak and off-peak operation and by type of service (central urban, fringe urban, suburban) or by special user group targets. Environmental, resource, or other standards can also be composed.

Problem identification from field data is another approach. The types and sources of important system performance data and indexes that will permit the identification of transportation problems must be route, site location, or service specific and describe the need for performance improvement. Indicators can be matched with potential TSM improvement actions. Examples of such data and indexes are

1. Volume/capacity ratios of major street links (peak-hour and 24-h periods),
2. Peak-hour factors at key street points,
3. Transit versus automobile travel times for significant origin and destination patterns,
4. Maximum load point data for transit,
5. Average operating speeds by route,
6. Percentage of transit coverage,
7. Bus stop spacing and bus loading and discharging delay, and
8. Complaints received from transit riders and the general public.

Since the above methodology involves system performance data (including possible field measurements) and systematic comparison with standards, it is not appropriate for relatively simple and extremely inexpensive TSM actions. In many cases, such as minor operational changes in which little capital investment is involved, experiments can be based on less rigorous definition of problems. Simple problem inventories can be made based on the existing local technical knowledge of system operation. Certain standard actions are already typically undertaken by action agencies without study. Examples include known areas of arterial friction suggesting new parking regulations, bus loading problems suggesting service changes, management adjustments to improve efficiency and marketing. Other TSM actions can be suggested by the existence of successful examples without carrying out any problem analysis. Innovative services and fare adjustments are examples. Indeed in many circumstances the normative model of TSM planning suggested in Figure 1 would not be necessary to initiate a TSM project. The goals-objectives comparison with condition approach would be superfluous.

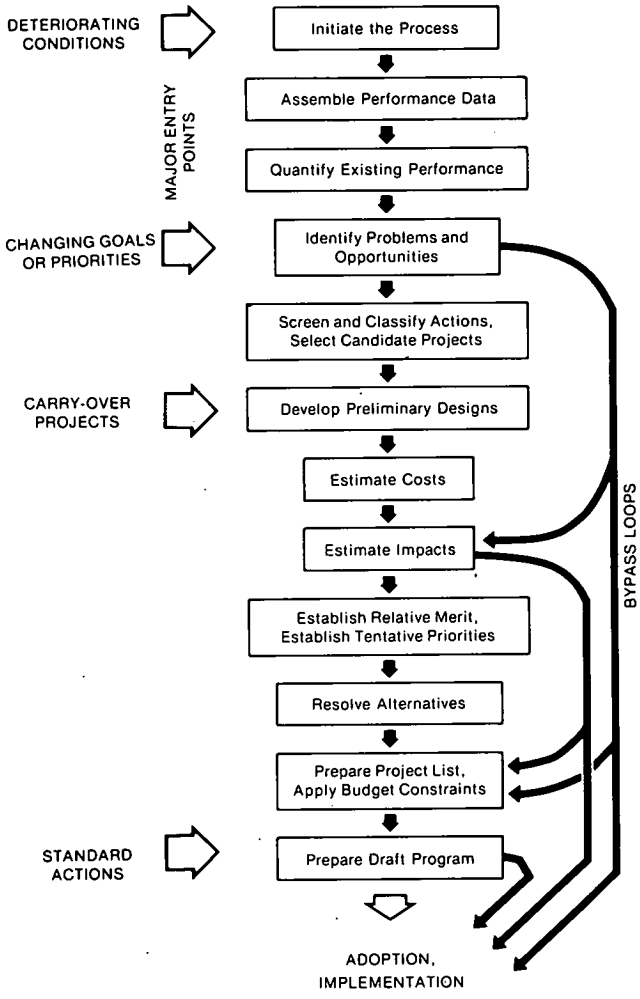
Figure 3 suggests that at least four events might trigger a TSM project outside the formal process:

1. Obviously deteriorating conditions requiring an early remedy;
2. Imposition of a new local goal or one imposed by a higher jurisdiction;
3. Carry-over projects not implemented from previous year evaluations; and
4. Standard actions typically taken by local operations on a day-to-day basis.

PROGRAM FORMATION

A systematic process must be developed for formulating TSM strategies in response to existing problems if TSM is to become an effective program. Program formation must be responsive to an analysis of the basic system

Figure 3. Short circuits in the normative process.



management concepts required to affect progress toward desired objectives. All the dimensions of travel are potential targets of specific changes in the amount, quality, or cost of transportation supply. Each dimension can be impacted by a large number of specific TSM actions, which include the complete range of supply optimizing and demand management actions. These actions in turn have certain characteristics—spatial, temporal, modal, behavioral, cost, institutional—that will determine their relative effectiveness in any given context and, combined with the dimensions of the target problems, constitute its warrant for application.

In combining TSM strategies into a program, one must recognize the breadth and complexity of the full range of potential TSM actions. Characteristics of each action must be understood so that they can be appropriately applied to achieve the increasingly varied number of objectives. The discussion below characterizes potential TSM actions by several of their key characteristics.

As a starting point in developing a TSM program, it is useful to make distinctions among certain definitions.

1. Management concept is the desired effect of a specific action on a specified target such as improved traffic flow or redistribution of demand modally.
2. Strategy category is the general class of action designed to achieve a specific management concept such as entry control (to improve automobile flow) or intermodal integration (to increase diversion to transit).
3. Action element is a specific tactic within a TSM strategy category such as ramp metering (an entry control strategy) or park-and-ride facilities (mode-diversion strategy). Action elements provide the level of specificity necessary for impact characterization.
4. TSM program is a set of TSM strategies (comprising actions from one or more strategy categories) designed to achieve any given set of objectives.

Central to these definitions is the idea that the various strategy categories can be composed of one or more action elements and that strategies themselves can be combined to support a given TSM management concept as part of an overall program. In addition, more than one TSM management concept may need to be implemented before progress toward a particular objective is made.

Strategy Categories and Action Elements

Although several lists of TSM strategies have been compiled, none represents a systematic functional classification of the complete range of relevant traffic operations and control, transit operations, and transportation management actions. Based on a review of the strategy categories presented in previous studies for the U.S. Department of Transportation and the U.S. Environmental Protection Agency as well as those presented in the recent joint FHWA-UMTA transportation improvement program guidelines, a preliminary set of TSM strategy categories has been identified and grouped into six basic classifications:

1. Mandatory usage controls,
2. User information and assistance,
3. Economic controls (pricing),
4. Transit operations modifications,
5. Minor supply additions, and
6. Demand modification.

The classification scheme for TSM strategies given below builds on those produced in earlier studies and the generalized definitions of concepts, strategies, and action elements discussed above. In particular, this approach indicates the usefulness of keeping the definition of management concepts deliberately abstract with respect to strategy—that is, a management concept does not necessarily imply a single strategy but may be achieved through a combination of strategies. Furthermore, it illustrates that there are a great many separate action elements associated with certain strategies.

Category	Action Element
Mandatory usage controls	
Crossing control	Bus priority signal system
	Signal timing optimization
	Signal installation or removal
	Pedestrian grade-separation provisions
	Computerized signal control systems
Entry control	One-way street
	Right turn on red
	Reversible streets
	Turning movement restriction
	Area restrictions
	Ramp metering
	Preferential entrance ramps
	Exclusive entrance ramps
	Entrance ramp closure
	Through traffic restrictions on residential streets
Lane usage control	Reversible lanes
	Preferential lanes for high-occupancy vehicles

Category	Action Element
	Lane use and turning movement restrictions
	Intersection channelization
	Bicycle lanes
Curb control	Parking restrictions
	Bus stop relocation
	Loading zones establishment
	Sidewalk widening
	Truck delivery restrictions
Speed control	Speed limits (maximum and minimum)
Parking controls	Preferential parking for high-occupancy vehicles
	Parking duration restriction
	Stringent enforcement of parking controls
User information and assistance	
Education	Broadening of driver education to transportation education
Pre-trip assistance	Pretrip traffic condition information
	Ride-sharing matching information
	Truck routing and scheduling optimization
	Transit route and schedule information
	Paratransit service information
En route assistance	System condition broadcasts
	Traffic flow condition signs
	Progression speed advisory signs
	Route advisory signs
	Incident detection and management
	Motorist aid
Pricing	
Road pricing	Facility tolls
	Area tolls or licenses
	Vehicle ownership taxation
	Vehicle usage taxation (fuel or mileage)
	Congestion pricing
	Differential tolls
Parking pricing	Parking duration pricing
	Elimination of parking subsidies
	Differential parking pricing for high-occupancy vehicles
	Parking taxes
Transit and paratransit pricing	General fare reduction
	Peak-period and midday fare differentials
	Free transit
	Paratransit subsidies
	Elderly and youth fares
	Commuter fare book discounts
Transit operating modification	
Operational improvements	Bus route modifications
	Bus schedule modification
	Increased passenger loading efficiency
	Simplified fare collection
	Fare collection elimination
	Substitution of demand-responsive service for fixed route and scheduled service in selected time periods
Mode transfer	Bus stop relocation
	Park-and-ride facilities
	Submodal integration
	Station and stop amenity improvement
	Feeder and distribution improvements
	Simplified transfers
Management efficiency	Technical cooperation (traffic and transit)
	Marketing improvements
	Programming improvements
	Accounting improvements
	Maintenance improvements
	Monitoring and surveillance
	Transit automated vehicle identification
	Improved security
Supply augmentation	
Transit	Shuttle bus services
	Express bus services
	Subscription bus services
Street and highway	Selective street and intersection widening
	New lanes for high-occupancy vehicles
	Special freeway ramp additions
	Bus loading bays
	Freeway bus stops (bus parks)
Paratransit operations	Ride-sharing incentives
	Ride-sharing brokerage
	Taxi deregulation and rule changes
	Jitney operation
	Demand-responsive transit
	Van-pool programs (employer)
Nonmotorized	Pedestrian malls
	Bicycle paths
	Sidewalk widening
Parking	Parking supply reduction or restraint
	CBD fringe parking
	Suburban park-and-ride facilities
Goods	Terminal consolidation
	Increase in truck lot sizes
	Off-street loading facilities
Demand modification	
Modification of time distribution of demand	Staggered hours
	Flexible time
	Shortened workweek
	Expanded evening hours for shopping and service establishments
	Expanded weekend opening of shopping and service establishments
Modification of frequency of demand	Expansion of home delivery of goods and services
	Substitution of communications for transportation such as written communications (e.g., bank by mail) and telecommunications
Modification of spatial location	Land use change

Travel Behavior Impact and Response Time

Effective TSM strategy development requires an understanding of how potential travel behavior impacts of proposed action take place. Generic management concepts that specify the desired effect on a specified target can be related to the objectives or problems analysis in terms of strategy formation. Actions often have single or multiple impacts that are more or less amenable to discrete targeting with respect to improvement objectives.

TSM focuses attention on the potential inherent in the complete range of behavior modification ranging far beyond the typical domains of the traffic engineer and transit operator. The enlarged palette of TSM includes actions to both improve supply and to manage demand. The fundamental management concepts can be stated in terms of the basic traffic and travel behavior targets:

1. Improve traffic flow characteristics,
2. Redistribute traffic spatially (path),
3. Redistribute traffic temporally (timing),
4. Redistribute traffic modally (mode choice),
5. Modify trip distribution and length, and
6. Modify trip frequency (total demand).

Many strategies have more than one impact—an immediate effect on one type of behavior and a longer term or secondary impact on another type of behavior in response to the short-run impacts. For example, any strategy having a substantial impact on flow (increase or decrease in travel time) will inevitably affect choice of path and may, depending on supply availabilities, affect choice of mode. At the extreme, flow impacts can affect the entire cluster of travel behavior choices. The following are some of the specific impacts associated with strategy groups.

1. Mandatory usage controls are targeted primarily on automobiles and affect flow positively or negatively; they have possible secondary impacts on path. If the

controls include high-occupancy vehicle priorities, the secondary effect may be mode choice.

2. Transit operations have their primary impact on mode choice and have possible long-range effects on traffic flow characteristics if substantial mode shift occurs.

3. Pricing or supply changes such as parking controls can have a primary effect on timing of trips and in the long run on trip frequency and distribution as well.

Primary Target

An understanding of who may be impacted by a TSM action is also essential to effective TSM strategy making. Each TSM action can be developed to affect specific people and goods who make up system users including automobile drivers, automobile passengers, transit passengers, pedestrians, bicycle riders, and those driving trucks (goods movement). Many strategies affect more than one mode, but large numbers of concepts can be focused on high-occupancy vehicles or other specific groups.

Area of Application and Zone of Influence

Where TSM actions work is another important dimension of TSM strategy making. Area of application of TSM strategy versus zone of influence is of special interest since application and influence are not always spatially or temporally congruent. The spatial units include spot (intersection, block, ramp), facility (street, highway), corridor (several parallel facilities), subarea (CBD, activity center, neighborhood), urban area (city, town), and region (urban area plus suburbs).

The following are examples of comparisons between scales of application and influence.

1. Most spot TSM actions, such as signal installation or removal, have their influence at the facility scale.
2. Some spot and facility scale TSM actions, such as the development of exclusive or reversible lanes, have corridorwide impacts.
3. Certain TSM actions, although applied regionwide, have impacts primarily in selected subareas. A car-pool encouragement program is an example.
4. Other TSM actions, such as gas taxes, transit fare change, and public information, have a regionwide impact.

Implementation and Response Time

When or how quickly TSM actions will be effective can be an important aspect of developing a continuing TSM program. The relation of implementation time and response time will be significant in selecting management and control strategies.

Relative Effectiveness

Which TSM action should be selected will depend, in large measure, on the estimates of their relative effectiveness. An important measure of the potential value of particular action elements is the scale or degree of impact it has on any particular objectives. There is a wide range of program objectives for TSM strategies including mobility, energy conservation, environmental and community preservation, and economic efficiency. Any given strategy composed of one or more specific action elements will have a differing impact on the measures of effectiveness that reflect objectives. Simulating or judging and evaluating such impacts should be a major focus of TSM studies before implementation.

For a limited number of strategies, the potential range of impacts with respect to any given measure of effectiveness can be judged a priori by investigating dimensions of the strategy as revealed by the scale and timing of impacts or through knowledge of hypothesized or known impact mechanisms. For more complex TSM actions or action combinations as part of a strategy, formal simulation may be necessary. As a starting point, tentative hypotheses about the range of effectiveness in respect to certain key measures in typical contexts should be organized and classified by using both existing data from the field and the results of previous simulation. The expected effectiveness of specific action elements within each strategy category can be used to indicate the most promising strategy combinations. Although the completion of this classification must await the accumulation of field experience with the various actions, suggested preliminary measures include

1. Change in average speed for given trip or given links,
2. Impact on modal choice,
3. Impact on vehicle travel, and
4. Impact on vehicle occupancy.

For certain strategy action elements, there has already been sufficient field experience so that the potential range of impact on limited measures of effectiveness is known. This is especially true for the flow-related impacts of some strategies and the mode choice impacts of others. In addition, current research, particularly in connection with the development of transportation control plans and ride-sharing programs, has developed estimates of mode-split impacts and vehicle-travel reduction impacts associated with certain TSM strategies. Trip frequency and distribution impacts are also becoming better understood. Table 1 gives the results of a recent simulation of relative effectiveness of certain TSM strategies applied in the city of Sacramento.

TSM ACTION COMBINATIONS AND INTERACTIONS

An important aspect of TSM planning results from the often localized and specific nature of the impacts of individual actions. To exploit the full potential of TSM, individual actions must be combined into program packages. With an understanding of the characteristics of potential TSM action elements and a knowledge of the priority objectives and problem areas, one can investigate the potential. Three general combination approaches can be considered.

1. Repetition of successful (or promising) actions on a regionwide basis. Many of the smaller scale TSM actions can have a maximum effect if they are applied at all like locations. Signal and parking strategies are typical examples.
2. Combinations of mutually supporting TSM actions. To be fully effective, many specific TSM actions require other related and coordinated actions. Area restrictions or parking programs may require compensating transit service. Curb control measures may require a special goods delivery program. Dynamic routing requires supporting information systems. Pooling programs may benefit from priority treatment.
3. Combinations to offset negative impact. Certain TSM actions may have a positive impact on one group or area and a negative impact on another without compensat-

Table 1. Effectiveness of TSM actions in Sacramento.

Actions	Travel Reduction (%)	Trip Reduction (%)	Comment
Increase vehicle occupancy			
Car-pool matching[a,b]	2.6	1.9	
Van-pool program	0.3	0.2	
Car-pool incentives[a]	2.0	1.0	
Improve transit service			
Transit service expansion	1.0	0.8	Increase service by 70%
Increased transit service frequency	1.3	1.0	Increase frequency by 70%
Transit fare reduction[b]	1.0	0.8	10-cent fare
Fare subsidy	0.5	0.4	Free return fare
Demand-responsive service	1.8	0.7	Collector service
Shuttle service	0.4	–	
Park-and-ride facilities	1.0	–	
Improve transit and car-pool operations			
Reserved bus and car-pool routes	0.1	0.1	Bus lane in CBD
Exclusive bus and car-pool lanes	0.1	0.1	
Ramp metering	0.1	0.1	
Discourage automobile usage			
Gas rationing[b]	20.0	16.6	20% rationing
Control parking			
Limit parking supply	0.1	0.1	
Increase parking fee	2.2	1.1	Increase cost by 100%
In-lieu parking regulations	0.1	0.1	20% "in-lieu"
Reduce need for travel			
Improve bicycle/walk access	0.3	1.0	

[a]Includes car-pool information program.
[b]Short-term impact—no impact in 5 years as consequence of changing to more fuel-efficient vehicles.

ing actions. For example, a TSM program diverting traffic from residential streets onto an arterial system may require a pedestrian safety program on the arterial system to compensate for increased traffic.

Whether any given TSM action is in conflict with or complements any other element can only be determined by examining their potential impacts on specific measures of effectiveness.

Program Comprehensiveness

The following guides toward comprehensiveness may be useful in combining TSM actions into an overall program.

1. Focus on people and goods, not vehicles. Mobility depends on person movement and goods movement rather than on traffic flow. TSM actions must consider the trade-offs among modes with different occupancies. Strategies must be broad enough to include those that are consistent with management concepts oriented toward improving transit service and diversion where appropriate as well as those oriented toward vehicle flow.
2. Determine primary and secondary impacts. When stringently applied, certain TSM strategies that may prove effective in accomplishing desired mode change, such as pricing or parking supply reduction, may affect demand—trip frequency or distribution—even in the short run. Such strategies that can reduce overall trip making may not be politically feasible in some areas and could have serious economic consequences. In some cases, transit substitutes or improved pedestrianization can offset strong automobile disincentives. In other cases, overall reductions in trip making may be acceptable to achieve other goals such as energy conservation and environmental quality.
3. Review polymodal options. Strategies may involve several mode targets to achieve objectives. Although not all automobile-related TSM actions impact transit, many transit-related TSM actions will require traffic operation changes. Improvements oriented to nonmotorized modes may also be included.
4. Use demand as well as supply management. Trip reduction or reorientation in time or space in certain instances can bring substantial nontransportation benefits. Staggered hours and automobile-restricted zones are two current examples of TSM strategies with considerable promise. Pricing and regulatory controls such as area or parking licensing are also being considered.
5. Include service and information strategies as well as facilities. Custom-tailored transportation services (paratransit) for specific groups can assist in minimizing transportation problems without requiring new equipment or facilities. In addition, the provision of information, both before and during the trip, can assist in relating demand more closely to supply and using existing investment more cost effectively.
6. Review potential for modification and upgrading. TSM strategies are relatively low-cost actions that can be incrementally implemented and modified in the light of experience to most effectively accomplish the intended objective. A premium may be placed on those TSM actions that permit continual improvement or flexible response to changing conditions.
7. Allocate scarce capacity. The competition for highway space or transit capacity where additional capacity is costly or not feasible in the short run suggests the possibility of giving preferential treatment to user groups in accord with local policy objectives. Emergency vehicles and vehicles that more efficiently use road space (multiple occupancy) are examples.
8. Employ real-time supply modification. Both highway and transit-oriented components of most transportation systems exhibit substantial oversupply except at peak periods. TSM actions that can modify the orientation of the existing system to accommodate peak loads, directions, special user needs, preferred modes, preferred paths, or emergencies will create the potential for truly managing the transportation system.
9. Use incentives and disincentives. Pricing, information, and service improvement all offer "carrot" rather than "stick" approaches to improving the effectiveness of transportation systems. Positive incentives may achieve a greater degree of popular support and avoid legal problems, but the full range of actions should be explored.
10. Form hierarchies of action. TSM actions can be applied at several scales—region, corridor, subarea, spot. Actions can be "nested" to reinforce each other and to offset negative consequences.
11. Integrate long- and short-range actions. TSM

does have a long-range aspect, that of continuing to multiply effective actions, modify less effective actions, and extend actions in space over time. TSM planning is a learning process, the effectiveness of which can be built up over time through a comprehensive approach on a regionwide basis.

Implementation Constraints

Annual TSM program development must necessarily consider those strategies and projects that appear to be most meritorious on objective-fulfillment grounds. Although this paper develops a normative systematic technical planning process for TSM, obvious practical constraints must also be considered.

1. Funding constraints. The absolute limits on funds available will sometimes limit TSM strategy selection. Just as often the timing of funds coming from different jurisdictions or functional agencies will delay implementation. Similarly, administration of funding from various senior government (including the federal government) categorical grant and formula assistance programs will sometimes prohibit or delay implementation.
2. Personnel restraints. The nature of certain TSM strategies is that they often require a high level of planning and design activity compared to their total cost. This means that some of the more complex projects may often have to be delayed to provide the necessary planning and design input. Similar limitations may be observed with respect to personnel needed for public relations, enforcement, and so on.
3. Institutional approval and coordination. Complex TSM strategies often involve numerous local and state government agencies. Such strategies are often necessarily costly in terms of effort and time required for approval and coordination.

Development of realistic annual TSM programs must consider these factors. Actual implementation, however, even after all approvals, funding, and planning have been accomplished, will usually depend on action agencies, often different from those with the main responsibility for planning and program development. This suggests as a minimum the active participation of action agencies in the planning and development of TSM programs. In many instances, such action agencies should bear the major responsibility for TSM, including planning and initiation. Implementation strategies then can be seen to be linked directly with the entire TSM process and thus must be custom designed for the communities affected.

IMPACT ASSESSMENT

The available knowledge about the relative effectiveness of various TSM actions varies widely. Program design requires some estimate of likely effectiveness. The level of rigor required in evaluation must be appropriate to the cost of the action and the scale of expected impacts. The need for systematic evaluation will be much less for cheaper strategies for which the cost of not knowing is less than the cost of finding out.

An important distinction between a TSM-oriented approach to providing transportation improvements and the typical capital-intensive approach is the potential for incrementalism and experimentation. Simple or isolated low-cost modifications of the existing infrastructure or the imposition of low-cost operation hardware, regulations, pricing, information, and other management devices offer the opportunity to develop a continuing cycle of improved design, implementation, testing, and modification without time- and resource-consuming simulation. In addition, such experimentation offers an opportunity to capitalize on increasing knowledge about the supply-demand interactions that constitute transportation system dynamics toward the end of advancing any particular current (or changing) set of local priorities, goals, or objectives.

In other cases in which a proposed TSM strategy is more expensive, more complex in application (such as strategy combinations), or more pervasive in expected impact, formal simulation and alternatives analysis will be useful. In the context of such improvement alternatives, the multiobjective approach will place a premium on a systematic process of goal and objective definition, derivation of appropriate measures of effectiveness, and evaluation methods that address the proper MOEs.

EVALUATION

The essence of evaluation is the comparison of objective-related costs and impacts, positive and negative, of each potential TSM alternative in a way that illustrates significant differences and similarities. The mix of impacts will vary by alternative and affect different groups (users or nonusers) and areas, leaving some losers and others gainers.

For some TSM projects and in some contexts, comparative evaluation can be a relatively simple process. As long as one TSM alternative action dominates others across all measures of effectiveness, the decision as to "best" is obvious—it is the alternative with more service and benefits and with less negative impact for a given investment. Very often, however, a more costly alternative has both more positive impacts and more negative impacts than another cheaper alternative; this is further complicated when certain types of impacts occur in one alternative but not in another. Then, dominance of one alternative is not at all clear, and selection of a "best" alternative depends on the relative importance given by the evaluator to one impact category versus another. Determining relative importance becomes particularly problematic when both monetary and nonquantifiable issues are involved.

Need for Trade-offs

Since the relative importance of impact categories and groups depends on values, evaluation is ultimately a political act; that is, selection of a "best" alternative depends on the evaluator's view of the relative importance of different cost and impact categories and his or her concept of an equitable distribution of impacts in society.

Evaluation becomes more complex when such trade-offs are implicit in selecting a best alternative. Many otherwise useful evaluation techniques lose their utility in these contexts. The transportation technical literature is replete with descriptions of evaluation approaches—benefit-cost analysis, ranking and rating techniques, objective weighted approaches, and various scoring approaches. The limitations of such approaches must be recognized. Key issues implicit in trade-offs among impact categories and among impact incidence on groups may be covered up by the desire to simplify into a "total score." Since various TSM alternatives can distribute their impacts differently so that some groups lose and others gain, use of a total score implies that different distributions of impacts do not matter. Such a simplistic approach fails to recognize that the often different or even conflicting interests in society legitimately deserve equitable treatment. Therefore, in most cases, the convenience of having a total score is outweighed by the loss of information about trade-offs involved in the choice among alternatives.

In addition, scoring techniques require the reduction of impact to dollar equivalents or numbers. Although this has the conceptual elegance of equivalence of measures as a useful technique, it is restricted in its inability to respond to noncostable or nonquantifiable positive or negative impacts. Even though a variety of approaches have been developed for converting nonmonetary and qualitative impacts to an abstract numerical rating, this approach violates fundamental rules of utility theory, decision theory, and common sense. Decisions must be based on differences among alternatives and not obscured by "uniform" evaluation techniques. Approaches that apply weight to various impact measures tend to substitute the technician's values for those of the decision maker and the various groups that may be impacted by the decision.

TSM Evaluation Framework Requirements

In such trade-off contexts, recent experience in transport planning suggests that several important conditions must be met in an overall TSM evaluation process:

1. All alternatives should be evaluated in a framework of common objectives, and measures of effectiveness should be derived from the objectives covering all significant impact areas;
2. The incidence and timing of impacts on groups and areas should be identified for all impact categories;
3. Standards or accepted impact significance thresholds for measures of effectiveness should be indicated where commonly accepted or required by law;
4. All measures of effectiveness should be treated at an equivalent level of detail and for equivalent area and temporal scales and expressed in the appropriate metric;
5. Uncertainties or probabilities or both should be expressed for each impact category; and
6. A sensitivity analysis of key impacts to a variation in the major dimensions of alternatives can be an important aid in understanding impacts.

Trade-off and Balance Sheet Approach

The class of evaluation approaches that satisfy the above conditions are known as balance sheet or trade-off methods. These approaches tend to display the impacts of plan alternatives to various individuals and groups for a broad range of impact categories. Within the balance sheet approach, impact categories can be stated in terms of measures of effectiveness (MOEs) with respect to a specific set of goals or objectives. Cost effectiveness or goal achievement can then be judged for any single goal or objective one at a time by comparing measures of effectiveness or impacts—positive or negative—with the cost of constructing or operating or doing both for a given alternative. Three types of costs and benefits are included: monetary impacts; quantitative but nonmonetary MOEs; and intangible MOEs, by which an alternative is judged to be either better or worse than another or rated as having subjectively determined negative or positive impact to varying degree.

The entire philosophy of balance sheet or evaluation account methods revolves around the notion that each reviewer of the data will superimpose his or her own set of values, or weights, on the information and reach aggregate judgments regarding the merits of the alternatives based on disaggregated data. Impacts may be allocated to various incidence groups in terms of the MOEs, but no attempt is made to derive total scores or rating of the alternatives. To some degree, the emphasis on nonscored alternative evaluation stems from the practical difficulty of determining techniques for relatively weighing the various categories of impact.

Each impact category or goal area may, of course, have one or more impact or effectiveness measures associated with it. Determining the impacts or cost effectiveness within each impact category in a balance sheet framework requires a single point of comparison. Use of a "do-nothing" base line broadens the scope of plan evaluation to include the potential choice of not constructing the subject project. In addition, when compared to making no investment, it provides a clear expression of the positive and negative impacts of any proposed project action.

Measures of Effectiveness

Measures of effectiveness play a critical role in evaluation of TSM plans as well as in post-operation reconfiguration of strategies to improve their effectiveness. Not only must MOEs be responsive to the complete range of relevant impacts, but they must also be carefully targeted on specific traffic and travel behavior variables that are the best indicators of effect. In addition, they must be clear and quantifiable as well as consistent with the data-handling and monitoring capabilities of the ultimate implementing local institution. Indeed, usable MOEs will provide the basis for the development of a structured, continuing TSM information system, which is the foundation on which an evolving program of TSM improvements must be built. In addition, considering the relatively crude state of knowledge about many TSM actions, monitoring and surveillance systems are especially important to provide the feedback needed to increase program effectiveness and, simultaneously, advance the state of the art.

Relevance Criteria

MOEs must be carefully designed to provide data to determine strategy effectiveness across a broad range of obective-related categories. To do so, they must be selected with both strategy dimensions (how strategies work) and objective indicators (what is effected) in mind. Good MOEs represent a compromise between these two concepts and must meet the following criteria.

1. They must defined as to target. Until recently, most research and evaluation in the field of traffic management and control dealt primarily with vehicular traffic flow performance and safety. It is essential to broaden the perspective of evaluation by considering multiple goals beyond mobility and safety. Many of these goals involve changing modal usage and occupancies. It is also essential to focus on people in vehicles—i.e., cars, car pools, van pools, taxis, buses, and trucks. Therefore, classifying traffic into its component vehicle subsets, each with its own unique set of attributes, is an essential prerequisite for determining the MOEs associated with different system objectives.
2. They must be responsive to the incidence of impact. Traditionally, traffic control system effectiveness has been viewed primarily from the perspective of the user of the system who is concerned with faster, safer, more reliable levels of transportation service at the lowest perceived cost. A comprehensive set of MOEs should also include measures meaningful to the transportation system operator and the nonuser, including both those most directly impacted by a TSM action and the public at large.
3. They must be characterized by geographic area of

application and influence. These may differ since measures of effectiveness must be formulated that are applicable to different scales of analyses. As a general rule, the larger the area of application of influence is, the less detail is appropriate in the MOEs used, and vice versa. For example, the impact of an areawide gas tax increase would probably be judged by areawide effects on vehicle travel and general levels of congestion rather than by changes in detailed flow characteristics on individual facilities. Conversely, the effects of a preferential traffic control scheme along one highway facility would be judged by MOEs related primarily to traffic flow characteristics on that facility and nearby ones to which traffic might be diverted and to mode choice in the corridor rather than to areawide measures.

4. They must be oriented to specific time periods and to specific finite lengths of time. These may vary and may be based on all day, peak hour, or weekly.
5. They must be directly or indirectly related to the objective. MOEs must be indicative of the primary or secondary travel behavior effects they are designed to induce. For example, an air quality MOE may require direct monitoring of air quality or be interpreted indirectly in terms of an algorithm incorporating vehicle-kilometers of travel, vehicle mix, and emission rates at various flow quality levels.
6. They must be formulated at a proper level of detail for type of analysis being performed. MOEs must be tailored for sensitivity at the appropriate scale for the planning analysis being undertaken. These may include the conceptual-level sketch planning in which many alternatives are being roughly screened, project feasibility planning in which a narrower set of alternatives are under scrutiny, detailed implementation design of a set of strategies, or evaluation of the operation of a set of implemented TSM strategies.

Technical Feasibility Criteria

In addition to criteria for evaluating the substantive relation of MOEs to impacts and impacts to objectives, a set of technical feasibility criteria must also be used to ensure that MOEs are practically useful in both simulation and in the field. Feasible MOE must meet the following criteria.

1. They must be quantifiable. Most objectives, by definition, are stated in terms such that system state changes toward or away from the objective can be measured. Although there are a few exceptions to this rule, it is important to structure MOEs in a manner that does not elude numerical representation. Often MOE proxies or indirect indicators will have to be employed for certain more qualitative objectives, such as aesthetics. Other objectives will be reflected in terms of composite MOEs. A classic example is congestion, which cannot be directly measured, but which can be determined in terms of a set of more specific measures of flow such as travel time, delay, or unscheduled stops.
2. They must be measurable in simulation and in the field. Both flow models and demand models have a limited number of variables by which strategy impacts can be measured to determine effectiveness. Measures of effectiveness related to flow and path must be derivable from the system performance variables of flow models such as delay, speed, stops, and volume. MOEs relating to trip timing, mode frequency, or destination must be derivable from the outputs of demand models—volumes on paths or travel times from point to point.
3. They must be practical in respect to field performance monitoring. To the extent possible, MOEs should be readily obtainable through direct field measurement or derivable from available or collected field data. Limitations on automated and manual field data collection place a premium on a few simple primary MOEs—especially those susceptible to automatic collection as an integral part of day-to-day traffic and transit control and operations.
4. They must be based on sensitive indicators. Accurate targeting on the system variables directly impacted by a strategy will ensure maximum sensitivity in effectiveness measures. Strategies can be used to judge the variable of travel behavior most likely to yield a robust indicator. Often the most sensitive indicator for certain objectives will be a combination of MOEs, since certain system characteristics such as volume, by themselves, without other indicators (such as speed or delay characteristics), may not be sufficient.
5. They must be statistically efficient. The question of how large a sample is needed in order to estimate a system parameter with specified level of statistical precision is an important cost consideration.
6. They must avoid redundancy. Given the potentially large number of MOEs, it is desirable to use common MOEs for multiple objectives if they are not inconsistent with the other criteria.

Effectiveness in Respect to Demand

No set of MOEs of urban transportation performance can be properly understood unless they are accompanied by a fundamental measure of travel demand. In the case of personal travel, demand is probably best measured as person-kilometers of travel within given time and space boundaries. Even if the main emphasis of TSM is to maximize effectiveness for a given set of person trip origins and destinations (i.e., fixed person-kilometers of travel demand), it is essential to formulate an evaluation framework in which demand can be different for two or more data sets being compared. This is essential because travel demand will be different for comparison data sets for several reasons.

1. Travel demand changes over time and space will include changes owing to random variability, seasonal fluctuations, population growth or decline, or major land use additions.
2. Travel demand changes due to external forces that are outside the control of the transportation system operator (e.g., gas prices and taxes, gas scarcity, economic recession).
3. Demand is sensitive to improvements in system supply. TSM actions constitute improvements in system supply from the perspective of the user. Effectiveness is increased for the user for a given level of travel demand, or more travel demand can be serviced at a particular level of effectiveness. By definition, significant TSM improvements in the system will induce significant increases in demand, and the part of this demand unrelated to locational choice will occur quite quickly.
4. Demand is also sensitive to degradations of supply; some TSM actions may constitute such degradations from the transportation user perspective (e.g., transportation price increases and traffic restraint measures) in order to achieve broader objectives, including ones of interest to the general public or the operator of the transportation system. If the system supply is degraded significantly (e.g., effectiveness perceived by the user is reduced for a given level of travel demand), then demand will decrease. Some TSM actions may be designed to restrain the growth of travel demand over time; in other words, TSM strategies may be used to reduce some future level of travel demand that otherwise would have occurred.
5. Some essential personal travel demand goes un-

satisfied because of unavailability of needed transportation services, insufficient funds, or lack of knowledge of available transportation services, and these can be considered latent demands. TSM actions of the type directed at improving transportation for the elderly, handicapped, and poor are examples of actions that transform latent demands into realized demands.

For all the reasons discussed above, it can only be concluded that travel demand will change, both as a result of TSM actions implemented and because of external forces. Therefore, travel demand must be measured and related to the array of measures of effectiveness in order to understand what is happening to system performance and why.

MOES AND OBJECTIVES

MOEs must be developed for each objective of interest. A partial listing of some of the objectives and associated MOEs is given in Table 2. For each entry on the final list of MOEs, an entry can be indicated for the criteria areas outlined above. This stratification permits the full range of potential MOEs to be reviewed and compared. With the controlling criteria being the objective with which an MOE is associated, each MOE must be

Table 2. TSM objectives and measures of effectiveness.

TSM Objective	Measures of Effectiveness
Improve level of service of urban travel	Total travel time in person hours Weighted average speed for person travel Total delay time in person hours Total number of unscheduled person stops
Improve reliability of urban travel	Variance of individual travel times between selected points (intraday) Variance of individual trip times (interday) Percentage of scheduled transit stops within "on-time" tolerance limits
Provide attractive alternatives to driving private automobiles	Total number of riders Mode-split percentages Average occupancy per vehicle trip Average occupancy per vehicle-kilometer Number of seat-kilometers of transit or paratransit in service Percentage of population within certain distance (walking distance) of scheduled transit service at home and at work Percentage of person trips with transit travel time no more than a certain number of minutes greater than automobile travel times Percentage of population to whom specified paratransit services are available
Provide good quality, affordable transportation services to the elderly, handicapped, poor, and very young	Percentage of special group population to whom any specialized transportation services are available Percentage of special group disposable income expended on transportation Average difference between travel time via mode provided versus automobile travel time
Improve facilities for nonmotorized travel modes (pedestrian, bicycle)	Total kilometers of improved bicycle or pedestrian pathways Total person-kilometers of travel by pedestrian bicyclists Percentage of population with continuous pathways from home to shopping places Percentage of school children with continuous pathways from home to school
Reduce the occurrence of traffic accidents	Total number of motor vehicle accidents Number of accidents per million vehicle-kilometers Number of accidents per million person-kilometers
Reduce the injuries and deaths resulting from traffic accidents	Total number of injuries or fatalities Number of injuries or fatalities per million vehicle-kilometers Number of injuries or fatalities per hundred person-kilometers Total number of pedestrian or bicycle injuries or fatalities
Improve personal security of urban travelers	Number of victims of crimes (by classification) while persons are traveling by different modes (particularly related to transit and paratransit modes and parking facilities) Victims of crimes per million person trips
Reduce automotive emissions and impacts	Grams of carbon monoxide, hydrocarbons, and nitrogen oxides emitted Grams of emittants per vehicle-kilometer Grams of emittants per person-kilometer Concentrations of emittants at different points Areawide air pollutant concentration indexes
Reduce noise and vibration impacts	Noise levels at different distances from transportation facilities Percentage of residents subjected to noise levels exceeding specified tolerance limits Frequency and magnitude of vibrations at different distances from transportation facilities Percentage of residents subjected to vibration levels exceeding specified tolerance levels
Reduce fuel consumed in satisfying urban travel demands	Gasoline and diesel fuel consumed Average fuel economy in vehicle-kilometers per liter Average fuel economy in person-kilometers per liter
Increase the person and goods movement capacity of existing facilities	Vehicle capacity at key points on facilities in equivalent passenger car units per hour Passenger capacity at key points on facilities in persons per hour Service rate along selected lengths of facilities in person-kilometers of travel per hour at specified levels of service Service rate in a network of facilities in person-kilometers of travel per hour at specified levels of service
Reduce personal costs of urban travel (out-of-pocket costs, exclusive of taxes)	Annual user costs per capita Total annual user costs Travel costs per person-kilometer Travel costs per person trip Percentage of disposable income used for urban transportation
Reduce public cost of urban transportation systems	Net annual cost of ownership and operation of transportation facilities by mode (total cost less direct fares, toll revenues, and parking charges) Net annual cost per capita for urban area Percentage of urban area public expenditures on transportation

Table 3. Hierarchical approach to urban transportation analysis.

Geographic Scale	Nature of Analysis	Level of Detail of MOE		
		Vehicular	Spatial	Temporal
Areawide	Conceptual evaluation	Modes	Network, subwork	Daily, typical, peak, and off-peak periods
Subarea or corridor	Feasibility study	Stream flow characteristics	Major route and intersection	Hourly distribution
Facility or spot	Design or operations analysis	Individual vehicle behavior	All links and intersections; individual lanes	Shorter time interval distribution (e.g., 15 min)

reviewed objective by objective.

Care must be taken to include variations on single MOEs that differ only by mode target, time or range of measurement, geographic scale, or level of detail. Many MOEs will have subvariants that can be used to respond to different objectives. In addition, certain MOEs can be normalized by person-kilometer to control possible demand variations. In each case, the most robust and clear MOE must be sought in respect to each objective. Direct relevance must, of course, be traded off against the technical computational and data collection-related feasibility issues. The criteria cited above will aid in the selection process.

MOEs for Mobility, User Costs, and Safety

Simulating mobility impacts of TSM strategies represents the most advanced aspect of the present state of the art. The general approach is to model demand characteristics on the one hand and traffic flow properties on the other. Strategies are introduced in terms of modified network and traffic control characteristics that may influence travel demand or traffic flow. These two modeling procedures, when coupled, will yield direct measures of person or vehicle trips for different purposes by various scales of origin-destination pairs in various time periods, number of trips by given paths, use of mode and automobile occupancy, speeds and volumes of various vehicle types by link, performance, and various means of congestion. The spatial, temporal, purpose, and market segment breakdowns possible within the proposed base data permit the incidence of most mobility impacts to be determined.

Important hierarchical characteristics of the approach are the geographic scale and the level of detail of analysis of a TSM strategy. These two stratification variables are closely correlated and directly affect the level of detail of MOEs that should be used, as shown by the example hierarchy given in Table 3.

Combining known socioeconomic characteristics with the simulation of demand and flow can result in a relatively rich description of the TSM strategy impacts on a wide variety of service measures. User cost information is easily derivable from the time, distance, and mode information, and safety impacts can be generated by correlating historical accident data by facility, location, and traffic characteristics with the output of simulation.

MOEs for Transportation-Related Impacts

The available methods for measuring environmental and energy factors associated with traffic characteristics can be broken down into the two broad categories of direct and indirect methods. Direct methods refer to those requiring field measurement by using instruments or other devices, data analysis, and interpretation of measurement results. However, the general approach taken in most studies of transportation-related impacts is to determine the fundamental traffic flow characteristic impacts such as traffic volumes, modal composition, and travel times directly and then compute other impacts of these traffic effects indirectly from traffic data by using statistical estimating relations, computer simulation models, nomographs, or table look-ups. Such an approach appears to be a valid way to estimate MOEs that are indicative of impacts such as emissions, energy consumption, and noise.

Simulation Techniques

The complexity of the challenge facing TSM arises out of the large number of potential strategies and the substantial gaps in state-of-the-art knowledge about their characteristics and effectiveness with respect to a broadened range of goals. Cost-effective application depends on an increased understanding of the relative impacts of various strategies in different combinations in terms of a sensitive (and efficient) number of measures of effectiveness. In larger cities and regions where there are significant potentials for the complete range of TSM strategies, considerable economies can be achieved through evaluation and screening of strategies via simulation prior to implementation. However, the simulation process must replicate, as closely as possible, the actual impact of the strategy on system performance and travel behavior.

Travel path, time of day, mode, and traffic flow characteristics are the primary travel behavior attributes that are affected in the short term by TSM actions. Trip distribution and frequency are attributes that will be impacted as TSM actions are implemented on a sustained basis. Given that these six aspects of travel will be modified by TSM strategies, the models used to produce quantitative MOE values must be structured to simulate these travel behavioral characteristics. This requires simulation that can respond both at the microscale to the flow and path impacts of traffic controls and at the macroscale to the mode and trip-making impacts of other strategies.

Current practice tends to treat these travel characteristics by different concepts. Trip frequency, destination, mode, and, in part, time of day choices are dealt with in the generic group of travel demand models. Path and flow are considered from a different viewpoint and fall into a generic grouping of traffic flow and path models. The simulation requirements can be met by combining travel demand and traffic flow models that have the appropriate characteristics into a simulation framework that can flexibly respond to various TSM strategy impacts. These models and networks must be carefully interfaced to simulate the results in time and space of various strategy combinations so that derived measures of effectiveness will provide a meaningful evaluation of strategy impacts for each major objective. There are numerous analytical techniques (models) available within each of the generic model groupings. In each case, however, the nature of TSM strategies and actions precludes the use of all but a very few of these, if valid estimates of the desired MOEs are to be obtained. The critical evaluation of alternative TSM strategies requires a demand forecasting procedure that is

1. Sensitive to a diverse and complex set of changes in transport system supply (level of service) that are differentiated spatially and temporally;
2. Capable of explicitly predicting changes in the full dimension of travel and mobility choice—work trip mode and route choice, nonwork frequency (generation), destination (distribution), mode and route choice, and household automobile ownership levels; and
3. Capable of forecasting demand by identifiable market segments.

These requirements suggest strongly the use of a behavioral, disaggregate simultaneous model with direct forecasting. There is an extensive literature describing models that fit this description.

To respond to TSM strategies, a flow model should

1. Respond to the complete range of street (physical and operational) characteristics including turning restrictions, channelization, and signalization;
2. Incorporate origin-destination capability along with minimum time path assignment;
3. Be capable of treating platoons or individual vehicles;
4. Incorporate simulation of buses, car pools, and priority measures;
5. Be capable of handling a large network; and
6. Contain a full range of output measures.

Several flow models exist that exhibit most or all of these properties and are described in the transportation literature.

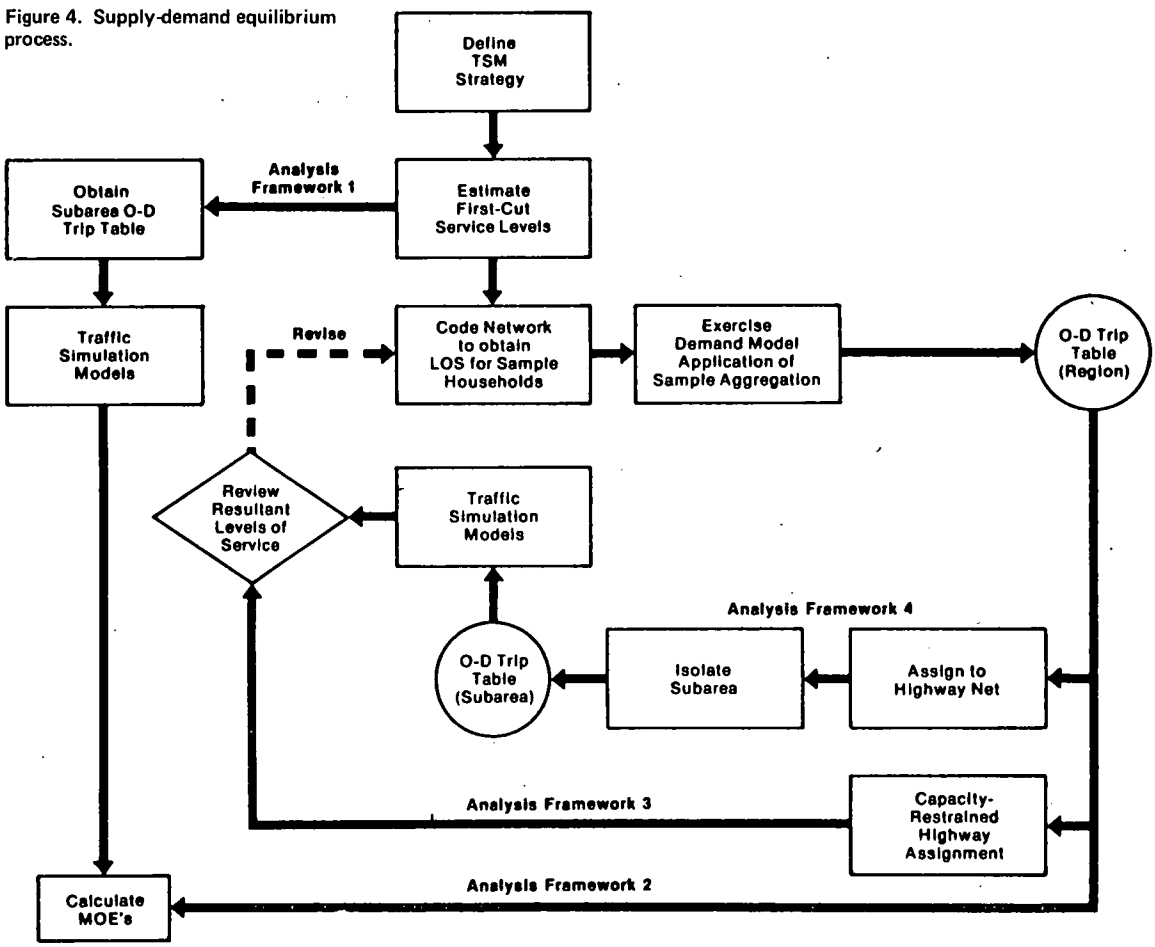
Since transportation is an equilibrium process, the feedback between supply and demand over the network must be accommodated in the simulation. A particular TSM policy may cause link volume changes, which in turn impact travel conditions and consequently demand itself. Depending on the TSM strategy to be tested, flow and demand models may be used separately, or in combination. Table 4 suggests alternative analysis approaches depending on TSM strategy, expected impact scale and type, and the network condition. The four analysis frameworks are outlined below and diagrammed in Figure 4.

1. Detailed flow simulation involves a detailed flow simulation of TSM alternatives that are characterized

Table 4. Alternative analysis approaches.

Strategy	Impact Scale	Anticipated Behavior Affect	Supply Condition	Analysis Approach
Localized signal strategy Channelization Right-turn-on-red Reserved lanes	Local	Flow, path	Congested	Detailed flow only
Pooking incentives Regional pricing Speed limits Fares	Regional	Mode, distribution	Uncongested	Regional demand only
Parking pricing Staggered hours	Regional	Path, mode, distribution	Congested	Regional demand and assignment
Automobile-restricted zone Ramp metering Freeway corridor strategy Transit operations and planning	Local	Path, mode, distribution	Congested	Regional demand and assignment and detailed flow

Figure 4. Supply-demand equilibrium process.



by localized impacts. Examples of this class of TSM strategies include computerized signal control systems on specific arterial segments, selective street widening and channelization, and implementation of right-turn-on-red controls at selected intersections. Because the area of impact is small and the strategies are primarily designed to improve traffic flow performance, this analysis framework focuses in detail on a simulation of vehicular movement with the impacted subarea. As shown in Figure 4, the input to this analysis framework is a (fixed) origin-destination trip table. The detailed flow simulation model selected depends on the specific characteristics of a proposed alternative. Most flow simulation models allow for a detailed and realistic determination of travel time statistics, vehicle travel, stops, delay, and other measures of vehicle type. These model outputs are directly used in the computation of TSM measures of effectiveness.

2. Regionwide demand prediction involves regionwide (and possible nonnetwork) impacts. Examples here are paratransit and car-pool and van-pool incentive programs, gasoline and vehicle tax policies, coordinated regionwide speed limit (maximum and minimum) policies, and off-peak transit fare reductions. The primary impact of these policies is on the patterns of resulting demand, i.e., mode choice, distribution, and generation of trips. Accordingly, the focus of this analysis framework is on the prediction of demand. As shown in Figure 4, the input to this analysis framework is a set of levels of service and other parameters characterizing a TSM strategy for a random sample of households in the region. The disaggregate predictions of individual household travel behavior in response to a given TSM strategy are then aggregated up to regionwide travel demands. No network assignments need be made because these strategies do not result in localized changes in traffic flows. The advantage of this approach is that it facilitates the evaluation of regionwide programs without necessitating the costly equilibration of demand and network assignment and path simulation models. However, it should be stressed that this analysis approach is not suitable for the evaluation of situations where significant demand shifts may occur in highly congested networks. Where significant demand and supply interaction is anticipated, one of the two remaining analysis frameworks must be employed.

3. Demand prediction and network assignment form an analysis framework that is best suited to evaluating the impacts of programs that significantly impact large, congested areas. This approach differs from the previously described analysis framework in that, after demand levels are predicted based on first-cut assumed levels of service, the aggregate flows are loaded on transport networks, and capacity-restrained assignment techniques are used to update link travel times. The revised travel time data are used to repredict travel demands, and the iteration process is continued until network equilibrium is obtained. This analysis framework would be used in cases in which the impact area is too large to be coded and simulated by using detailed path flow models. However, the use of capacity-restrained assignment techniques in an iterative fashion with the disaggregate demand models should provide realistic analysis results for programs that affect large, congested areas.

4. Demand prediction and flow simulation form a framework for TSM strategies (or strategy composites) that may be expected to radically alter the supply characteristics (and the consequent modal demands and trip distribution) in relatively small areas. Examples include the imposition of an automobile-restricted zone, congestion pricing on selected freeways, or ramp metering. These policies require a more detailed representation of system supply than that provided in most network assignment routines. Moreover, the scale of these actions makes it feasible to employ the detailed path simulation models. Accordingly, this analysis framework involves the interaction of the previously described demand models and path flow models. These demands are first predicted by using an assumed first-cut network level of service. The predicted flows are then assigned to a representative highway network, and link flows on the TSM-impacted subarea are isolated. These flows are then input to an appropriate traffic (path) simulation model to determine detailed level-of-service information. The entire process—demand prediction, network assignment, and traffic simulation—is repeated until network equilibrium is achieved.

Several comments are in order regarding this proposed procedure. First, not all of the previously discussed demand models need be applied in this iterative process. For example, for many of the strategies, it may be appropriate to focus solely on work-trip, mode-split behavior only. Second, the procedure can be straightforwardly applied to either an areawide or corridor analysis. Moreover, the representative sample used for mode estimation and forecasting need not be strictly random. A disproportionately high number of observations may be drawn from zones with low trip productions to ensure an adequate number of data points. Sampling in this way (stratified sampling) has been shown not to bias estimated model parameters. For aggregate forecasting, unbiased results can be obtained by factoring the aggregated forecasts by the appropriate zone-specific sampling rates. Third, the outputs from this procedure are a set of equilibrium travel flows, travel volumes by mode, purpose at origin and destination, and corresponding equilibrium level of service. As indicated earlier, the travel flows can be disaggregated into any desired set of market segments and used directly in the derivation of measures of effectiveness of the TSM strategies.

The simulation approach outlined above in combination with the state-of-the-art flow and demand models represents an ambitious approach not yet undertaken. However, it offers the most systematic framework available to pretesting a broad range of TSM strategies.

MONITORING AND SURVEILLANCE

Although the requirements for formal transportation planning in U.S. cities have been established since 1962 and procedures and planning methods have been established for virtually all aspects of the long-range process, relatively little has been done toward development of a formalized system monitoring process. The usefulness of such a process is well established since it would provide information on changes in system performance over time and if augmented in special situations provide better insight into the effects of system supply changes. The need for monitoring in a TSM program is even greater, however, since the development of annual TSM programs will depend in part on noting those deteriorating aspects of system performance that need TSM attention; and, just as important, the lack of knowledge concerning the impacts of various TSM actions makes it imperative that monitoring systems and special impact studies be conducted as required.

Whether through judgment or formal simulation and evaluation, the promising strategies must be identified along with the required capabilities for monitoring and surveillance. Surveillance is especially important given the potential to adjust many TSM improvements.

Indeed, one of the advantages of the low-cost, operational aspects of many TSM actions is the possibility of very short cycles between implementation, testing, and modification. In addition, a surveillance program will provide feedback to improve the state-of-the-art knowledge about relative TSM action effectiveness. Data requirements for field monitoring must be identified and collection feasibility and cost determined so that trade-offs between the sensitivity of MOEs and their cost and accuracy can be assessed. The data collection methodologies must be subjected to real-world tests to verify analytic approaches and revise MOEs as necessary. TSM actions and MOEs by which they are judged have varying scales of application and levels of detail. The data collection methodology must conform to basic hierarchical concepts outlined earlier. Key questions for field monitoring and surveillance effort are how, where, and when to make the measurements.

1. Should data be collected by fixed automatic surveillance systems, portable automatic devices, manual observations, or from records of others?
2. For how many and which locations are data needed? Should these be the same set of locations each time measurements are made?
3. Are data needed continuously, weekly, monthly, quarterly, annually, or only before and after actions?
4. In what time units should data be recorded?

AREAWIDE DATA COLLECTION METHODOLOGY

Only a few of the TSM strategies need to be applied in a total areawide context (e.g., vehicle and gas taxes, transit fare changes, public information). Areawide actions tend to be ones that are aimed at changing total vehicular travel demand. These can best be evaluated by using behavioral travel demand forecasting models rather than by measuring system performance in the field. Although most TSM strategies will be planned, designed, and evaluated for a particular corridor or subarea, areawide measurement and evaluation are of interest for several reasons: evaluation of areawide effects of a total program, even though it is applied in a large set of smaller scale projects; evaluation of the impacts of external events whose locations and times of occurrence are unpredictable; and use of areawide measures as a control case when specialized TSM strategies are evaluated in only a small number of selected areas or corridors.

In areawide evaluation, the questions are very macroscopic. For example, total area statistics on the following types of traffic measures might be of interest: total vehicle trips and travel distances by vehicle classification, total person trips and travel distances by trip purpose, mode-split percentages, overall average speed, overall average automobile occupancies, and hourly and daily distributions of traffic.

Several approaches to direct areawide measurement can be considered. Most of these involve random or quasi-random selection of locations or entities to survey repeatedly.

1. Random survey links could be selected throughout the urban areas. Measurements of traffic flow characteristics would be made repeatedly on these links. Some data could be collected automatically (e.g., speeds, volume, percentage of occupancy), but other data would require manual observation (e.g., vehicle classification and vehicle occupancy). The automatic data could be connected by communication devices to a central data facility. The frequency of data collection at each location would depend on the type of variable and on whether manual or automatic sensing was used. Paired comparisons of links and other appropriate statistical methods would be used to determine the relative degree of changes in traffic characteristics.
2. Random test sections of a given length would be selected on streets and freeways throughout the urban area. Traffic performance data would be recorded repeatedly on these routes. Speed and delay data would be collected by using floating car methods. Volume count, classification data, and vehicle occupancies would be observed simultaneously.
3. Instrumentation in private automobiles would be furnished, and trip characteristics data would be automatically recorded on a frequent basis. Automobiles would be randomly selected, and special arrangements and instructions for the owner-driver of the automobiles would be needed. The concept is to record performance statistics on typical automobile usage and level of service. Other means would be needed to obtain data for other modes.
4. Randomly selected households would be periodically surveyed to obtain travel data for all members. If the same households were repeatedly surveyed, parts could be self-administered. Such a scheme could be combined with the instrumented private automobile technique.
5. Randomly selected parking facilities could be repeatedly surveyed to determine changes in total parking demand, time distribution of demand, and vehicle occupancies.

SUBAREA OR CORRIDOR DATA COLLECTION METHODOLOGY

Most TSM strategies are currently planned and implemented for a subarea or corridor or their subcomponents rather than for a total urban area. Subarea or corridor TSM evaluations will often necessitate measurements of changes in traffic flow quality on given paths, changes in the distribution of demand on paths and time of day, and changes in mode. More detailed data will be needed to evaluate all these elements of performance.

The choice of volume data collection method will depend to some degree on what periods of time the data are required. If repetitive counts are needed for an extended period of time at a given location, consideration might be given to the use of automatic sensing and recording. On the other hand, if counts are needed only during short periods of the day for only a few days at a given location, manual counting methods might be more appropriate, especially if some other data requiring direct observation (such as vehicle classification or vehicle occupancy) were needed simultaneously. The choice of measurement technique is often determined by the choice of time and location sampling scheme. If volumes (including turns) at many different intersections are required, then manual counts could be used; if total volumes on different links are needed, portable counters might be the best measurement tool.

A large number of time and location sampling schemes can be devised. For example, a street network might consist of hundreds or even thousands of intersections, links, or unique travel routes. Obviously, not all of them can be sampled. The problem is to determine how many and which ones should be sampled to provide a sufficiently large and representative sample of the total network. An important step is to establish the time and space dimension boundaries within which to measure system performance. The concept of planning for and applying TSM strategies on a corridor and subarea basis, in addition to areawide planning, neces-

sitate defining the boundaries of the area of application and zone of influence of TSM strategies. Then within those boundaries, alternative plans for sampling performance at different locations are devised. Certain parts of the corridor (e.g., closer to the CBD) or certain classes of facilities (e.g., freeways versus surface arterials) may be considered of greater significance or may be more directly impacted by the range of alternative under study. If so, then a purely random selection of locations to collect data would not suffice; it would be necessary first to stratify the network into parts with varying associated importance factors and then sample more heavily in more important locations.

The question of how many locations to sample must then be answered. The sample size-precision interrelations can be estimated theoretically if reasonably valid assumptions can be made about the underlying distribution of traffic variables of interest across all locations. Similarly, time boundaries can be established by considering factors such as how long the response time is for the kinds of TSM strategies under consideration, whether seasonal variations in system performance are significant, whether general levels of areawide transportation system effectiveness are of concern or impacts of specific TSM actions are being measured, and whether travel during certain hours of the day or total daily travel is of interest. After these general time boundaries have been defined, then the alternative sampling plans within these boundaries can be defined.

In some larger cities, automated capabilities for surveillance and control systems already exist and could be used to test new and additional TSM measures in prototype application. Many cities in the United States have installed or are installing automatic surveillance and control systems in signalized arterial intersection networks. A few, like Washington, D.C., have a concentration of sensing capability and evaluation processing programs and procedures that provide evaluation comparisons of fine differences in traffic performance for alternative signal control algorithms. Similar technology is used in a few major cities for freeway surveillance and control. The most comprehensive systems are in Los Angeles, Dallas, Houston, Minneapolis, New York City, and Chicago.

A basic deficiency in all of these network evaluation efforts is that MOEs have been stated in vehicle units rather than in person units or some other vehicle value units. The UTCS/BPS in Washington, D.C., has detectorized bus priority links (lanes), and performance on these links can and was separately evaluated to show the trade-off of bus delays and general traffic delays when bus priority schemes are in operation. In general, however, little rigorous attention has been given to value discrimination between vehicle types and occupancy levels. UMTA is engaged in research on methodology for automatic counting devices on transit vehicles to yield data on passenger occupancy, boarding, and alighting. Research and development currently being conducted on areawide automatic vehicle monitoring methods may result in more sophisticated techniques for direct measurement of buses in a mixed traffic stream. For the near term, however, reliance on manual observation of bus travel times, loads, and schedule adherence will continue.

TSM PROGRAM DEVELOPMENT NEEDS

The rationale for TSM as the primary focus of future transportation planning is compelling. Efforts to understand and exploit its full potential are just beginning. Institutional experience and habits with components of TSM may tend to inhibit a comprehensive approach. The role of the metropolitan planning organizations (MPOs) and other local institutional actors in developing coordinated TSM programs is unclear. It is likely that different regions will evolve their own relations and procedures for program development and implementation.

In each case, however, there is a need for increased knowledge through formal development of the TSM planning state of the art. The apparent gaps in substantive knowledge and available techniques for developing effective TSM programs for any institutional context call for a coordinated program of research and demonstration in combination with a systematic attempt to monitor and codify the experience gained at the local level. Such an effort will require close cooperation between local government, MPOs, state transportation departments, and the federal institutions responsible for transportation-related planning. To improve the technical capability to carry out continuing TSM planning, several state-of-the-art improvements are needed.

First, more efficient use of the existing urban transportation system implies combinations of traffic engineering, transit operations, and transportation management into TSM strategies; the narrow focus of traditional traffic engineering transit operations is no longer appropriate. A comprehensive and systematic strategy must focus on moving people and goods—not on moving only vehicles. Research and field experience are needed to characterize the broad range of possible TSM strategies and combinations for both transportation and nontransportation objectives.

Second, hypotheses about the impact of combined TSM strategies must be carefully refined through actual application and analysis so that resources can be directed toward those actions that demonstrate substantial effectiveness with respect to transportation and related objectives. Although traffic flow will remain an important measure of mobility, a comprehensive but efficient set of measures of effectiveness must be designed to evaluate the ability of TSM strategies to produce positive benefits in the areas of safety, air pollution, energy use, environmental and community disruption, and public and private economics.

Third, combined strategies and MOEs must be tested in demonstration contexts so that reliable and valid performance data are produced and the most promising strategies are identified for use at the local level. Cost-effective application depends on an increased understanding of the relative impacts of various strategies in different combinations in terms of a sensitive (and efficient) number of measures of effectiveness. For simple TSM actions, analysis of current experience for its transferability and the development of generalized warrants for TSM strategy application may be possible. In the case of more complex strategies, considerable economies may be achieved through evaluation and screening by simulation before implementation. A wide range of methods and techniques, both computer-assisted and non-computer-based, currently exist and appear to be applicable to TSM planning activities. This is so because the concept of TSM itself is so broad, cutting across many specialized transportation disciplines including transportation planning, transit operations, traffic engineering, transport service regulation, and finance and pricing policy. The methods and techniques in use and under development by all these types of specialists, individually, are considered pertinent to the diverse aspects of TSM planning.

Fourth, research findings on both relative strategy effectiveness and MOE robustness must be continually subjected to the test of transferability to real-world

conditions, with appropriate attention to data collection requirements, strategy feasibility, and local capabilities. Results of this process can then be translated into usable guidelines for local planners and engineers as well as an agenda for continuing research and development activities.

The transition from the traditional approach to TSM may be one of such fundamental proportions that it will not take place quickly but may take a decade or more, with the shift being more evolutionary than revolutionary. The coordination of many small-scale actions toward objectives agreed on in a multi-institutional context poses a far greater challenge than did the implementation of large-scale, capital-intensive projects. During this transition one must, of course, necessarily look for those second best solutions that experience shows will work in the short run. However, capturing the full potential of TSM requires selecting those actions that at the same time will move us another increment toward the more normative process described in this paper.

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PACKAGING TRANSPORTATION ELEMENTS TO MEET ENERGY GOALS

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The need to consider energy in the development of transportation plans and programs is a relatively new development. The relation between the national energy problem and state and local actions is not widely understood. This paper discusses the Federal Energy Administration's program to support the development and implementation of state energy conservation plans and describes the required and optional transportation elements of such plans. It identifies various actions that can be instituted at the state, local, and regional levels. Finally, it discusses the trade-offs that may have to be made in developing the transportation programs to meet energy, air quality, and other objectives.

An effective transportation energy conservation program will require not only expanded efforts to develop and bring on line more energy-efficient technology but also concerted initiatives to bring about the institutional changes needed for the most efficient use of existing technology. A number of programs are under way to develop more energy-efficient transportation technology; nontechnology programs are less numerous. The program of the U.S. Department of Transportation to encourage the development of transportation system management (TSM) plans at the local level is one such program that will be an important test of the ability of governmental institutions to respond to the problems that confront our nation.

THE CASE FOR CONSERVATION

Until the late 1940s, the United States was a net exporter of petroleum. During the next 25 years, we gradually became more and more dependent on foreign petroleum because the use of foreign petroleum, which was cheaper to produce than increasingly scarce domestic oil, enabled the United States to maintain an expanding economy with minimal inflationary impacts.

In the 5-year period ending in 1965, real energy costs in this country decreased by 3 percent. Energy costs, measured in constant dollars per joule, declined by 8 percent between 1965 and 1970 and by 9.5 percent between 1970 and 1973. Small wonder that the warnings of an impending energy crisis fell on deaf ears! During this 13-year period, the United States went from importing less than 0.32 Mm^3 (2 million barrels) of oil per day to importing about 1.03 Mm^3 (6.5 million barrels), 38 percent of domestic consumption. Domestic production peaked in 1970 and has been declining ever since.

In 1973 the rules changed. The oil producers found that our dependency had reached such a level that we had no option but to pay a fourfold price increase. The result was an Arab oil embargo that caused the loss of 500 000 jobs and $10 billion to $20 billion in gross national product. The embargo was followed by the price increase that raised our negative balance of payments for petroleum to $27 billion in 1975 (it was less than $4 billion 4 years earlier), enough money to generate more than a million new jobs and significant industrial expansion had it been spent within the United States.

Our economy has not responded well to these new realities. In the first 7 months of 1973, 39.6 percent of the crude oil used in this country (in the form of refined products) was imported; in the first 7 months of 1976, 45 percent was imported. Domestic production fell 1.48 Mm^3/day (9.3 million barrels) from January through July 1973 to 1.30 Mm^3/day (8.2 million barrels) for the same period in 1976. During the week of March 12, 1976, for the first time in our history, we imported more than half of the petroleum we used. In 1973, less than half of our imports came from the OPEC countries; today about two-thirds of our imports are from OPEC countries. Canada, once considered a dependable supplier, announced a program to cut off all exports during the next few years. We imported 1.03 Mm^3/day (6.5 million barrels) before the embargo; by the end of 1977, if current trends continue, we will probably be importing more than 1.35 Mm^3/day (8.5 million barrels).

Gasoline is the primary fuel used for transportation. An average of 1.05 Mm^3 (6.6 million barrels) of gasoline were used each day during the 7-month period from January to July 1973. The daily average was 1.02 Mm^3 (6.4 million barrels) for the same period in 1974, 105 Mm^3 (6.6 million barrels) for the same period in 1975, and 1.10 Mm^3 (6.9 million barrels) for the same period in 1976. The 1976 amount is 4.1 percent higher than that in 1975 and is equal to the pre-embargo levels of growth in gasoline demand in spite of the fact that the average fuel economy of new cars was 13 percent higher in 1976 than in 1975.

The trends, then, are all in the wrong directions: Consumption (especially gasoline) is growing, domestic

production is declining, and imports are increasing. The vulnerability of our economy to price and supply disruptions is, and will continue to be during the next few years, greater than it was in 1973. At one time, our energy policy was aimed at eliminating imports by 1985. Our current goals are much lower: to reduce our 1985 vulnerability to levels at which we will be able to cope should another supply or price disruption occur.

A 1985 situation can be constructed with the following assumptions: (a) Oil and gas deregulation occurs during the next few years; (b) the world price of oil, in constant 1975 dollars, rises to $\$82/m^3$ ($13/barrel); (c) moderately optimistic projections of exploitable oil reserves and recovery technology improvements prove to be valid; and (d) present provisions of the federal tax code that affect crude oil economics remain unchanged. The 1985 situation would then be something like this: Petroleum consumption—including natural gas liquids (NGL)—will have increased from the current level of 2.66 to 3.29 Mm^3/day (16.7 million to 20.7 million barrels), domestic production (including NGL) will have increased from the present 1.56 to 2.34 Mm^3/day (9.8 million to 14.7 million barrels), and petroleum imports (including NGL) will have decreased from the current level of 1.11 to 0.95 Mm^3/day (7.0 million to 6.0 million barrels), almost as much as we were importing before the embargo. Obviously, energy will continue to be a major national problem.

Even with the automobile fuel economy standards mandated by the Energy Policy and Conservation Act of 1975, petroleum requirements for transportation will continue to grow from 1.43 Mm^3/day (9 million barrels) in 1974 to approximately 1.83 Mm^3/day (11.5 million barrels) in 1985, still more than half of U.S. demand for petroleum.

Because of its importance as a petroleum consumer, the transportation sector will have an important role in our national energy conservation program. Urban transportation accounts for more than 40 percent of that consumption, and therefore policies and programs developed for urban transportation will have a major impact on whether the United States is able to deal effectively with its energy problem during the next 15 years.

Since the embargo in the fall of 1973, the significant amount of energy legislation enacted has focused primarily on establishing national policies and programs for developing new energy sources and making more efficient use of the existing ones. The Emergency Highway Energy Conservation Act of 1974 made federal-aid highway funds available, at a 90 percent-10 percent matching rate, for funding ride-sharing projects. The Federal Energy Administration (FEA) was established by the Federal Energy Administration Act of 1974. The authorities given to FEA were to advise the president and the Congress on the establishment of a comprehensive national energy policy and to develop and implement programs to promote energy conservation. The Energy Supply and Environmental Coordination Act of 1974 (a) extended the emission standards for 1975 model-year cars through model-year 1976; (b) required the U.S. Department of Transportation and Environmental Protection Agency, in consultation with FEA, the Council on Environmental Quality, and the U.S. Department of Treasury, to study the practicability of a 1980 automobile fuel economy improvement standard of 20 percent; and (c) prohibited EPA from requiring states to impose parking surcharges as part of their transportation control plans.

STATE ENERGY CONSERVATION PLANS

The first relatively comprehensive law regarding energy was the Energy Policy and Conservation Act (EPCA) signed by President Ford on December 22, 1975. Among its various provisions were the establishment of a series of domestic crude oil price controls to be phased out during a 40-month period, a strategic petroleum storage program, new automobile fuel economy standards aimed at doubling the fuel economy of new cars by 1985, and a mandatory appliance efficiency program.

The section most pertinent to transportation system management is Title V, Part C, State Energy Conservation Programs. The law authorizes FEA to establish a program whereby it would fund each eligible state to develop and implement a state energy conservation plan (SECP) aimed at achieving "a reduction... of 5 percent or more in the total amount of energy consumed in such State in the year 1980 from the projected energy consumption for such State in the year 1980" (section 362a1). Section 362c stipulates that each "proposed State energy conservation plan to be eligible for Federal assistance under this part shall include" five separate measures. Three of these minimum requirements relate to public building lighting efficiency standards, state and local government procurement practices, and thermal efficiency standards and insulation requirements for new and renovated buildings. The two transportation measures required for funding approval are (a) "Programs to promote the availability and use of carpools, vanpools and public transportation" (section 362c2) and (b) "A traffic law or regulation which, to the maximum extent practicable consistent with safety, permits the operator of a motor vehicle to turn such vehicle right at a red stop light after stopping" (section 362c5).

In addition to the required measures, section 362d describes five categories of optional actions, two of which relate to public building operations and restrictions on decorative lighting. The remaining three, which have some relevance to the transportation sector, are (a) "Transportation controls," which are defined for the statute as "any plan, procedure, method or arrangement, or any system of incentives, disincentives, restrictions, and requirements, which is designed to reduce energy consumed in transportation, except that the term does not include rationing of gasoline and diesel fuel" (section 362d3); (b) "Programs of public education to promote energy conservation" (section 362d4); and (c) "Any other appropriate method or programs to conserve and to improve efficiency in the use of energy" (section 362d5).

EPCA authorized $50 million/year for fiscal years 1976, 1977, and 1978, of which $5 million was appropriated for 1976 and $25 million for 1977. In determining the amount of federal financial assistance to be provided to any state, FEA was directed to consider the amount of energy to be saved and the number of people affected by the state's SECP. With the exception of not providing financial assistance, EPCA provided no sanctions against states that did not establish an effective plan.

In summary, to be eligible for SECP funds, a state must propose a plan that, at a minimum, includes the five specific measures discussed earlier. An SECP could include any effective additional measure that a state may wish to propose; in fact, by tying the level of federal assistance to be allocated to each state, in part, to the total conservation impact of the state's plan, each state is encouraged to institute additional measures.

The program will be administered through the states, most likely through the energy offices of each state, for the program aims at reducing energy consumption in all end-use sectors. Although the guidelines make clear the need for coordination with the metropolitan planning organizations in the development of program measures to promote the use of ride sharing and transit, the states

are given considerable discretion in determining how this is carried out. In addition, the legislation and the guidelines are clear that all funds go specifically to the states. Although FEA recognizes that an effective state energy conservation plan needs the active participation of the cities, counties, and MPOs, it believes that the distribution of the grant funds within the state should be done by the state. Additional details regarding the administration of this program are in the final guidelines, which were printed in the Federal Register November 3, 1976.

PACKAGING TRANSPORTATION MEASURES TO ACHIEVE ENERGY CONSERVATION

This section discusses various issues that should be considered when the transportation elements of the SECP are developed. Since no state has yet developed a comprehensive SECP, the discussion will be primarily theoretical. As state energy conservation plans are implemented and monitored, the relation among their impacts and the attainment of other social objectives will become clearer.

Identification of Transportation Energy Conservation Measures

Nontechnological, low-capital measures for reducing transportation energy consumption can be grouped into four major categories: increasing load factors, shifting demand to more efficient modes, improving operational efficiency of any or all modes, and reducing the demand for travel and transportation services. Because of the nature of the State Energy Conservation Program as defined by EPCA and the relation of this report to urban passenger transportation, the following categories will be use in this discussion: promoting the use of more efficient modes, improving the efficiency of automobiles in operation, and discouraging the use of private automobiles. For purposes of this classification system, car pools and van pools (whether operated by a public agency, an employer, or a private individual) are considered as paratransit modes. Thus, measures to increase automobile occupancies are subsumed under the category of shifting travel to more efficient modes.

Promoting Use of More Efficient Modes

There are several ways by which the use of more efficient modes can be promoted:

1. Legislative or administrative actions to allow van pools and car pools to operate without official certification as a common carrier;
2. An areawide matching program that provides commuters with an accurate, up-to-date list of others with whom they could share their ride to and from work and that is structured in such a way as to support transit in areas served by fixed-route systems;
3. A ride-sharing and transit education and marketing program, aimed particularly at employers and commuters, to foster commuting by means other than the single-occupant automobile and to generate employer support not only for an areawide ride-sharing campaign but also for active internal car-pool, van-pool, and, where appropriate, subscription bus or transit subsidy programs;
4. Park-and-ride lots where commuters can transfer to high-occupancy vehicles for final stages of their trips to work;
5. Preferential traffic control techniques to give priority to high-occupancy vehicles, including public transportation vehicles;
6. Preferential parking, i.e., more convenient locations or lower rates, for car pools and van pools, especially in lots controlled by a public agency;
7. Low-capital improvements that tailor transit service to better serve identified needs, possibly identified by means of an effective commuter-matching program; and
8. Staggered and flexible working hours to allow better distribution of demand for transit services and the formation of car pools and van pools.

Improving Efficiency of Automobiles in Operation

Ways to improve the efficiency of automobiles include the following:

1. Low registration fees for automobiles having lower fuel consumption, lower power, less weight, or smaller engine displacement to encourage a shift to more efficient automobiles;
2. Vehicle inspection programs that require or encourage engine tune-ups, when appropriate;
3. Traffic flow improvement measures such as elimination of unnecessary control devices, timely changeover of traffic signals to flashing operation, right turn on red, speed limit reductions on selected facilities, designation of reversible lanes, and elimination of on-street parking; and
4. Procurement of more efficient vehicles for state and local government fleets.

Discouraging Use of Private Automobiles

The use of private automobiles can be discouraged by

1. Increasing the marginal costs of vehicle operation through measures such as parking taxes, fee regulation, or surcharges, that can be geographically and temporally selective;
2. Establishing automobile-free or limited-access zones to encourage use of alternative modes or multi-occupant vehicles;
3. Reducing the supply of on-street or off-street parking;
4. Eliminating publicly financed parking subsidies for automobile drivers (this action combined with incentives for ride sharing or transit usage);
5. Establishing tolls for entry into congested areas; and
6. Revising zoning standards to foster reduced reliance on the automobile.

Examples of Transportation Energy Conservation Programs

No state has yet developed or submitted an energy conservation plan. Thus, there is no example of a comprehensive, effective package of transportation measures for conserving energy. However, a number of states and local governments have taken actions that can serve as useful prototypes for adoption by other governmental units. The following is a brief discussion of programs and program measures that have accomplished significant energy savings or that have almost no nonenergy benefits and, therefore, would not be examined in descriptions of measures that focus on environmental or transportation system concerns.

Promoting Use of More Efficient Modes

The most effective areawide program for increasing the use of more efficient commuter modes is probably the commuter ride-sharing program in Knoxville, Tennessee. This program, funded in part by the Urban Mass Transportation Administration, is a coordinated effort by the city of Knoxville, the Knoxville Transit Authority, private bus operators, major employers (including the Tennessee Valley Authority and Levi Strauss), the Tennessee Bureau of Area Mass Transportation, and the University of Tennessee. It is multimodal in scope (encompassing express commuter bus service, van pools, car pools, and social services) and comprehensive in approach (using advanced marketing and matching techniques and legislative changes to "deregulate" van pools and thus facilitate their formation and reduce associated insurance costs).

The success of this program has been incredible. The express bus service, begun in 1973, carries 24 000 passengers/month; the private carriers began operating in the winter of 1975 and carry 12 000 passengers/month. Van-pool operations became legal March 22, 1976, and by August nearly 60 vans were operating (26 leased city vans, 24 TVA employee vans, and 7 identified private vans) and carrying 24 000 passengers/month. TVA, the largest employer in the Knoxville CBD, had 62 percent of its employees commuting by single-occupant vehicles in 1972; in the summer of 1976, this had decreased to 18 percent. During this time, vehicle-kilometer travel by commuters decreased by about 50 percent (3). According to Frank Davis, a member of the Knoxville Transit Authority Board of Directors, the authority and the city are beginning to feel that their primary role is to determine needs, locate potential suppliers, eliminate institutional barriers, and promote all forms of public transportation.

These are the exact functions that FEA hopes will be assumed by various state and local agencies as an element of the state energy conservation plans. No better model for promoting the availability and use of car pooling, van pooling, and transit exists in the United States.

Improving Efficiency of Automobiles in Operation

The Vermont Energy Office conducted a study of the composition of the state's passenger vehicle fleet and the impact of a proposal that would vary the annual registration fees between $20 and $60, depending on weight. This study resulted in a proposed bill that will probably be reintroduced during the 1977 session of the state legislature. A number of other states already have fee structures that vary the charge by vehicle class although energy was not a consideration in developing them.

Vehicle weight, power, and engine size are not completely equitable surrogates for fuel efficiency. Unfortunately, since consistent fuel efficiency ratings are not available for model years earlier than 1974, states are forced to rely on those vehicle characteristics for a few more years. Starting in 1978, EPA mileage ratings will be available for a sufficient proportion of the automobile fleet so that registration fees can be tied directly to the fuel efficiency of each automobile.

Maine has changed its official procurement specifications to provide for energy-conserving characteristics to be considered in the purchase of automobiles for state use (2). Alaska has a State Motor Vehicle Energy Conservation Program that aims for a 10 percent reduction in state vehicle fuel consumption within a 1-year period through instituting and enforcing energy conservation maintenance and operation practices (3). New York State has adopted the policy of purchasing small automobiles with adequate, but smaller engines for state use (1).

Discouraging Use of Private Automobiles

Because the energy problem is not felt in local communities as continually and directly as traffic congestion and air pollution, no areas have adopted automobile-disincentive strategies as a means for conserving energy.

Consistency With Transportation and Environmental Objectives

Energy conservation measures generally contribute to the achievement of the overall goals of reduced traffic congestion and pollution. This is clearest in the case of those measures aimed at shifting travel to more efficient modes and reducing travel demand. It is much less clear for those measures that foster a shift to more efficient automobiles.

Promoting Use of More Efficient Modes

If we could double the use of transit, we could save 7900 to 15 900 m^3 (50 000 to 100 000 barrels) of oil per day (4). If we could increase commuter automobile occupancies from the current level of 1.4 persons/automobile to 2.0 by 1980, we could reduce daily gasoline consumption by 55 500 m^3/day (350 000 barrels). The direct impact on pollution would be proportional to the energy impact, about a 10 percent reduction in daily automobile-related emissions. The reduction in traffic congestion would be even greater since mode shifts of this magnitude would reduce the number of commuter vehicles during peak periods by more than 30 percent.

The subject of pooling as it relates to transit ridership is worth discussing. When the potential of car pooling and van pooling became obvious, FEA did all it could to encourage ride sharing. However, the competition between ride sharing and transit for the same market deserves serious consideration. Obviously, getting someone out of a bus into a car pool saves no energy. The nation's transit systems are and will continue to be an essential element of our national energy program. Unfortunately, there is no way to guarantee that effective car-pool programs will not divert some riders from transit. However, effective ride-sharing programs can benefit existing transit systems if structured with the following thoughts in mind:

1. Few commuters prefer fixed-time, inflexible ride-sharing arrangements over transit if the transit system provides reasonably good service (since "reasonably good service" is a relatively subjective concept, the programmatic value of this finding is not altogether clear);
2. Commuter-matching procedures can be an effective way to pinpoint those areas that have travel demands sufficient to justify fixed-route transit service; and
3. Effective ride-sharing programs in areas not served by transit can help reduce pressure for the introduction of new service that would be underused, further aggravating the financial problems facing metropolitan transit agencies.

Improving Efficiency of Automobiles in Operation

Inproving automobile efficiency has the greatest potential for conflicting with the achievement of transportation

system and environmental objectives. An obvious indicator of such conflicts is the continuing debate regarding the relation between new automobile emission and fuel economy standards. A more basic conflict is that between encouraging the development of more efficient automobiles on one hand and attempting to foster shifts to more efficient modes on the other. Reducing the marginal costs of driving the automobile is not totally in concert with efforts for reducing the demands on the nation's overloaded transportation system and reducing the pollution associated with those demands. Not all measures for increasing operating efficiency are inconsistent with other social objectives. Lower speed limits not only decrease fuel consumption rates but also serve to reduce travel demands and automobile-related pollution.

In any event, it would make little sense from a national viewpoint to impede the development of more efficient automobiles as a means for increasing the cost of automobile travel. Such a strategy would artificially punish those travelers for whom the private automobile is the only transport mode. The use of economic disincentives that can be targeted at those who have other travel options would be a more equitable, effective approach not only for conserving fuel but also for achieving other transportation goals.

Discouraging Use of Private Automobiles

Clearly, discouraging automobile use is the most effective way to reduce traffic congestion, automobile-related air pollution, and energy consumption. However, unless applied with extreme care, this measure conflicts with a basic goal of our society: providing mobility for people and commerce.

A strong case can be made for meaningful disincentives if alternatives to single-occupant automobile travel are available and the public costs of providing for such travel are not prohibitive. Most people are familiar with the concept of marginal cost pricing and recognize that forever building new transportation systems to accommodate peak vehicle demands is a luxury we can no longer afford.

Out-of-pocket marginal costs make up about one-third of the total costs of operating an automobile. Further, the total costs of operating an automobile during peak periods in congested urban areas make up only about one-third of the total economic costs (5). Broader public support for most TSM initiatives should be achievable if the public is given a clear understanding of the three available options: (a) enormous expenditures for expanding the transportation systems, (b) long periods of widespread congestion, or (c) implementation of effective transportation system management measures, including carefully developed and justified disincentives. Transportation analysts must not only design effective, equitable, and appropriate disincentives but also present the costs and benefits of such measures in such a way that decision makers and travelers can fully weigh the advantages and the disadvantages of instituting such measures.

SUMMARY

A wide range of effective actions can be taken to reduce energy consumption in the transportation sector. Many of the important decisions necessary to implement such actions can be made only at the state and local levels. Since nearly all of these actions will contribute to solving other pressing national concerns (such as our reduced ability to build new transportation facilities and unacceptable pollution levels), these actions will have the support, financial or otherwise, of DOT, EPA, and FEA. The real work, however, will have to be done not at the federal level but at the state, regional, and local levels. The energy problem is national in scope and its effects are important to each level of government; dealing with it, therefore, will require the involvement of all levels.

FEA realizes that some of these options have important social and economic implications. Therefore, it supports further study and phased implementation. However, as we study and debate and postpone decisions, we should be aware that we are using up our cheap oil. A cheap, clean, infinite source of energy is not going to be available when we run out or when the next embargo hits. The question is, Do we have the wisdom and the will to act now or will we allow events to act for us?

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PACKAGING TRANSPORTATION ELEMENTS TO MEET ENVIRONMENTAL OBJECTIVES

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Controversy over the relation between air quality requirements and urban transportation planning appears to center around two basic issues. The first is whether the implementation of transportation measures that improve air quality is consistent with the achievement of other transportation objectives. The second concerns the changes in the planning process needed to accommodate air quality requirements. This paper outlines the basic elements of a potential resolution of these issues. The transportation measures that have been proposed to improve air quality are virtually identical to the measures now being proposed to achieve a wide variety of other transportation objectives. However, the various measures are

not necessarily equally effective in improving air quality and achieving other objectives. Thus, the process of selecting transportation measures for implementation often will involve making trade-offs between air quality objectives and other objectives. The need for such trade-offs is recognized by the Environmental Protection Agency, and the changes in the transportation planning process needed to enable the trade-offs to be made are consistent with current planning trends. However, three problem areas may require further attention in the future: encouraging the implementation of innovative demand-management approaches, developing procedures for mediating disputes between EPA and state and local agencies over the rate at which transportation change should take place, and preventing the planning process from becoming overly cumbersome.

Air pollution control is unique among federal environmental programs affecting urban transportation in that it attempts to influence the outcomes of the urban transportation planning process as well as the mechanics of the process. Specifically, one of the objectives of this program is to ensure that urban areas develop and implement transportation options that are consistent with federally established air quality standards.

The concern of the air program with the outcomes of the planning process became controversial when the Environmental Protection Agency (EPA) announced in 1973 that drastic traffic curtailments would be needed in several large cities to achieve the air quality standards within the time periods prescribed by law. It is now clear that EPA will not require cities to implement such traffic curtailments. However, the controversy over the relation between air quality requirements and urban transportation has continued, despite the removal of its initial cause. This continuing controversy appears to be centered around two basic issues. The first is whether the implementation of transportation measures needed to achieve air quality goals is consistent with the achievement of other transportation objectives. The second concerns the nature and extent of the changes in urban transportation planning and decision-making processes needed to accommodate the federal government's responsibility to ensure that the outcomes of these processes are consistent with air quality requirements.

Although these issues are likely to remain troublesome for the foreseeable future, the basic elements of a potential resolution are becoming increasingly apparent. The transportation measures that have been proposed to improve air quality and the measures being proposed to achieve a wide variety of other objectives, such as reduced congestion, reduced reliance on capital-intensive projects, and energy conservation, are virtually identical (1, 2, 3, 4, 5). However, the various measures are not necessarily equally effective in achieving improved air quality and other objectives. Thus, trade-offs between air quality objectives and other objectives often will have to be made during the process of selecting measures for implementation. The need for such trade-offs now is recognized by EPA, and changes in urban transportation planning and decision-making processes that will enable these trade-offs to be made within the framework of federal environmental law are beginning to take place. These changes are consistent with the current movement toward multiobjective, multimodal transportation planning, increased interagency coordination and public participation, increased emphasis on short-range transportation options, and a closer connection between planning and implementation (5, 6, 7).

ROLE OF TRANSPORTATION SYSTEM MANAGEMENT IN CONTROLLING AIR POLLUTION

The Clean Air Act Amendments of 1970 directed EPA to establish national ambient air quality standards whose attainment would protect the public health and welfare from the adverse effects of major air pollutants. The pollutants for which health-based air quality standards now exist include carbon monoxide and photochemical oxidants, whose presence in urban air is primarily attributable to emissions of carbon monoxide (CO), hydrocarbons (HC), and nitrogen oxides (NO_x) by motor vehicles. The areas in which one or more of these air quality standards are exceeded include most large cities in the United States and contain approximately two-thirds of the nation's population. The automobile is the source of roughly 70 percent of the CO, 50 percent of the HC, and 30 percent of the NO_x emitted in urban areas. Other transportation sources are responsible for approximately 20 percent of CO, HC, and NO_x emissions in these areas.

Because of the importance of motor vehicles relative to other sources of CO, HC, and NO_x, the reduction of motor vehicle emissions is a major objective of programs to improve air quality. The principal means of achieving this objective is the control of emissions from new vehicles. New automobiles, for example, have been subject to increasingly stringent emission standards since 1966 in California and 1968 nationally. As a result, new automobiles now emit roughly 20 percent as much CO and HC as pre-1968 automobiles. Further reductions in new automobile emissions will be achieved in future years as the emission standards become more stringent.

Despite these emission reductions, controls of new motor vehicle emissions are not by themselves sufficient to achieve CO and oxidant standards in all places. Therefore, the Clean Air Act requires states to develop and implement plans to control emissions from existing sources and certain types of new sources as needed to attain and maintain the air quality standards within their boundaries. If a state fails to develop an adequate plan, EPA is required to promulgate a plan or portion of a plan that satisfies the provisions of the Clean Air Act.

In many large cities, the current and projected future magnitudes of motor vehicle emissions are such that the CO or oxidant air quality standards cannot be attained and maintained through the control of emissions from new motor vehicles and from nonvehicular sources alone. In effect, the transportation systems of these cities are major emission sources that, like other major sources, must be controlled if the air quality standards are to be achieved. Emissions from urban transportation systems can be reduced by improving traffic flows and reducing traffic volumes. The measures through which these objectives might be achieved include virtually all of the ones currently encompassed by the term "transportation system management" (1, 2, 8). The Clean Air Act refers to transportation system management measures as "transportation controls" and requires their inclusion in state implementation plans as necessary to ensure the attainment and maintenance of the air quality standards.

IDENTIFYING TRANSPORTATION SYSTEM MANAGEMENT MEASURES THAT ADDRESS SPECIFIC AIR QUALITY NEEDS

A variety of urban problems, including air pollution, congestion, and high levels of energy consumption, are related to excessive traffic volumes or poor traffic flow conditions and can be alleviated to a greater or lesser extent by reducing traffic volumes and improving traffic flow. Thus, transportation system management measures that benefit one of these problem areas are likely to benefit the others as well. However, air pollution, congestion, and excessive energy consumption are different things, and they have, to some extent, different

physical remedies. Consequently, the transportation measures that might be selected if, for example, congestion relief is the principal policy objective are not necessarily identical to the measures that might be chosen if air pollution control or energy conservation were the principal objective (9).

Excessive CO concentrations occur mainly in areas of high traffic density, such as the central business districts of large cities. Excessive CO frequently is associated with congestion, and measures that reduce congestion also tend to reduce CO. However, CO tends to be a problem during more hours of the day than congestion. Whereas severe congestion normally occurs only during peak periods, excessive CO concentrations typically occur as violations of the 8-h CO air quality standard, meaning that the CO concentration averaged for an 8-h period is too high.

Controlling CO therefore involves reducing CO emissions during an 8-h period. Although peak-period congestion relief is likely to help reduce 8-h CO concentrations, it cannot be assumed that peak-period congestion controls alone necessarily will achieve the reductions in CO concentrations needed to achieve the CO air quality standard. Peak-period traffic typically accounts for only a third of total traffic in an 8-h period that includes a peak. Thus, traffic engineering improvements and reductions in peak-period traffic sufficient to eliminate congestion may not produce reductions in 8-h CO emissions that are large enough to achieve the CO air quality standard (9). Moreover, the principal effect of some peak-period traffic management measures is to encourage the substitution of off-peak-period travel for peak-period travel. This causes CO emissions during peak periods to be replaced by CO emissions during off-peak periods. Owing to improved traffic flow conditions, the resulting increase in off-peak emissions may be less than the decrease in peak-period emissions. Even so, the change in 8-h CO concentrations may be negligible.

The foregoing considerations suggest several ways in which transportation system management measures that are oriented toward CO control may differ from measures whose principal objective is to reduce peak-period congestion. Measures whose main effect is peak spreading may be relatively ineffective for CO control. Traffic engineering measures that improve traffic flow during peak periods are likely to help in reducing CO concentrations, provided that they do not significantly increase traffic volumes, as are measures designed to alter peak-period mode choice. The latter class of measures includes peak-period transit improvements, car-pooling incentives, and pricing or restraint programs whose periods of operation are sufficiently long to discourage peak spreading. However, to achieve the 8-h CO air quality standard, the various peak-period measures may have to be supplemented with measures that reduce off-peak traffic. The supplementary measures could include improvements in off-peak transit service, including the use of paratransit, and the extension of pricing or restraint programs into the off-peak period. Finally, all-day automobile-free zones are a highly effective means of controlling CO in small areas.

Oxidant, unlike CO, is not emitted directly by motor vehicles or any other emission source. Rather, it is the product of atmospheric chemical reactions involving HC and NO_x, both of which are emitted by motor vehicles among other sources. The chemical reactions that produce oxidant require at least 3 h to take place and, under appropriate conditions, may continue for several days. During this period the atmosphere is being mixed by winds and is receiving new injections of pollutants. Consequently, excessive oxidant concentrations tend to occur over entire metropolitan regions rather than in small geographical subareas. Moreover, oxidant is caused by total HC and NO_x emissions within a region rather than emissions in certain subareas or at certain times of day.

The geographical extent of high oxidant concentrations makes oxidant control a significantly different problem from the problems of controlling congestion and CO, both of which tend to be restricted to distinct corridors or subareas. To significantly reduce the contribution of the transportation system to excessive oxidant concentrations requires the achievement of motor vehicle emission reductions, and particularly HC emission reductions, that are significant on a systemwide scale. Thus, transportation system management measures to control oxidant should be oriented toward reducing total regional traffic. Measures that affect only peak-period travel to congested areas and even measures that achieve moderate reductions in total daily traffic in these areas, as CO control measures might do, are likely to have relatively minor effects on oxidant. Similarly, measures whose principal effect is to alter the temporal distribution of travel or the choice of travel routes are unlikely to have significant effects on oxidant (9).

The transportation system management measures that are most appropriate for the control of oxidant are ones that can be applied over large geographical areas. These include transit improvements, particularly for suburban and circumferential travelers, areawide carpooling incentives, and pricing techniques such as parking taxes, vehicle metering, and HC emission taxes. Gasoline taxes also might be an effective approach to controlling oxidant, at least in the short run, provided they are sufficiently high. In the long run, however, gasoline taxes tend to encourage the replacement of vehicles with poor fuel economy by vehicles with good fuel economy. The resulting improvements in fuel economy would reduce the effects of the gasoline tax on the cost of travel, thus reducing the effects of the tax on traffic volumes and on HC emissions.

Energy consumption by motor vehicles, like oxidant, is a consequence of total regional travel. Thus, with two possible exceptions, measures that are effective in reducing the contribution of the transportation system to excessive oxidant conentrations also are likely to be effective in reducing energy consumption by motor vehicles. Conversely, measures that are ineffective for controlling oxidant are likely also to be ineffective for reducing energy consumption. The two possible exceptions are the HC tax and the gasoline tax. The effects of the HC tax on the cost of travel are likely to decrease over time as old vehicles with high emissions are replaced by new vehicles with lower emissions. Accordingly, the effects of an HC tax on traffic volumes and energy consumption are likely to decrease over time. On the other hand, it is likely that the long-run price elasticity of demand for gasoline is greater than the short-run elasticity. Thus, the beneficial effects of a gasoline tax on energy consumption are likely to increase over time, although the effects of the tax on emissions may decrease.

INTEGRATING AIR QUALITY CONSIDERATIONS INTO THE TRANSPORTATION PLANNING AND DECISION-MAKING PROCESS

Because the transportation system management measures needed to achieve air quality objectives are not necessarily identical to the measures needed to achieve other objectives, it cannot be assumed that transportation policies designed to meet these other objectives

automatically will satisfy air quality needs as well. Rather, air quality must become an explicit factor in the transportation planning process that, along with other factors, affects the design and selection of transportation policies and measures. Moreover, means must be developed for making trade-offs between air quality objectives and other objectives when the measures needed to achieve these various objectives do not coincide.

The procedures for integrating air quality considerations into the planning process, especially the procedures for making trade-offs, must be consistent with the federal government's substantive concern with the air quality impacts of the transportation plans, programs, and projects that result from the planning process. The Clean Air Act requires the air quality standards to be achieved and, in addition, specifies that they must be achieved "as expeditiously as practicable." Moreover, Federal Highway Administration regulations implementing section 109j of the Federal-Aid Highway Act require annual determinations by the policy boards of metropolitan planning organizations (MPOs) that the transportation plans and programs of these agencies are consistent with the state implementation plans. Thus, achievement of the air quality standards is not an objective that planners and policy makers can accept or reject as they see fit. Indeed, the term "as expeditiously as practicable" implies that air quality improvement must be included among the highest priority transportation objectives. This does not mean that air quality must be the dominant objective or that measures that have severe adverse effects in other respects must be implemented solely because they improve air quality. However, it does suggest that other objectives may, on occasion, have to be compromised or delayed for air quality reasons.

Fortunately, the characteristics of a planning process that adequately incorporates air quality considerations are consistent with process changes that are already taking place for reasons that include but are by no means restricted to air quality requirements. These characteristics include

1. Regional coordination of transportation system management planning as well as planning for major capital improvements,
2. Increased involvement of transportation agencies in air quality planning,
3. Increased coordination among transportation agencies and other agencies,
4. Increased emphasis of transportation system management measures,
5. Alternatives analysis and trade-off identification,
6. Flexible planning approaches and incremental implementation, and
7. Increased involvement of elected officials and the public in the planning process.

The transportation planning process must include a strong element of regional coordination to enable it to deal satisfactorily with air quality issues. The need for regional coordination is most apparent when oxidant, a regional pollutant, must be controlled, but it is also present in the case of CO control. Although excessive CO concentrations tend to be restricted to distinct corridors and subareas, uncoordinated efforts to reduce CO concentrations in each area individually are likely to shift CO problems from one area to another and fail to take advantage of complementary efforts in different areas.

A logical agency for effecting the necessary regional coordination is, of course, the MPO. In the past, transportation measures to improve air quality frequently have been developed in isolation from the process through which other transportation actions are planned and programmed. As a result, the air quality measures often have been infeasible, have been in conflict with other transportation actions and objectives, or otherwise could not be implemented. The involvement of the MPO and, through it, other transportation agencies in developing transportation measures to improve air quality will enable transportation decisions concerning air quality and decisions about other transportation objectives to be made together, thus making it possible for coincidences and conflicts among objectives to be identified, trade-offs to be made where necessary, and advantage to be taken of coincidences between air quality objectives and other transportation objectives. In discharging its regional coordination responsibilities, the MPO should ensure that

1. Air quality requirements receive appropriate consideration at all stages of the transportation planning process;
2. All participants in the process understand how air quality requirements affect their respective areas of responsibility;
3. Air quality implications of the transportation options under consideration at various stages of the planning process are evaluated early enough to affect the selection of options for inclusion in plans and programs; and
4. Transportation plans and programs developed through the planning process are consistent with air quality requirements.

In addition, the MPO can serve as a forum for making trade-offs among air quality objectives and other objectives when conflicts arise.

Although transportation agencies should have the primary responsibility for developing transportation measures for improving air quality, coordination between transportation agencies and agencies with nontransportation responsibilities is necessary. State or local air quality agencies, for example, may be able to provide data and skills relevant to air quality analyses that are not otherwise available to transportation agencies. More important, air quality agencies are responsible for controlling stationary-source emissions of some of the same pollutants that motor vehicles emit, and decisions must be made as to how emission reductions will be allocated among the two types of emission sources. Coordination also is necessary with land use, water quality, and housing agencies, all of which affect the transportation system and its emissions through their influence on land use.

The requirement of the Clean Air Act that the air quality standards be achieved as expeditiously as practicable implies that the transportation planning process should include a strong short-range programming activity and that air quality improvement should be a high-priority objective of this activity. This does not necessarily mean that the air quality standards will be achieved quickly or that long-range measures may not be needed. However, it does suggest that steady progress toward meeting the air quality standards should be made, starting now. The principal means whereby such steady progress can be made is through the implementation of appropriate selections of transportation system management measures. Transportation organizations should make systematic and continuing efforts to identify, develop, and implement transportation system management options, including innovative ones, that appear capable of reducing the emissions of transportation systems.

The development of both short-range options and the longer range elements of the transportation plan should include analysis of the likely impacts on air quality and other factors of a range of alternative courses of action (10). The alternatives selected for analysis should be sufficiently different in their impacts to provide a real choice and should be defined and analyzed in a way that illustrates the complementarities and trade-offs among objectives. One of the uses of the results of the analysis should be to assist decision makers in determining which course of action enables the air quality standards to be met as expeditiously as practicable. This determination can be made only if information is available on what would be gained or lost by reducing emissions more or less rapidly. The necessary information, insofar as it is available, should be developed during the analysis of alternatives.

Even the best analysis of alternatives is unlikely to develop information that is as complete or precise as would ideally be desired. Available analytical techniques are imprecise, and there has been too little experience with many of the most promising transportation system management options to enable their impacts to be forecast with confidence. The planning process and the transportation implementation process both should contain sufficient flexibility to accommodate the resulting uncertainties. Untried measures should be implemented on a small scale and their effects carefully monitored. Depending on the outcome of the monitoring, the measures can be modified, expanded in their application, or withdrawn. Contingency plans can be prepared so that progress toward achieving transportation objectives does not halt if one or more innovative measures fail to produce the hoped-for results.

Finally, it is necessary to increase the involvement of elected officials and the public in the transportation planning process. Heretofore, transportation planning, particularly transportation planning for air quality improvement, has taken place in relative isolation from elected decision makers and the public. In consequence, the resulting plans could not and have not represented commitments to implementation. Indeed, they sometimes have represented attempts to avoid commitments and to keep all options open. Implementation commitments have tended to develop on a project-by-project basis during long periods of time with the result that implemented projects and planned ones often have had little in common. However, under the Clean Air Act, transportation plans and programs to improve air quality must include commitments to implementation. These commitments need not extend to all elements of what might be a 20-year plan, and they do not require the continuation of measures that prove unsuccessful. But assurance is needed that the near-term elements of transportation programs will be implemented and that the policies contained in the plans and programs will be carried out until such time as experience or changed conditions may require their modification. The necessary commitments can be obtained only if those who can make or impede them, including elected officials and the public, are involved in the planning process earlier and more systematically than often has been the case in the past.

The participation of elected officials and the public in the planning process should be oriented toward achieving the public acceptance, budgetary commitments, and legal authority needed to implement the near-term measures and longer range policies contained in the resulting plans and programs. Insofar as possible, public acceptance, budgetary commitments, and legal authority should be developed during the planning process rather than through subsequent efforts of the planners to "sell" the plan to elected officials and the public. Thus, the participation of elected officials and the public in the process must involve more than exchanges of information and ideas; it must be a decision-making activity designed to produce plans and programs that are ready for implementation.

UNRESOLVED ISSUES

The achievement of substantial improvements in the efficiency and reductions in the emissions of urban transportation systems is likely to require the implementation of some of the more innovative approaches to managing travel demand. There has been little experience with most demand management measures, and their effects are not well understood. Thus, there is a risk entailed in implementing the measures: They may prove to be socially costly and fail to produce the expected benefits. Understandably, elected officials and the public are reluctant to implement risky and potentially disruptive transportation measures. However, the innovative demand management measures cannot be obtained unless the measures are implemented on at least an experimental basis. Thus, it is necessary to consider how the barriers to implementation created by risk might be overcome.

A policy of fully involving elected officials and the public in the process of planning innovative demand-management measures, gradually implementing the measures, carefully monitoring their effects, and modifying or withdrawing the measures as necessary should help to overcome reluctance to implement the measures. However, other risk-reduction policies also may be needed. For example, it may be necessary to develop procedures for compensating persons who are adversely affected by innovative attempts to manage travel demand. It also may be necessary to wait. The public may not yet perceive its transportation problems as being sufficiently severe or the traditional transportation measures as being sufficiently ineffective to justify the risks associated with innovative demand-management approaches.

The determination of whether the air quality standards are being met as expeditiously as practicable is another potential source of difficulty. This determination requires a value judgment. Different individuals may disagree over what is the proper judgment, even if they agree on the underlying information. In particular, EPA may disagree with state and local officials. The Clean Air Act requires EPA to promulgate a state implementation plan or portion of a plan if it determines that the plan submitted by a state is inadequate to achieve the air quality standards as expeditiously as practicable. However, there is much experience indicating that this is not a satisfactory way of resolving disagreements over transportations plans. An improved planning process that examines a broad range of transportation options should help to minimize disagreements between EPA and state and local officials. Moreover, there is preliminary evidence that informal bargaining may be sufficient to resolve the disagreements that do arise (11). However, it is too early to determine whether the combination of an improved planning process and informal bargaining will be adequate to resolve disagreements between EPA and local authorities or whether the development of more formal mediation procedures will be needed.

Implementation of the planning approaches presented here will significantly increase the complexity of the transportation planning process. More potentially conflicting objectives will have to be considered, more analyses and evaluations will be needed, and more

people and agencies will be involved. This complexity undoubtedly will cause transportation planning to become more expensive, thus necessitating increased federal financial support of planning agencies. More important, the planning process may become so cumbersome that it inhibits the informed, efficient decision making it is supposed to promote. If an overly complex planning process is to be avoided, the people who design, operate, and participate in the process will have to exercise considerable skill and wisdom in balancing the need to maximize information, coordination, and participation against the need to maintain simplicity.

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ROLE OF THE MPO IN FORMULATING THE TSM ELEMENT

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Developing and implementing effective transportation system management elements in urban transportation plans will depend greatly on the ability of the metropolitan planning organization to develop an acceptable institutional framework for cooperation and joint action that does not detract from the basic responsibility and authority of participating local and state agencies. MPOs, particularly those operating within the framework of councils of governments, can play a key role in the further refinement and implementation of TSM elements because of their ability to work with local and state policy and decision makers to achieve consensus in a metropolitan area. Because of their concerns with a wide range of functional and social service goals and needs, MPOs can recommend trade-offs among competing objectives, identify opportunities for applying locally successful TSM measures to other parts of a metropolitan region, and integrate and relate TSM planning to other elements of the areawide transportation planning process.

Regulations promulgated by the U.S. Department of Transportation in September 1975 required the submission by March 30, 1976, of a transportation improvement plan containing transportation system management (TSM) elements. During this 6-month period, metropolitan planning organizations (MPOs) had to develop and gain acceptance of a strategy for action by state and local constituents, many of whom unhappily perceived that the September regulations threatened their prerogatives and authority; carry out the agreed-to strategy; and prepare and submit the TSM element of the plan. Many of these first efforts were hasty and drew criticism for lacking comprehensiveness and not being systematic in the approaches, evaluations, and trade-off analyses.

Although generally valid, these criticisms should be considered within the perspective of institutional relations and concerns and of the time needed to overcome such institutional concerns so that adequate attention can be given to the technical problems and their solutions. The first role of the MPO in TSM planning is to develop a political and institutional strategy and process that will allow all MPO participants at the state and local levels to engage in areawide TSM planning without losing their responsibilities and authority. Implementation of effective TSM plans will depend greatly on the MPO's ability to develop an acceptable institutional framework over time for cooperation and joint action.

This paper draws on the experience of TSM planning in the Washington, D.C., metropolitan area in discussing the role of the MPO in formulating TSM plan elements.

TSM PLANNING WITHIN THE FRAMEWORK OF A COUNCIL OF GOVERNMENTS

TSM planning must be viewed within the larger context of the particular characteristics and political and institutional relations of a given metropolitan area. A brief description of these characteristics and relations for the Washington, D.C., metropolitan area follows.

Area Characteristics

Metropolitan Washington is a unique urban community in terms of its economic, social, and political composition. It covers some 6200 km^2 (2400 $miles^2$) in Maryland, Virginia, and the District of Columbia (Figure 1). During the past 3 decades, the Washington metropolitan area has had the highest growth rate of any major metropolitan area. Washington's current population of more than 3 million is three times what it was in 1950. It is now the seventh largest metropolitan area in the United States.

From its beginning, Washington has been a specialized community because it is the capital of the nation. Most, if not all, of the area's growth has resulted from the expansion of the federal government in terms of both its size and its influence. Of the 1.3 million persons employed in the Washington area, about 25 percent are employed directly by the federal government. This proportion increases to nearly 75 percent if those jobs created as a result of federal funds or related to federal programs are included. According to the 1970 census, metropolitan Washington had the highest level of educational attainment, the highest income per capita, the highest rate of population growth, and the lowest unemployment level of any major metropolitan area.

Despite the outstanding strengths of the metropolitan economy, Washington has not escaped the multitude of problems facing urban communities, such as pollution, traffic congestion, crime, proverty, urban decay, and urban sprawl. Like those of other communities across the country, the local governments in the Washington area are struggling to obtain the resources necessary to combat these problems.

Although the Washington metropolitan area contains more than 100 units of government, most of the governmental authority is exercised by the six counties and four independent cities. The existence of strong county governments in the area has produced a far simpler set of governmental units than in most other areas of comparable size. The most complex governmental factor in the Washington area is that the area is divided into three separate parts, subject to three separate legislatures. The Virginia state government, the Maryland state government, and the District of Columbia government along with the federal government on its behalf have strong voices in the governing of the Washington metropolitan area. Since the states establish the local government and set the limit on what it may do and since many federal-aid programs provide strong roles for the states, the needs of the metropolitan area can be met only through the cooperation of both local and state governments across jurisdictional lines.

Organizational Responsibilities and Relations

A brief discussion of the major institutional participants in transportation planning may help to provide some insight into the rationale for the TSM process initially developed.

At the metropolitan level, the Metropolitan Washington Council of Governments (COG) is the regional organization of the local governments and their governing officials. COG coordinates comprehensive planning, transportation planning, and transit planning and programming by the many regional, subregional, and local agencies. COG has been designated as the metropolitan clearinghouse for the area and has the responsibility to review and comment on the consistency of proposed federal-aid projects with areawide policies, goals, and objectives.

The National Capital Region Transportation Planning Board (TPB) is the organization responsible for conducting the continuing, comprehensive, and cooperative transportation planning process for the Washington metropolitan area in accordance with the requirements of the Federal-Aid Highway Act of 1962 and the Urban Mass Transportation Act of 1964, as amended. Its policy body is made up of local government officials and representatives of the state transportation agencies and the regional transit authority, and appropriate federal agencies. The governors of Maryland and Virginia and the mayor of the District of Columbia have designated TPB as the MPO for the Washington metropolitan area. TPB also serves as the transportation planning arm of COG to ensure that transportation planning is integrated with comprehensive metropolitan planning and development and is responsive to the local political decision-making process.

The Washington Metropolitan Area Transit Authority (WMATA) was created by interstate compact in 1966 and is charged with the planning, development, financing, and operation of the rail rapid transit system for the Washington metropolitan area. Early in 1973, WMATA assumed ownership and operation of the area's four bus companies. The first section of a planned 160-km (100-mile) rail rapid system is now in operation.

At the state level, the Maryland Department of Transportation, the Virginia Department of Highways and Transportation (VDH&T), and the District of Columbia Department of Transportation are responsible for the planning, design, and construction of the major highway systems in their respective jurisdictions and for transit planning related to providing roadway access to rapid transit stations and facilities for preferential treatment of buses. The Maryland department also has responsibility for other modes of transportation and provides a substantial portion of the Maryland local government share of capital and operating costs of the Metrorail and Metrobus systems.

At the local level, the Arlington County (Virginia) Department of Transportation, the Montgomery County (Maryland) Department of Transportation, and the Prince George's County (Maryland) Department of Public Works and Transportation are responsible for the construction, operation, maintenance, and signalization of all county roads within their specific jurisdictions. Other responsibilities include traffic operation improvements, preferential transit treatment, and bikeway construction. The Montgomery County department maintains more than 12 000 public parking spaces in four business districts, operates a fixed-route minibus system, and controls a general aviation airport.

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Figure 1. Washington, D.C., metropolitan area.

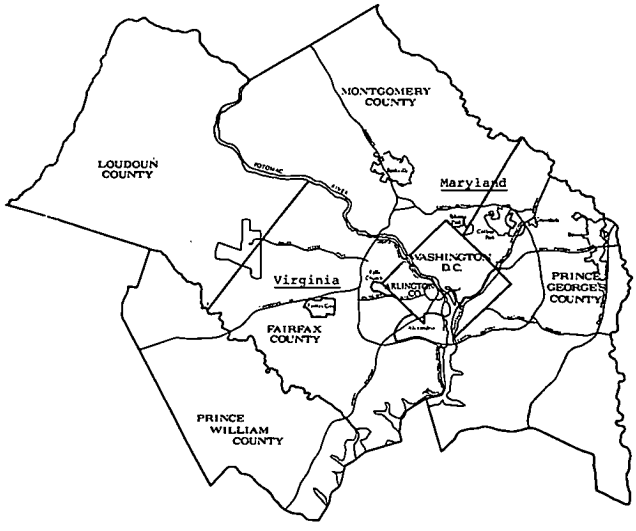
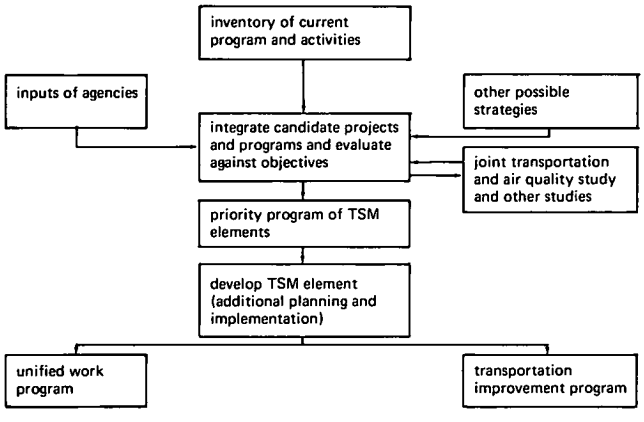


Figure 2. TSM development process.



region, three subregional planning agencies participate in the areawide transportation planning process. The Northern Virginia Planning District Commission was formed to promote the orderly and efficient development of the physical, social, and economic elements of northern Virginia by planning and encouraging and assisting governmental subdivisions to plan for the future. The Maryland-National Capital Park and Planning Commission is a bicounty agency that was created by the Maryland General Assembly and that exercises physical planning jurisdiction in Montgomery and Prince George's counties. The commission also acquires, develops, operates, and maintains a regional park system in both counties. The National Capital Planning Commission is a federal agency established by Congress to develop plans for federal installations in the region. The commissioners are appointed by the President of the United States.

INITIAL TSM ELEMENT

Given the area characteristics and institutional relations described above, and the tight time schedule for producing an initial TSM plan element, the TPB staff in cooperation with the Technical Committee produced the TSM development process shown in Figure 2. A summary discussion follows of each of the activities.

Inventory

TPB elected to inventory all existing, programmed, and proposed projects and activities that could be identified as having TSM characteristics to serve as a frame of reference. Each participating agency identified and submitted, in both statistical and narrative form, their accomplishments and goals in promoting TSM projects and activites. This approach enabled the various government agencies and organizations in the region not only to document their achievements but also to express their particular philosophies with respect to goals and priorities in TSM planning and implementation for their individual areas of responsibility. This in turn provided a regional overview and insight on the challenges and problems to be faced in aggregating TSM planning to a metropolitan scale.

We discovered that many of the TSM actions recommended for consideration in the federal regulations had been implemented, programmed, or proposed by responsible agencies throughout the region. We also discovered that the degree of activity, as well as goals and priorities, varied considerably in the region by level of government, agency responsibility, and geographic location.

Integration and Evaluation by Objectives

All existing, programmed, and proposed TSM projects and activities were included in the initial TSM report and grouped into the following eight major categories:

1. Traffic operation improvements to manage and control the flow of motor vehicles;
2. Preferential treatment for transit and other high-occupancy vehicles;
3. Appropriate provision for pedestrians and bicycles;
4. Management and control of parking;
5. Changes in work schedules, fare structure, and travel and to encourage off-peak use of transportation facilities and transit services;
6. Actions to reduce vehicle use in congested areas;
7. Actions to improve transit service; and
8. Actions to increase transit management efficiency.

For each TSM action, a matrix was prepared that indicated those agencies that have responsibility for implementing various types of action, the actions that had been implemented, and the actions that are proposed.

In establishing objectives and evaluation criteria, the staff and the Technical Committee drew on the preamble to the National Mass Transportation Assistance Act of 1974, which states in part that the act is to improve the efficiency of transit service "not only to achieve greater economies in operation, but also to help contribute to the wider national objectives of energy conservation, improving air quality, and increased social and environmental amenities." Based on this philosophy, each of the TSM actions contained in the federal guidelines was considered for its relative impact on the following two objectives:

1. Increase the efficiency and use of a roadway facility, and
2. Increase the efficiency of a transit facility.

In addition, within the context of the wider national objectives of energy conservation, air quality, and increased social and environmental amenities, an attempt was made to determine whether each TSM action offered for consideration would

1. Decrease vehicle-kilometers of travel,
2. Contribute to improved air quality,
3. Decrease automobile dependency, and
4. Contribute to energy conservation.

From this process, TSM actions were identified that appeared to have high priorities in terms of meeting those objectives. The word "appeared" must be emphasized because, within the time constraints of the initial TSM effort, the list represents the results of a largely qualitative and judgmental effort rather than a detailed quantitative analysis of the potential of each individual TSM action. The following priority TSM actions emerged:

1. Efficient use of existing road space—channelization of traffic, better signalization and timing, and reversible traffic lanes;
2. Preferential treatment for transit and other high-occupancy vehicles—reserved or preferential lanes, exclusive lanes to bypass congested points, conversion of selected streets to bus use, bus preemption of traffic signals, strict enforcement of reserved transit right-of-way, and special turning lanes or exemption of buses from turning restrictions;
3. Appropriate provision for pedestrians and bicycles—bicycle paths and exclusive lanes;
4. Management and control of parking—elimination of on-street parking (especially during peak periods), regulation of the number and price of public and private parking, and fringe and transportation corridor parking to facilitate transfer to transit and other high-occupancy vehicles;
5. Changes in work schedules, fare structure, and automobile tolls to reduce peak-period travel-reduced transit fares for off-peak users;
6. Reduction in vehicle use in congested areas—car pooling and other forms of ride sharing, and area licenses, parking surcharges, and other forms of congestion pricing;
7. Improvement of transit service—better collection, distribution, and internal circulation, greater flexibility and responsiveness in routing, express bus service in coordination with local collection and distribution services, park-and-ride services from fringe and corridor parking, shuttle transit services from CBD fringe parking areas to downtown centers, and jitneys and other paratransit services; and
8. Increase in internal transit management efficiency—improved transit information and real-time monitoring and transit information control.

Priorities and Implementation

Based on the inventory work and the qualitative assessment of priorities related to general objectives, the initial TSM report identified a number of actions that merited further consideration and development. For each action, recommendations were put forth with regard to potential applicability to other parts of the region, opportunities for a coordinated approach on a metropolitan scale, and opportunities for further development and refinement of techniques and procedures through the unified work program for transportation planning.

TPB, the Technical Committee, and the staff all recognized that this first report was intended as an initial benchmark in the continued development and implementation of TSM actions. As new actions were identified, evaluated, and developed and as current actions were expanded and further implemented, they would be monitored and the results would be used in the updating and refinement of the next TSM element the following year. Proposed TSM actions requiring further study would be identified in the unified planning work program, and TSM actions that appeared to be ready for implementation would be included in the short-range transportation improvement program.

Finally, because of the general concern by responsible state and local agencies that the TSM recommendations might be taken out of context, the initial report noted that the implementation of or continued emphasis on a given recommended action depended on the fiscal resources, policies, regulatory powers, and responsibilities of the appropriate implementing agencies.

FUTURE TSM PLANNING

The initial effort of TSM planning in the Washington metropolitan area resulted in identifying a number of accomplishments not previously considered within the broader context and philosophy of transportation system management, a number of deficiencies in carrying out the initial effort because of time constraints and conceptual and definitional problems, and a number of opportunities for future refinement and improvement of the process.

Deficiencies

It is clearly desirable to pursue a more quantitative approach both to the development of criteria for establishing priorities and to the evaluation of specific actions and strategies designed to meet those criteria. In addition consideration must be given to packaging strategies that are mutually supportive in achieving specific objectives. And finally, we need to do more work in evaluating trade-offs among competing and sometimes conflicting objectives (such as mobility, air quality, energy, and traffic safety).

Some of these points can be illustrated by referring to a nearly completed transportation-related air quality study for the Washington metropolitan area. The purpose of the study is to evaluate transportation-related control measures and combinations of measures to achieve ambient air quality standards in the region. Table 1 gives candidate measures that were analyzed in terms of potential emission reduction. Most of these measures fit within the general definition of TSM actions.

So that the individual transportation control measures could be ranked on a common scale with respect to their potential for reducing emissions, the criterion "composite potential emission reduction percentage" was devised. This numerical measure is roughly equivalent to an estimate of the potential each control measure has for reducing hydrocarbon emissions from 6 to 9 a.m. The values of this criterion are not based on a detailed air quality analysis of each measure and are intended only to provide an order-of-magnitude comparison of relative effectiveness among the measures. Table 1 also gives an acceptability ranking of the measures that reflect the judgment of transportation policy makers and professionals on the relative likelihood of implementation of various measures.

The information in Table 1 illustrates several points. First, individual TSM actions can be quantified in terms of their potential to meet specific objectives. Second, the likelihood of implementation, a significant factor in real-world decision making, can be entered into the equation, in at least a subjective and judgmental fashion, by soliciting the opinions of key policy and decision makers in the region. And third, by adding quantitative values for each measure related to energy, traffic con-

Table 1. Potential emission reduction of candidate measures.

Measure	Acceptability Ranking	Composite Emission Reduction Percentage
Eliminate daily and monthly parking rates and charge hourly rates throughout the day	47	9.6
Require heavy-duty air and fuel control catalytic retrofit	48	8.6
Institute inspection and maintenance programs	32	8.1
Have seasonal controls such as "smog days" for federal workers	34	7.4
Impose a parking surcharge of $2 within any district with accessibility level 3 or 4	46	6.7
Increase fuel tax 50 cents per gallon	62	5.1
Impose a parking surcharge of $2 within any district with accessibility level 4	43	4.4
Institute flexible work hours so as to stagger work hours and encourage car pooling	15	4.0
Impose a parking surcharge of $1 within any district with an accessibility level 3 or 4	45	3.7
Impose a parking surcharge of $1 within any district with accessibility level 4	41	2.6
Institute commercial hourly parking rates at all federal parking facilities	42	2.5
Allow car-pool vehicles only in 50 percent of garages during morning peak periods	10	2.3
Increase fuel tax 20 cents per gallon	52	1.9
Make ring 0 automobile free	58	1.6
Institute commercial parking rates for all federal parking	28	1.4
Convert one lane to buses and one lane to car pools on all facilities with three or more lanes in the peak direction	50	1.2
Have a flat peak-period transit fare of 40 cents	57	1.1
Stagger work hours primarily for federal employees	19	1.0
Install progressive signalization so as to increase regional average speed 1 percent	31	1.0
Have monthly transit pass of $15	40	1.0
Eliminate all on-street nonresidential parking for more than 2 hours in all districts with accessibility level 3 or 4	44	1.0
Have a flat peak-period transit fare of 40 cents for the District of Columbia and 50 cents elsewhere	56	1.0
Increase fuel tax 10 cents per gallon	36	0.9
Have a monthly transit pass of $20	33	0.8
Impose restrictions on peak-hour truck deliveries in the District of Columbia	38	0.7
Reserve one lane for car pools on all facilities with three or more lanes in the peak direction	27	0.7
Reserve convenient parking spaces for car-pool vehicles in parking facilities	14	0.7
Establish a regional and localized car-pool matching service	9	0.6
Eliminate 10 percent of all privately owned parking spaces in parking lots and garages in the core	61	0.6
Eliminate all on-street nonresidential parking for more than 2 hours in all districts with accessibility level 4	39	0.6
Reduce transit fares 25 percent	59	0.5
Eliminate all on-street nonresidential parking in the core	55	0.5
Encourage van pooling in the private sector	17	0.4
Allow no more than two lanes for automobiles on inbound facilities	53	0.3
Reduce transit fares 10 percent	49	0.2
Encourage employers to subsidize transit fares of employees	21	0.2
Reduce parking fees for car-pool vehicles in lots and garages	25	0.2
Provide circumferential bus service on the beltway with bus pull offs at interchanges	54	0.1
Encourage contract bus services	13	0.1
Increase express bus frequencies by scheduling extra buses displaced by Metrorail facilities	8	0.1

Table 2. Transportation control measure packages.

Acceptability Ranking	Measure	Package 1	2	3	4
1	Provide additional exclusive bus lanes		X	X	X
3	Give car-pool vehicles priority at Metro stations		X	X	X
5	Provide preferential bus treatment at Metro stations	X	X	X	X
7	Build additional bicycle lanes and install bicycle racks			X	X
8	Increase express bus frequencies by scheduling extra buses displaced by Metrorail facilities		X	X	X
10	Allow only car-pool vehicles in 50 percent of garages during morning peak periods		X		
11	Establish a reciprocal violations enforcement system	X	X		
12	Expand parking at outlying Metro stations		X	X	X
13	Encourage contract bus services		X	X	X
14	Reserve convenient parking spaces in parking facilities for car-pool vehicles		X		
15	Institute flexible work hours so as to stagger work hours and encourage car pooling	X	X	X	X
17	Encourage van pooling in the private sector		X	X	X
18	Reduce peak-hour headways on commuter rail lines to 15 min		X	X	X
25	Reduce parking fees for car-pool vehicles in lots and garages		X	X	X
28	Institute commercial parking rates at all federal parking facilities	X	X	X	X
31	Install progressive signalization (where applicable)	X	X	X	X
32	Institute inspection and maintenance programs	X	X	X	X
33	Have monthly transit pass of $20		X		
38	Impose restrictions on peak-hour truck deliveries in the District of Columbia		X		
39	Eliminate all on-street nonresidential parking for more than 2 hours in all districts with accessibility level 4	X	X		
43	Impose a parking surcharge of $2 within any district with accessibility level 4		X		
44	Eliminate all on-street nonresidential parking for more than 2 hours in all districts with accessibility level 3 or 4			X	X
45	Impose a parking surcharge of $1 within any district with accessibility level 3		X		
47	Eliminate daily and monthly parking rates and charge hourly rates throughout the day at all parking facilities			X	X
48	Require heavy-duty air and fuel control catalytic retrofit	X	X	X	X
52	Increase fuel tax 20 cents per gallon				X
53	Allow no more than two lanes for low-occupancy automobiles on highway facilities inside the beltway in the peak direction, excluding limited-access facilities			X	X
58	Make ring 0 automobile free				X
59	Reduce transit fares 25 percent				X

gestion, traffic safety, cost, and other specific factors, one can begin to identify potential payoffs and trade-offs for and among various measures in achieving a group of objectives.

Table 2 gives an example of packaging the individual measures. In this case, the individual transportation control measures were combined into four candidate packages of measures to be tested and evaluated in accordance with adopted quantitative criteria. The intent in forming the packages was to make each one progressively harsher and as a result presumably more effective than the preceding package.

Analysis of the estimated impacts of the four packages of candidate transportation control measures generally indicated that, to achieve significant reductions in travel, the transportation control plan for the area must contain disincentives for low-occupancy vehicle use in addition to incentives for car-pool, van-pool, and transit use. However, it was also found that, once several stringent low-occupancy vehicle disincentives have been implemented, the marginal effectiveness of additional disincentives can be expected to decrease.

Although this example illustrates packaging of measures for a specific objective, a similar if more complex approach can be used to package TSM measures to trade off and optimize groups of strategies to meet a number of objectives.

Opportunities

MPOs, particularly operating within a COG framework, can play a key role in the further refinement and implementation of TSM plans.

1. Because the planning process is under the policy guidance and direction of local elected officials, many of whom have become increasingly more interested in and committed to low-cost, short-range actions and strategies to meet transportation demands, significant leverage can be applied to encourage transportation staffs at all levels of government to expedite their efforts on the most effective and acceptable actions and strategies.
2. Through their responsibilities for coordinating and monitoring transportation activities at a metropolitan scale, MPOs can identify opportunities for applying locally successful TSM measures to other parts of a metropolitan region.
3. Because many MPOs are concerned with a wide range of functional and social service goals and needs, particularly at the local government level, they are in an excellent position to address trade-offs among competing objectives in transportation and related social and environmental strategies and impacts.
4. MPOs are in an excellent position to integrate and relate TSM planning to other elements of the area-wide transportation planning process, such as the long-range plan element, the short-range transportation improvement program, and the unified planning work program, all within the larger framework of comprehensive metropolitan planning and development.
5. Since most MPOs bring local and state policy makers and decision makers throughout the region together, the opportunity exists for resolving policy and institutional conflicts by bringing the weight of metropolitan consensus at the political level to bear on specific policy and institutional issues.

IMPLEMENTING TSM: A DISCUSSION

Douglas Kelm,
Twin Cities Area Metropolitan Transit Commission, presiding

Presentation

John D. Wysong, Engineer, Montgomery County, Ohio

The Dayton Area Transportation Planning Agency has three major operating groups. The Transportation Coordinating Committee (TCC), which heads the planning agency, is a group of elected officials from the member communities (communities become members by paying an assessment of 7 cents/capita). The TCC is the governing body, the policy-making body, and the body for which the paid staff and executive director work. It has a technical advisory committee made up of professional planners and engineers and other professional people. The local planning agency also has an executive director and a full-time paid staff of professionals with interdisciplinary expertise.

We have been involved with the planning agency for many years. In fact, our local area was the first to use its 1972-1973 allocation of urban funds for a computerized traffic signal control program. It is very much a "bottom-up" agency. It is probably the only agency we have in our area to bring together the many communities, including some 20 different cities and villages in a two-county area.

TCC has been involved in TSM for many years, and we now have a formalized TSM plan. As an elected offical, I think our major problem is one of communication, even though cooperation is also a major one. As professional people, we must communicate to the public about the needs and the reasons. If we are going to restrict vehicles, stagger work hours, and do other things that affect the freedom of citizens to come and go as they please, then we must communicate with them and tell them why. If we cannot tell them why, then we should not be doing those things.

Presentation

O. D. Gay, Minneapolis Downtown Council

There was a great emphasis at the conference on what government can do and what various commissions can do, but it is my strong opinion that unless the business community is involved these actions will not be as successful as they should be. I represent a business community that has been involved not only in transit but

also in every phase of local transportation and other activities in the Twin Cities area. We were the first private, nonprofit organization to support public ownership of the private bus lines when the president of the bus lines sat on our board and voted against that action.

Every city has a tremendous amount of business skill and business acumen, and public professionals would be amazed how easily it is available to them if they just ask for it. One way to obtain this expertise is to have business people serving on boards and commissions.

One thing that the business community asks of public officials and other people who make major decisions: Don't spring surprises on us. Don't come to us with no advance warning and say, "We are going to turn this street into a bus lane" and then expect us to say, "That is a great idea!" We have exclusive bus lanes on two streets in downtown Minneapolis. When this was first proposed, very frankly, the business community thought that everyone was crazy, except it of course. But by getting a committee of business, labor, and government officials to sit down, we were able to work out the difficulties, real difficulties, that business would face by making exclusive bus lanes. We got the Transit Union involved, and we got the Transfermen's Association involved because taking the curb away from truck delivery causes a major problem. Again, had we said, "It won't work," and had the planners said, "It's got to work," nothing would have happened.

I have also got news for planners who talk about staggered work hours. Unless you involve the business community, you are not going to have staggered work hours because those in the business community make the decisions. They can be talked to and they can be persuaded, but they must be involved. We have been working on this, and it is an extremely difficult issue. We have to have your expertise (How much do the hours have to be staggered—5 minutes, 10 minutes, 15 minutes?), but you also have to have ours.

The Downtown Council of Minneapolis was the primary sponsor of the Nicolet Mall, which was paid for exclusively by private funds except for two grants, one a transit grant and one a beautification grant. The entire project, including maintenance of the mall, bus shelters, and heating mats in the sidewalks, today is being paid by the benefited property owners and costs just under $500 000 a year. Without an enlightened business community that is willing to take on that sort of expense because it is good for the city and for the area, we would not have the mall.

We worked a long time with the highway department and the transit commission trying to get people to car pool, but were not successful (I guess maybe it is harder to get people out of their automobiles than we think it is). We have 95 000 people working downtown, and we cannot get them all downtown by automobile. For a week, Monday through Saturday, our local newspaper surveyed 2070 people who were downtown shopping. Of those people interviewed, more than one-half usually got downtown by bus. So we do have a stake in good transportation. However I do not think the final answer to transit in the Twin Cities is the bus. I think we have to have a better system than that.

Presentation

Glenn Olsen, Minneapolis City Council

Those who conduct the public's business are going to have citizen participation today whether they want it or not. I recall that some years ago a freeway was constructed through south Minneapolis. If that project were to start over again today, there is no way that that portion of south Minneapolis could be taken for a freeway. But at that earlier time, people accepted highway department decisions that the route had to go here or there, and it went through.

It seems to me that we are down to two ways of having citizen involvement. Either we have it through a formal, structured approach, or we wait until the public hearing and end up with lawsuits and requests for environmental impact statements and the delays and sometimes stoppages they bring.

I have been active on a number of citizen advisory committees, and we find they work in this area. We have also tried to go beyond the structure of government and the formalized approach and have undertaken marketing surveys. We asked bus riders and potential bus riders their ideas on transit and what would happen if we did this or did that. We asked the bus riders on Interstate 35W what their thoughts were on service and fares, and they answered that they thought a surcharge on freeway express was fair and reasonable, an answer we did not expect. On our route ridership studies in various areas of the metropolitan area, we do go through a formal process. We start with general goals and objectives, and these are used in the final analysis to evaluate the final plan. Then the professionals take over—consultants, engineers, and designers—and work on the project, but at each step a review is conducted by the citizen committee until we have the concept plan and the final plan.

In some ways, it would be easier to push through a program without bothering with the citizens because they can ask some ridiculous questions—and some hard questions. But the product is better because of their participation. They sit at the table usually with no axes to grind and no personal recognition to gain; they are simply interested in their community, and they ask good questions. They know the territory far better than the staff. Not every citizen can be involved in a program, but those that are not know that they have representatives on the particular committees who are asking the questions that they, themselves, would ask were they there.

Citizens are going to have their say one way or another, and it seems to me that it is far better to lead them through the process, explain it to them in a rational, calm manner, and incorporate their knowledge and concerns. Then, when the project is ready to proceed, it will have their full support.

Presentation

A. C. Fields, Jr., WGN Continental Broadcasting Company

I have been involved in the broadcasting business for more than 25 years, and I think I know what the public is but I sometimes wonder if the public knows what the "media" are. The media are really made up of four parts: radio, television (two entirely different types of electronic media), the daily press, and the weekly neighborhood press. All four of those components of the media have entirely different qualifications and needs. Let us just take television, for instance. An agency calls a news conference. It sends out the notice over the wire service if it is in a large city. In a smaller city, it notifies the stations by telephone that it is having a press conference at 2:00 tomorrow afternoon. When that time comes and few people show up, the agency is disturbed and wonders why. The main reason is that the press was not told what the conference was about. Too many times we have been called to a press conference that turns out

to be a play by an elected official to get his or her name on the air or in the papers.

Television is a business of sight, sound, and motion, and all three of those elements have to be present or television just is not going to cover the event. Holding a press conference and only giving out a release may work once or twice, but will not get long-range press support. For a long-range project such as a mall or a new concept, you should wait until there is a model or some visual presentation before the news conference is called. You will then be amazed how many times that will be used on the air.

A press conference anytime in the afternoon is bad for the electronic media. They "go to bed" with the editing of their film and tapes about 3 p.m. for their 5 p.m. news shows (normally the 10 p.m. news is just a refined version of the earlier news). They will not cover a press conference at 2:00 p.m. because they cannot get the news on the air by 5 p.m. and they know the papers will carry the news and it will therefore be stale before they can use it.

I have another little piece of advice that I would like to offer: When you have a problem, call the media together, explain the problem, but don't give the answer at first even though you know what the answer is. Pose the problem and let the media help you with the answer. Maybe that is subterfuge, but it works.

The media have to look at all sides of a question because they have all types of people—the rich, the poor, the unemployed, the middle class, the union people, and management people. They may not always be fair, but at least they try to be objective in most cases. If you are not satisfied with how your story was presented, don't try to take on the media yourself because you are not going to win. If you want to get your message across to the people who get their news and information from the media, then you are going to have to cooperate with those who represent the media and in most cases you will find that they will cooperate with you.

CASE STUDIES

BOSTON, MASSACHUSETTS

Emily Lloyd
Office of the Mayor

The Boston case study deals with the development of an automobile-restricted zone (ARZ) in the retail center of the city through a reordering of circulation patterns of all transportation elements converging in the area: private automobile, transit, service vehicles, taxis, pedestrians, and paratransit vehicles. This plan is one of several transportation system management elements included in the broad transportation plan for the Boston region. This is a report of the process of developing a TSM plan and not of the implementation and success of such a plan.

I want to focus on two aspects of the plan. First, this plan reflects the development of Boston's transportation policy during the past several years. Second, the implementation of a transportation system management element can be a complex process. In fact, the short-range approach through the use of existing resources may save money, but it can be as difficult to implement as the big new project approach.

EXISTING SITUATION IN REGION

Boston is a labyrinthian city whose street patterns evolved from cowpaths. While other new towns were laid out with an eye to coherent development and easy movement, Boston reflects the preoccupation of its early settlers with commerce and politics, resulting in the jumble that we live with today. A side benefit (or disbenefit) has been a persistent resistance to automobile traffic in the downtown. Early on Bostonians recognized their dependence on public transportation and developed suburbs around the streetcar lines. Has this hurt Boston in the automobile age? It is impossible to say, but I would argue that in the long run Boston has preserved the essential characteristics that make a downtown unique and that Boston will remain the Hub (a name that goes back to when Boston was considered, or considered itself, the hub of the universe) long after other downtowns have become indistinguishable from major suburban shopping centers.

This is reflected in the continuing vitality of the downtown. Filene's, home of the famous Filene's basement, has recently built a new store. Next door, Jordan Marsh has a major new store under construction. Bonwit Teller continues to be a bustling center in a historic building, where those suburbanites who insist on driving queue up patiently for room in the tiny parking lot. Lord and Taylor and Saks Fifth Avenue opened major stores in the downtown (with no suburban branches) during the last decade. And although Bloomingdales and Jaeger went to the suburban Chestnut Hill Mall, Brooks Brothers lives on downtown, and Bergdorf Goodman is rumored to be considering a branch nearby.

The existing transportation system is extensive. Four rapid transit lines cover virtually every compass point overland route to Boston. One of these lines has four spur streetcar lines connecting with it. Nearly 200 bus routes provide service between the radial rapid transit lines and beyond their termini. In addition, there are 14 express bus routes to the downtown. Two commuter rail systems provide 13 feeder lines terminating at the two rail stations in Boston; and four trackless trolley routes using new equipment run through the cities of Cambridge, Arlington, and Watertown just to the north of Boston.

The major highway system in the Boston region consists of only one north-south route (I-93), only one east-west route (I-90), and two concentric ring routes. The north-south route traverses the downtown area via the Central Artery. The east-west route terminates with I-93 in the central business district. Three major road systems that were planned in the early 1960s have not been built: The Southwest Expressway from I-95 into downtown, an extension and upgrading of Route 2 from the northwest into Boston, and a proposed inner belt looping the downtown residential neighborhoods.

AREA GOALS

Of course, our perception of Boston's resistance to the automobile as heroic is hindsight. During the 1940s and 1950s there was a strong belief that developing automobile access was the only way to save the city, and this belief fostered the construction of the Southeast Expressway and the planning of a second expressway through the heavily traveled southwest sector of the city.

In 1972, after prolonged controversy, then Governor Sargent halted the clearance of land already under way for the Southwest Expressway. The landmark decision not to build any more highways within the circumference of Route 128, which rings the Boston metropolitan region, stimulated a reordering of transportation planning around the primary goal of preserving the vitality of the regional core through an improved transportation system.

The availability of new Interstate transfer funds (highway funds diverted from the Southwest Expressway project) to supplement UMTA funding produced an ambitious capital program for the public transportation system. The broad goals of this program have been to restore the existing rapid transit, trolley, and commuter rail lines and to expand rapid transit lines as well as feeder bus lines. At the same time, increased commuting by automobile has been discouraged by a freeze on the number of downtown parking spaces and an ongoing policy by city officials not to increase capacity on the major arterial routes into the downtown.

TSM STRATEGIES

Yet with all these elements in place—thriving downtown, extensive transit, constrained automobile capacity—Boston continues to wrestle with the transportation problems that plague other cities: falling transit ridership, a rising deficit, and too many automobiles moving through the residential communities adjacent to the downtown. Clearly, massive capital investment in transit is not enough; we need better management of an overall transportation system as well. As I have indicated, transportation system management strategies are not new to Boston. The no-highway decision evolved as part of an overall plan for transportation in the region that directed us toward TSM types of policies.

The major thrust of our urban system project development during the past few years has been toward increasing the operating efficiency of our major arterials without expanding the total number of vehicles flowing into the downtown. These projects have emphasized improved signalization and channelization as well as pedestrian amenities and landscaping. We have resolutely maintained that pedestrian movement is an integral part of any street redesign project. More recently, we have increased our emphasis on incorporating elements to improve transit operation as well. In fact, we are currently negotiating the resolution of a dispute over neck-downs, which are enormously popular with community residents but which the Massachusetts Bay Transportation Authority fears may slow bus operations.

Preferential treatment has been tried in Boston, most notably on I-93 north of Boston, which provides a short preferential lane for multiuser vehicles, but so far enforcement problems have inhibited the introduction of such lanes on city streets. Implementation of the EPA-mandated on-street parking ban between 7:00 and 9:30 a.m. could open some potential bus lanes, but that is still in the future and would not apply to residential neighborhoods where we plan to exempt automobiles bearing resident stickers from the ban, pending court resolution of the legality of the resident sticker program.

In addition to our subway and trolley system, Boston's strong point must be our fine record of reclaiming major pedestrian spaces. Starting with Olmstead's plans for an "emerald necklace" of open space around downtown Boston, the city has maintained a uniquely serious commitment to pedestrian space. This has allowed planners to carve out the Christian Science-Prudential complex in the Back Bay, the Government Center in the downtown, and the walk to the sea from the State House through Government Center past Faneuil Hall and the new Faneuil Hall Markets to the city's new Waterfront Park.

One possible strategy sorely neglected by Boston to date is the potential beneficial effect of flexible work hours. This does not reflect lack of interest, just lack of staff time to figure out how to implement a flexible hour plan for the city and to encourage others to follow suit.

In addition to the on-street rush-hour parking ban in the downtown, our EPA regulations include (with our consent) a freeze on the number of off-street commercial parking spaces. This means that, unless drivers wish to circulate endlessly through the downtown, there is an effective ceiling to the number of automobiles that will use the downtown. Overall, our goal is to phase out some of the less efficient older garages and to focus parking in areas readily accessible to the major automobile routes, decreasing circulation through the downtown.

In conjunction with the parking freeze, we have been working with the residential communities that cluster around the central business district—the South End, the Back Bay, Beacon Hill, the North End, and the Waterfront—to reduce through commuter traffic and discourage commuter parking. This has been accomplished through the resident parking sticker program that exempts residents from many parking restrictions within their own neighborhoods and through measures such as street direction patterns and street design that discourage through movement. In fact, a combination of street direction changes in the South End has created a mini-ARZ.

In short, the city of Boston has started to focus efforts on a cluster of approaches emphasizing parking restrictions, measures to discourage commuter traffic through residential communities surrounding the downtown, and concurrent development of pedestrian amenities in the downtown.

AUTOMOBILE-RESTRICTED ZONE DEVELOPMENT PROCESS

The automobile-restricted zone plan represents a microcosm of the approaches I have described. The retail core was chosen as the area for planning an ARZ because of a convergence of elements. First, large numbers of workers and shoppers are attracted into this area, where the four radial subway lines converge within four blocks; two of the lines exit directly into major department stores. There is already an established pattern of transit and pedestrian movement: A survey at one of the major stores showed that only 15 percent of workers arrive by automobile and that 75 percent of the shoppers arrive by subway, bus, train, taxi, or foot. In addition, the area contains only about 10 percent of the downtown parking spaces.

Nonetheless, the area is plagued by automobile congestion. As a result, the major bus routes terminate at the periphery of the district, and taxis cruise endlessly because of the limited space available for waiting. Only one limited shuttle service carries patrons from an outlying garage into the district. Service vehicles both

cause and suffer from the congestion, often double parking to make a delivery. So our goal was to manage our street space so as to divert through traffic, to open up surface transit movement, to rationalize deliveries, and to encourage pedestrian travel.

The downtown retail district has been the focus of numerous studies to improve its environment. Two small parks have been built adjacent to Washington Street, the major thoroughfare of the district. The first phase of a plan to widen the sidewalk and add pedestrian amenities is being built on that major shopping street. The reason this project is being done in phases is to honor the concerns of merchants about radical changes in the use of streets. They feel Boston is a relatively thriving city, as we do, and are wary of making too rapid a change.

The process for planning the ARZ began with the clear understanding that the enforcement of traffic regulations in the downtown area is quite lax. Because of a complex ticket collection system, the extensive tagging of illegally parked vehicles does not have the desired deterrent effect. In addition, the towing program is working under limited resources, both in personnel and space available for storage. A scandal involving contracted towing companies in the early 1970s has made us cautious of using private companies, and hence we have had to rely on our own limited personnel and tow vehicles. The availability of tow lots has been a problem in that it is difficult to find a location that is close to where towable violations take place and that does not adversely impact residential neighborhoods. Boston's limit on parking fines is only $15, and an increase requires state legislative action, which the legislature has so far withheld. With these difficulties in mind, we set out on the ARZ process with the idea of setting the broadest parameters possible for an ARZ. We took the outer limits of the retail district and instructed our consultants to reassign the traffic by using accepted traffic engineering principles and concepts. The constrained entry points to the retail district were identified, and we studied these points of entry with the goal of maintaining the existing level of service overall and developing increased volume at necessary points through various capacity-building approaches such as channelization, phasing, and enforcement measures.

After this exercise was complete, we had established that an extensive ARZ could work from a traffic point of view, which gave us the flexibility to look at a range of alternatives as we addressed our major goals. We ultimately settled on a plan that was less extensive than the broad first cut for several reasons. Because of its size, the larger plan threatened to lack the "happy bustle" that we feel characterizes a healthy retail environment. Our analysis of other large pedestrian spaces in the city showed that their one drawback in many cases has been a lack of activity in the space. We, therefore, chose to restrict automobile use to a few streets rather than to ban automobiles from the area altogether.

The final plan consists of completion of the Washington Street mall, development of a major pedestrian cross street along Winter-Summer Street, and development of an exclusive surface transit loop for both MBTA and shuttle buses, entering the district along the Washington Street mall and returning via an exclusive lane on Chauncy-Arch Street on the other side of the major stores. Pedestrian and transit streets will be used for deliveries during certain optimal hours, thereby facilitating movement by all modes during peak hours. A more generous allocation of taxi waiting space within easy distance of stores will reduce cruising and reinforce the convenient use of taxi stands, already well established in Boston.

The changes in travel that we can expect by implementation of the ARZ have been forecast through the use of a travel demand model developed by one of our consultants. Depending on the use of a shuttle system and the effectiveness of traffic and parking regulations that we employ, it is predicted that we can increase transit travel by 6500 persons and decrease automobile trips by as many as 8000 daily.

Since we are dealing with the retail district, our strategy will be that which maximizes the increase in nonwork trips to the ARZ. That strategy would involve improved enforcement and the development of a three-route shuttle system. We expect an increase of 3996 nonwork transit trips and a reduction of 1766 nonwork automobile trips, giving us a net increase in nonwork trips of 2230.

The percentage changes in automobile and transit trips are modest: a maximum increase in nonwork transit trips of 5.13 percent and a maximum decrease in nonwork automobile trips of 6.56 percent. Also, if one ascribes to the theory of induced demand, one can expect that the increased capacity of street space for pedestrians will result in an increased daily volume of pedestrians in the retail district. Of course, a major factor in increasing pedestrian volume will be the activity provided at the end point of the trip, (i.e., shopping, eating, and entertainment), and we will make sure in our implementation of the ARZ that we do indeed plan for an interesting and active street space.

IMPLEMENTATION

The generous support of UMTA has facilitated the development of the ARZ plan. Now only we can implement it, and I wish I could give a facile outline of steps to take. Adopting the plan itself is no easier or harder than getting approvals for a capital project. Myriad departments must sign off: the Traffic and Parking Department, the Law Department, the Public Works Department, the Real Property Department, the Boston Redevelopment Authority, the Police Department. Ultimately, of course, cooperation and implementation rest on having the mayor's support for the plan. At this point we have that support and the cooperation of all departments—some grudging, some skeptical, some enthusiastic.

The next step is to expand and formalize our informal contacts with the retail and business communities. In the past these groups have been wary of tinkering with one of the few healthy, downtown retail districts on the East Coast, but it is our hope that the good cooperation built up during the development on the Washington Street mall project and the good feeling toward the part of the mall scheduled for completion this fall will foster a receptive climate for the complete ARZ plan. We feel that our careful analysis of potential impacts will allay merchant concern about automobile restriction and that they will applaud both the pedestrian amenities and the improved bus service.

Finally, the decision must be made as to the best structure to implement the plan, and this must be a local decision wherever made. Where should project management responsibility reside? Are existing agencies able to handle the implementation of the diverse elements in the plan? Will departmental and agency autonomy abrogate successful plan coordination?

In addition to these anticipated constraints, funding will, of course, be a problem. Because of the court-mandated construction of several new schools and a new jail, Boston has virtually no capital budget flexibility. For what money there is, there is the tendency to give priority to big development projects or to projects in the troubled residential communities.

And, we must find a way to give enforcement priority among Police Department responsibilities. We have had excellent cooperation from the police, but the strain put on the department by Boston's court-ordered busing plan has made it difficult for them to promise full enforcement of any traffic plan.

If and when we overcome these systemic hurdles, we feel the plan will work. The opening of a transit way will be an "ice breaker" as far as transit priority is concerned and may smooth the path for other short-range transit improvement projects. The linking of pedestrian spaces will encourage the sense of Boston as a "walking city." Shuttle service can expand the shopping range for transit users and pedestrians. Giving priority access at some locations to taxis will increase their effectiveness as a paratransit mode. Of course, we are hoping for increased sales for the retail establishment, a phenomenon that has taken place on other pedestrian malls and automobile-free zones elsewhere in the United States and Europe.

Federal officials told us that we were chosen to develop an ARZ demonstration proposal because we had so much going for us and because we had so many problems. That is a fair description of the situation in Boston. We feel that, if we can do it, anyone can. And if we do accomplish what we have set out to do, we will be an example that other cities will want to emulate.

MINNEAPOLIS-ST. PAUL, MINNESOTA

Larry Dallam and Stephen Alderson
Metropolitan Council of the Twin Cities Area

This paper describes the transportation system management (TSM) approach to planning and development in the Twin Cities metropolitan area. The Metropolitan Council of the Twin Cities Area is the designated metropolitan planning organization. A formal TSM plan has not been completed at this writing, but the long-range transportation plan was adopted in January 1976 and is in essence a TSM plan. The Metropolitan Council believes that TSM strategies and actions are appropriate ways to attain long-range goals. This belief is the end result of several past projects designed and implemented to demonstrate the suitability and applicability of TSM actions. Major arterials and freeways are viewed as transportation (multimodal) routes and should be designed and managed as such. Transit riders are broadly defined as those people who ride rather than drive, and less emphasis is placed on the type of vehicle and the provider of the service. Great concern is being expressed about the rising operating deficits of the public transit operator (the Metropolitan Transit Commission) and its philosophy for expanding conventional service. In response to this situation, the Metropolitan Council has adopted policies that emphasize paratransit services, especially for commuter work trips and service within the developing suburbs.

The Twin Cities metropolitan area comprises seven counties encompassing about 7800 km^2 (3000 $miles^2$) within which about 2 000 000 people reside. About 1200 km^2 (450 $miles^2$) are urbanized; that is, the services and facilities necessary for urban living are in place.

This paper presents a brief overview of long-range planning in the area and an abstract of the transportation plan. Several TSM projects that have been implemented are generally described to indicate the basis for the optimistic confidence this area has in the TSM approach to planning and implementation.

PLANNING FRAMEWORK

Regional Goals

The transportation plans, policies, and strategies were developed in response to the goals and development policies for the region. The most significant goals affecting transportation are

1. Maintain and enhance the quality of life in the Twin Cities area (social, economic, and environmental);
2. Maintain two strong, vital metropolitan centers, which include the central business districts of St. Paul and Minneapolis;
3. Have orderly, economical growth and development in the Twin Cities area; and
4. Provide urban residents with choices of efficient, convenient, and attractive transportation to both subregional and regional opportunities.

Development Framework

The Development Framework is the document containing the adopted policies for guiding growth in the Twin Cities area. In essence, it delineates two distinct planning areas: an urban service area and a rural service area. The urban service area (planned to accommodate the expected growth to 1990 at current densities) is to receive all urban services necessary to support urban development, and the rural service area is to remain rural.

The major thrusts of the framework are to stop leap-frog development and urban sprawl, preserve commercial agricultural land, better use existing (and planned) investments and services, and enhance the central cities and older, fully developed suburbs—and do this without diminishing the diversity and quality of life-styles prevalent in the Twin Cities. The state legislature responded to the Development Framework by enacting the 1976 Land Planning Act, which requires counties and municipalities to prepare comprehensive plans and programs consistent with the Development Framework and metropolitan systems, including transportation, sewer, and parks.

Transportation Policies and Philosophy

After the formulation of regional goals and the adoption of the Development Framework, the overall approach to transportation planning and development was reviewed. In transportation terms, attainment of the goal of a high quality of life requires good accessibility to the activities and opportunities that exist within the region. Accessi-

bility is determined by travel time—how long it takes to get to the desired activity or opportunity. If the time is excessive, the activity is not accessible and the quality of life of those who seek that activity is diminished. Therefore, transportation policies were prepared (and adopted) that specify travel times by transit and highway to various areas within the region from the urban and rural service areas. Special attention was given to the two metropolitan centers.

The accessibility policies specify maximum acceptable travel times during both peak and off-peak periods for trips by transit and during off-peak periods only for trips by the private automobile. These are significant policies, for they state the philosophy that major traffic arteries should henceforth be designed and sized for vehicular traffic volumes projected for the off-peak rather than the peak hours. This philosophy is directly counter to that employed by most traffic engineers and transportation planners throughout this country. It means that, for the metropolitan system to function without serious congestion in peak rush hours, people will have to adjust their travel behavior. More people will have to ride than drive. There are also policies that call for the provision and marketing of car pools, van pools, and public transit—all of which are to receive priority treatment along the major arterials. These policies promote strategies such as metering, preferential access for public transit, car pools, and van pools, and preferential treatment along the route, such as reserved lanes, bottleneck bypasses, and bus preemption of signals during peak travel periods.

Transit is viewed as a service that provides for people traveling as passengers (nondrivers) to their destinations, regardless of the type of vehicle and its owner. That is, the important factor is the service and not who provides the service. Both the public and private sectors are important suppliers of transit services, and whichever can provide the needed service at the least cost should do so.

Major Deficiencies

Based on the regional goals and policies, there are two major deficiencies of the existing transit and highway systems.

1. Accessibility to St. Paul and Minneapolis. There are several congested corridors to the two downtowns, resulting in excessive travel times in both the peak and off-peak periods.
2. The absence of alternatives for travel within the suburbs. The transit system is almost totally oriented to serve the two downtowns, where only 9 percent of the total regional travel begins and ends. More than 50 percent of the travel begins and ends in subregions, where there is no alternative to the private automobile. This lack of subregional transit service is a problem especially for the young, elderly, and handicapped.

Strategies

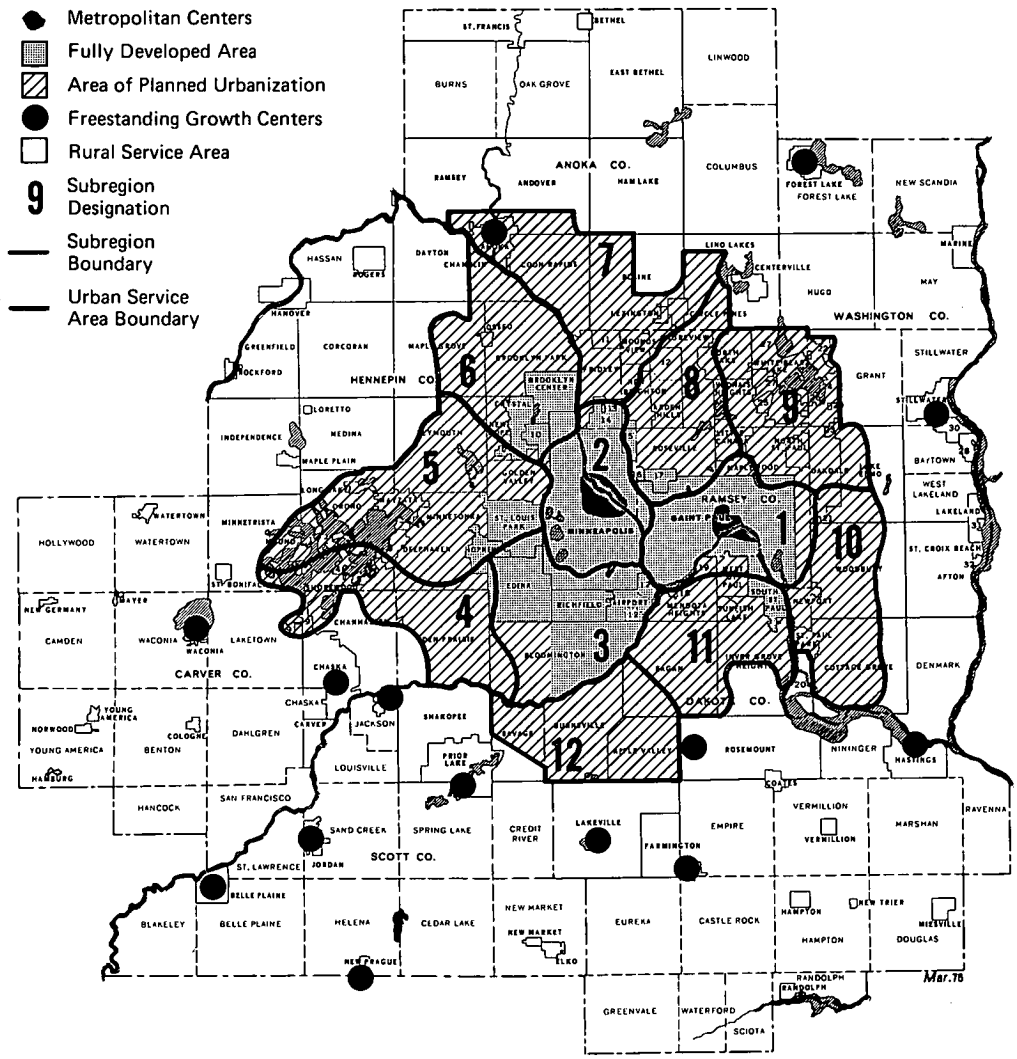
Based on the adopted accessibility policies, the existing highway system was analyzed as to how travel times could be decreased without major capital expenditures. In some corridors, synchronization of signals, channelization, and increased provision of transit (express buses, car pools, and van pools) were sufficient. However, five corridors will require new freeway construction. Even so, the new transportation plan has 180 fewer kilometers (112 miles) of freeways and expressways than the 1972 plan. As previously mentioned these new freeways are to be designed differently from those in the past (and present). Sufficient capacity to accommodate off-peak travel (assuming current travel behavior) is to be provided; peak-hour capacity is to be determined by assuming an automobile occupancy of 1.6 and conventional transit ridership of 35 percent of all downtown-destined travel. This policy position will require about a 25 percent reduction in automobile drivers, and a transit performance equal to the metered freeway demonstration project on Interstate 35W.

The other major deficiency is the absence of transit service for trips to destinations other than the two downtowns. The adopted strategy to remove this deficiency is a new concept and approach to transit service called the subregional concept. The urban service area, as defined in the Development Framework, is divided into 12 areas called subregions, two of which are the central cities of St. Paul and Minneapolis (Figure 1). These subregions are the primary market or trade areas of the activities located (or planned to be located) within these areas. Each subregion has (or will have) the basic necessities for daily living—employment centers, shopping center, health care center, education facilities, government services, and recreation and entertainment areas. Each subregion is designated as a transit service area. Transit service is to be provided for the residents of the subregion to the activities and opportunities located within that subregion. The type of service (conventional transit, dial-a-ride, shared-ride taxi) will be determined based on the characteristics and needs of each subregion. Since regional activities and opportunities are generally located in the metropolitan centers of Minneapolis and St. Paul, each subregion is to be provided with express service to the metropolitan centers. The express service is to operate out of transit terminals and be coordinated with the subregional transit service. The transit service plan is shown in Figure 2.

Analysis of travel behavior sampled in 1970 shows that more than 50 percent of all daily travel stayed within these designated subregions. This means that most people shop, do personal business, receive health care, recreate, and are entertained on a daily basis within 8 km (5 miles) of where they live. The existing public and private transit system is almost entirely oriented to taking people to and from the metropolitan centers and, therefore, does not serve these subregional trips. In the event of a critical fuel shortage, people living in the suburban subregions would be without transportation to subregional opportunities and activities. Also, those segments of the population without private transportation are limited in their choice of housing location. The subregional approach has been adopted to provide people with an acceptable transit alternative to the private automobile for daily travel within the area in which they live.

In summary, transit service is to be provided within subregions and between each subregion and the appropriate metropolitan center. Before 1990, transit service between subregions is generally discouraged because of the wide dispersion of the origins and destinations of of those trips and the high cost of providing the service. The Metropolitan Council has determined that the metropolitan highway system is to provide that level of accessibility necessary to accommodate these scattered intersubregional trips during off-peak hours. It means that the person who chooses to live in the western suburbs, work in an eastern suburb, and shop in a southern one will have to use an automobile. People are not to be restricted in their choices of life-styles, but they should realize that there are costs associated with the choice: the cost of owning, operating, and ensuring their automobiles, the increase of travel time during rush hours because of congestion, and the absence of a transit alter-

Figure 1. Transportation service and planning areas.



native if there is a critical shortage of fuel.

TSM PROJECTS

The Twin Cities transportation plan, both its long-range and TSM elements, is based in great part on the knowledge derived from past projects designed to more effectively use existing investments. Some of the more significant TSM projects follow.

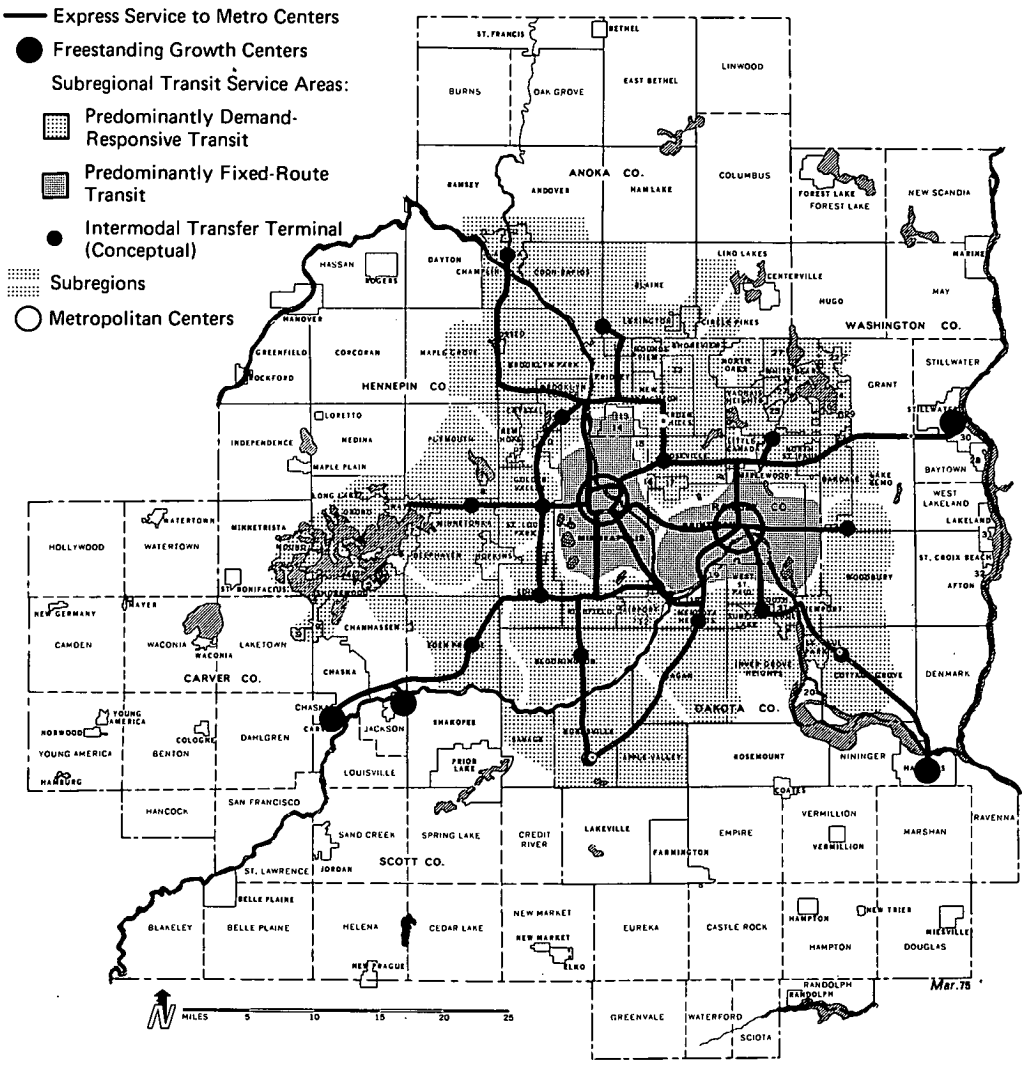
Bus on Metered Freeway

The bus on metered freeway project is an urban corridor demonstration project of the U.S. Department of Transportation. The project, on Interstate 35W, is broad in concept in that its purpose is to better manage automobile traffic, to improve transit service, and to improve accessibility to the Minneapolis CBD. Automobile access is metered by computer-controlled traffic signals at on-ramps. Special bypass ramps are provided for express buses. The whole operation is under computer surveillance and control. The basic objectives were to improve the service and operating characteristics of a 25-km (16-mile) segment of urban freeway and to increase transit service and use by providing express buses.

Noticeable success was attained in improving freeway service, transit service, and transit ridership. Express buses in the corridor currently carry 4000 one-way peak-hour passengers, most traveling to the Minneapolis CBD, which is equivalent to about 2800 cars. Originally, transit was expected to carry 40 percent of all CBD-destined passengers within the corridor served. Before the project began in 1972, buses (all local) were carrying 33 percent of CBD passengers. In 1974, express buses carried 15 percent and local buses 24 percent, a total of 39 percent. The percentage of CBD-bound travelers going as automobile drivers dropped from 25 to 22 percent between 1972 and 1974.

Improvements in the operating characteristics of the freeway were significant. Although peak-hour vehicle volumes dropped only slightly from 1972 to 1974, average speeds were increased during peak periods from about 8 to 16 km/h (5 to 10 mph). In 1974 the average speed was 74 km/h (46 mph) southbound and 80 km/h (50 mph) northbound during peak periods. The travel time saving for automobiles offset delays encountered at the metered on-ramps. Automobile driver response to the on-ramp signals has been good; minimal enforcement is required. There were no noticeable changes in environmental factors as measured by noise levels and only minimal decreases in gasoline consumption and emissions. Preferential access for car pools is being phased into the corridor.

Figure 2. 1990 transit plan.



Preferential Transit Lanes

Closely related to the I-35W project are two projects in the Minneapolis CBD for preferential transit. Nicollet Mall, conceived in 1956 and executed in 1967 as a joint pedestrian-transit way, has been a key element in the revitalization of the Minneapolis CBD. As a transportation facility, Nicollet Mall provides pedestrians with automobile-free movement along the major retail spine of the CBD and allows transit vehicles an exclusive facility. Rerouting of automobile traffic and transit lines accompanied the opening of the mall without any major adverse impact on downtown traffic.

Preferential treatment for transit vehicles has been extended to two parallel streets to the south of Nicollet Mall, where exclusive contraflow lanes for buses have been in operation for a year. The basic concept here has been to continue the preferential treatment given I-35W buses into the downtown area and was planned in the I-35W design. Other buses use the lanes also. Thus express buses make the best possible travel time after getting off the freeway. Travel times on the Marquette Avenue and Second Avenue segments are 20 percent less than when they operated in mixed traffic. The lanes have a potential for a 50 percent increase in bus volume, which is anticipated by 1980.

Minneapolis Computer Traffic Control System

The Minneapolis Traffic Engineering Division, Department of Public Works, is currently installing an upgraded traffic control system featuring a computer-based system master. Initially conceived to replace an "at-capacity" master controller, the new system is designed to handle signal operation for the next 10 to 20 years.

Out of slightly more than 700 signalized intersections within the city, 644 will be connected. The system will monitor about 600 detectors initially and will be able to adjust signal phasing on the basis of traffic flow conditions. A limited-capability, bus-priority operation system will be included in the initial phase. The system can be expanded to handle 850 intersections and 1500 detectors. Future plans also call for a changeable-message sign operation (as many as 200 signs), pollutant monitoring, and expansion of bus priority capacity. The

system has 139 intersections currently under control.

Skyways

The Twin Cities climate presents a hindrance to outside walking in the winter months, particularly in areas of high pedestrian traffic. Both Minneapolis and St. Paul now have substantial portions of their downtown blocks linked by second-level pedestrian bridges (11 blocks in Minneapolis and 10 in St. Paul). These fully enclosed, heated, and air conditioned bridges link major offices, department stores, financial institutions, models, and residences within the downtown areas. They provide extremely pleasant environments for walking, protect pedestrians from conflicts with automobiles and from weather, and benefit business. The Minneapolis system in 1974 had average weekday crossings from a low of 77 600/day in July to 131 000/day in December. This is a diversion of 50 to 75 percent of trips from surface sidewalks.

Pooling

Many parties in this area have been interested in the potential for decreasing peak-hour congestion and reducing parking requirements by increasing vehicle occupancy during the work trip. This has resulted in a number of actions aimed at encouraging the use of car pools and van pools, and both the public and private sectors have been involved. The Minnesota Department of Transportation has offered address-matching services to interested employees and to the whole region. A compaign organized by the American Automobile Association resulted in 24 000 responses from 76 firms requesting matching of home and work locations. The Department of Transportation and the Governor's Office have sponsored an areawide address-matching program. Every household with phone service received a car-pool matching application form with its February 1974 phone bill. The form was also made available through post offices, chambers of commerce, and newspapers.

Several companies, with 3M Company pioneering, have been operating van pools for their employees. The 3M effort is a major one, now involving 92 vans and more than 1000 riders. Success has been such that the 3M Company is now planning a major new corporate research and office complex on the assumption that work trips to the complex will be made with an average vehicle occupancy of 2.0 and that parking needs and access road capacity can be reduced 25 percent or more. 3M calls its program Commute-a-Van. The company purchases the vans at a fleet rate of around $7000. A pool of riders is organized with one member designated coordinator, who serves as chief driver, issues monthly fare billings to riders, and sees to it that gasoline, oil, and routine maintenance are provided at a 3M garage. Each van must have at least eight passengers. Their fares, calculated on a basis of distance from work, amortize the van. The current average monthly fare in St. Paul is about $26. Any fares above the basic eight are kept by the coordinator, who is also entitled to use the van in leisure time, paying a rate of 5 cents/km (8 cents/mile). 3M estimated that the 1975 operations saved 12.9 million km (1.8 million miles) of vehicle travel and more than 511 000 L (135 000 gallons) of gasoline.

PORTLAND, OREGON

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Portland Bureau of Planning

The final federal regulations concerning the institution of a transportation systems management (TSM) element as part of the transportation improvement program (TIP) were not set forth until September 1975. However, the nature and purpose of many decisions, programs, and projects acted on in the city of Portland and in the Portland region before that date were consistent with the objectives and rationale of the TSM program. Because of this and because of the relatively high level of success on TSM efforts in Portland, the Portland experience provides a perspective on the early application of the TSM approach. More specifically, the TSM experience in Portland offers some useful commentary on the relation between broad policies and TSM strategies and projects, considerations that should be addressed in the implementation of individual TSM projects, and apparent problems that must be confronted if TSM is to play an effective role in a regional transportation planning and implementation process.

To provide understandable comments on these Portland TSM considerations, we must briefly review the rather dramatic changes that have taken place in transportation planning policy in the Portland area during the past half decade. In large part, the fundamental shifts in transportation planning policy have established the framework for TSM project and strategy development.

Fewer than 5 years ago, the Portland region was making decisions on both major and minor transportation capital and operational investments on the basis of a regional transportation plan called the Portland-Vancouver Metropolitan Transportation Study (PVMATS) (1). Though never formally adopted by many local jurisdictions in the region, including the city of Portland, this plan was the only regional plan of any sort available and, consequently, was acknowledged by many as the region's official transportation plan and used to guide transportation decisions. The PVMATS plan was narrow in conception and purpose, but quite broad in its implications. The plan was singularly oriented to future investments in roadways to serve automobile movement, making only passing mention of transit investments. Moreover, with respect to its highway orientation, the plan called for a massive investment in a regional system of freeways and expressways, which if built would have left few areas of the region untouched and surely would have been self-fulfilling in terms of the automobile-oriented transportation system that the plan forecast for the region. In addition, and perhaps more important, the plan's freeway system implied fiscal requirements for the state and region that were, in retrospect, so excessive as to be totally unrealistic.

Of course, concerns such as these have not necessarily altered the plans, planning processes, and capital investment programs of many regions. What were the factors that made the difference in Portland? There were several, and these factors not only resulted in a dramatic

change in the regional transportation plan but also formed the influencing considerations on subsequent projects and policies, including the logical progression to a TSM approach.

One important consideration had as its impetus the thinking of a new city of Portland administration. Political leadership in the city recognized that Portland was, and still is, in a rather unique situation among U.S. cities. Having seemingly lagged behind the strong shift to investment in urban freeways that characterized other cities, Portland found itself in a position to learn and profit by the experience of other cities. Two important lessons were learned: (a) For a central city, freeways are not necessarily the most beneficial and productive transportation investment that can be made; and (b) using transportation capital solely for the purpose of attempting to solve travel demands is not an effective way to deal with many urban problems, including transportation. These basic perceptions led, in turn, to more resultant policy directions, including

1. Protecting and preserving the city's neighborhoods by designing transportation projects and services that are aimed specifically at city needs;
2. Reinforcing the Portland downtown as the region's primary business and commercial center but recognizing that this cannot be accomplished by sustaining the automobile as the primary mode of transportation to the downtown;
3. Recognizing that regional transportation investments and regional transportation planning cannot be separated from the interests of the city; and
4. Recognizing that for a long time to come the predominant elements of the transportation system are already in place and that the real challenge is to more effectively use that existing resource rather than to rely on future investments, which require substantial fiscal commitments.

A second important consideration that influenced the change in the direction of transportation planning was the increased concern and action in environmental matters. Although part of the new city administration's concerns, these matters went beyond the scope of the city. In response to the directives of the U.S. Environmental Protection Agency, the state of Oregon established a statewide environmental organization—the Department of Environmental Quality (DEQ)—charged with responsibility for environmental protection. Findings on the quality of the Portland region's airshed led rapidly to several key regulatory decisions. Within the city of Portland, a downtown clean air plan was developed and adopted in response to DEQ requirements. Among other things, this plan called for the increased reliance on transit for trips to and from the downtown and noted that a similar shift was needed on a regional basis if the airshed was to be protected. In addition, the DEQ established an approval process that required all transportation projects, including all off-street parking lots beyond a certain size, to receive DEQ review and approval. The city responded by initiating studies that resulted in the adoption in the winter of 1975 of transportation policies for the Portland downtown. Among other things, the policies established a parking limit for the downtown beyond which no additional parking spaces could be allowed (2). This limit, 39 683 parking spaces (nearly equaling what existed in the downtown at the time of adoption), immediately weighed heavily in decisions on transportation projects, for this policy regulation implied that future additional trips to the downtown (such as those represented in the approximately 50 percent increase in downtown employment forecast for 1990) would have to find a means of movement other than the automobile. The increased concern over regional air quality also had a less dramatic but nonetheless important impact on many regional transportation actors, who began to realize the implications of the then-current freeway plan in terms of future environmental impact.

The third important consideration that helped to focus the decision-making process on a wide range of implications in the PVMATS plan was the local, regional, and state decisions on the withdrawal of the Mt. Hood Freeway, a major freeway segment of Interstate 80N. Through the process of debate and deliberation over the withdrawal of the freeway—which was to be located in the city's southeast side—the Portland City Council, the Multnomah County Commission, other regional and state officials, and the public were forced to directly confront many issues as they applied to a specific decision. Decision makers were forced to consider the questions of freeway impact on neighborhoods, of freeway impact on downtown development objectives, of consistency with environmental concerns, and of critical fiscal implications of the segment in question. At the same time, they were forced to examine possible alternatives to the freeway, including many less costly and less environmentally damaging investments, which nonetheless provided important transportation benefits. Decision makers began to realize that there were other ways to solve transportation problems that did not result in the problems of freeway construction.

From these and other considerations came a series of more specific decisions. The first such decision, which provided the framework for others to follow, was the adoption in June 1975 of a new regional transportation plan (3). This plan, called the Columbia Region Association of Governments Interim Transportation Plan, departed from the previous PVMATS plan in several critical ways.

1. The new plan called for a major commitment of future transportation capital resources on major transit project investments in the region, including a number of such investments on existing rights-of-way. This basic diversion from previous plans was the result of a greatly increased awareness on the part of regional decision makers about environmental, energy, social, and fiscal concerns and was reflective of the city's explicit policy positions on such matters.
2. The plan called for an almost total reliance on existing transportation corridors, or rights-of-way, as the location for new regional transit facilities. This was in marked contrast with the previous plan, which called for new corridors requiring great displacement and disruption as well as excessive costs. This change in direction reflected the increased awareness of the region to the many problems and costs associated with new corridor development. More important, it seemed to reflect a better understanding of the thinking of the city of Portland in its Mt. Hood decision: that existing resources of housing stock, commercial and industrial facilities, local streets and areterials, and other elements must be reinforced and served by transportation investments, not arbitrarily displaced or disrupted.
3. The new plan set forth potential transportation investments that reflected a more realistic assessment of future transportation resources. The earlier plan prescribed a transportation system that, according to travel forecasts, would solve future transportation movement demands at a cost that was clearly unrealistic in terms of available and forecast capital resources. Instead, the new plan set forth capital investment opportunities that reflected a careful assessment of future

funding levels and described clearly the nature of the problems that would exist even if those investments were made. This analysis led to a better understanding that operational changes in the transportation system would have to be relied on to ameliorate many of the current and forecast problems and that the region could not realistically rely on continued capital investments—for which funds are unavailable—to solve all of its transportation problems.

4. The plan explicitly called for a substantial effort to more effectively and efficiently use the existing transportation system. This objective was influenced by an awareness of the fiscal constraints that the region would face in the future in seeking investments in new rights-of-way. Concerns about energy consumption patterns and automobile impact on the environment lent support to modifications of the existing street system to induce greater transit ridership. In addition, studies were initiated with the purpose of detailing points of excess capacity in the street system and exploring ways through which this capacity could be better used (4).

The city of Portland played an important role in the development of the new perspective set forth in the interim transportation plan. The city's deliberation over the Mt. Hood Freeway forced transportation planners and engineers and council members to examine alternatives to the freeway. The answer that emerged from several months of study was that there was no single answer, no single project alternative that comprehensively addressed the problems the freeway was supposed to address. It was found, however, that a broad range of specific minor projects, policies, programs, and operational modifications in the existing system could go far in meeting the travel demands that the freeway was supposed to serve and do so at greatly diminished capital, social, and environmental costs. This thinking was applied to other transportation problems within the city, and the logic of the approach was carried by the city to the regional forum.

Within the city, this approach of attempting to deal with transportation problems through an examination of minor capital investments and operational modifications has been carried somewhat further. A fairly lengthy study is attempting to clearly define the functional relation between the city's street system and the remainder of the regional transportation system so that classification policies will be established for every street within the city. These policies, which have been developed on the basis of a careful examination of street characteristics, neighborhood needs and problems, existing and forecast land uses, and travel demand forecasts, are not a plan for the city street system, but rather functional policies that give direction to the use of streets and establish parameters defining future project and operational designs. Through this analysis, it became clear not only that future transportation movement would have to greatly increase its reliance on transit but also that improvements within the city could be accomplished through operational changes and relatively minor capital improvements that would better use the resources represented in the existing street system.

Consequently, the proposed city street classification policies indicate which streets should serve as automobile-carrying or automobile-oriented arterials and which should serve as transit-oriented arterials. Subsequent project and operation decisions will be guided by the policies. The policies will also provide the basis for city comments on the propriety of proposed projects elsewhere in the region in terms of the impact of those projects on the transportation system within the city.

TSM PROJECT REVIEW

The specific project decisions that were generated from the change in approach were quickly forthcoming and, in some cases, actually preceded adoption of the new regional transportation plan. A brief review of some of the projects and programs undertaken provides not only a survey of what has been accomplished in Portland but also an opportunity to judge the manner and level of success.

Efficient Use of Road Space

A number of projects have been completed that had the objective of more efficiently using existing road space.

Banfield High-Occupancy Vehicle Lane

Faced with a resurfacing requirement on the most congested radial freeway in the Portland area, the Oregon Highway Division proposed to expand the freeway surface within the existing right-of-way and add two additional lanes for high-occupancy vehicle use. This was accomplished by removing the shoulder for much of the distance, narrowing the lanes, and adding emergency parking bays (to replace the shoulder). Although the high-occupancy vehicle lanes, which are used only in the peak hours in the peak direction, are not continuous for the entire length of the freeway (because of right-of-way obstructions), their use by both express buses and car pools has resulted in measurable relief to the congestion, as reflected in improved automobile speeds during peak periods and some reduction of traffic on parallel arterials. The project was accomplished with a relatively small capital investment beyond that required by the resurfacing project.

Portland Mall

The Portland Mall is a $15 million UMTA-sponsored project, which is converting two parallel downtown Portland streets to bus-only routes. When completed by the spring of 1978, 11 blocks of Fifth and Sixth streets will be characterized by widened sidewalks, landscaping, bus shelters, and other amenities. The mall will serve as a linear transfer and distribution system for Tri-Met and, at the same time, will result in significant improvements in automobile circulation and movement on other downtown streets. The mall is an integral part of the downtown clean air plan, providing another incentive to use the transit system by improving the level and efficiency of operation within the downtown.

Downtown Parking Policies

Adopted by the City Council and based in part on the objectives of the downtown clean air plan, the parking policies not only establish a maximum parking space allocation for the downtown but also call for a deliberate transition from long-term parking to short-term parking and for improved transit service to accommodate significant increases in downtown trips, particularly work-related trips.

Transit Stations

As part of the improved Tri-Met service to the entire region, dozens of park-and-ride sites have been established during the past 2 years throughout the region at practically no cost to the transit agency. Using church lots, unused parts of shopping center lots, and other

locations, Tri-Met has offered free parking facilities in both suburban and city areas along transit routes. The public response to these lots has varied from location to location, but a number have been fully used since the date of their opening. In addition, work is under way on several major, permanent transit stations that not only will serve park-and-ride and kiss-and-ride trips but also will accomplish major transfer functions. Sited in suburban areas and on the fringe of the city of Portland, three such stations are in planning phases while one—the West Portland station—is nearing completion.

Bicycle Paths

Using funds made available from state gas tax resources, the city and the region have developed a comprehensive bicycle path program, which is being implemented on an annual basis. Already many improvements have been completed including a number of both grade-separated and on-street bicycle routes. In addition, the city has spent funds to ease physical access for bicycles on streets and bridges leading into the downtown to allow for increased bicycle commuting.

Other

A number of other TSM improvements have been completed or are in the planning process. Through the encouragement of several agencies and officials, a number of industries have shifted their working hours to diminish the peak-hour problem. In several instances, Tri-Met has directly assisted by implementing the Early Bird transit service, which provides express buses directly to industrial centers before the regular peak hours. On another project, work will begin next year on a contraflow bus lane on an arterial, in this case providing a partial connection between the downtown and the West Portland transit station. Finally, proposals are now being prepared by city staff for a wide range of projects, including peak-hour signal preemption for buses and curb extensions at bus stops (which allow the bus to remain in the moving lane of traffic at stops), for implementation during the next year on a number of arterials. These improvements are intended to increase the operating efficiency and competitiveness of the transit service and are being carried out as part of the city's arterial street study and program.

Vehicle Reduction in Congested Areas

During the energy crisis of 1973-74, a major commitment to a regionwide car-pool program was established by the Oregon Department of Transportation. The program proved so successful during the energy crisis that it has been continued under the supervision of the transit agency. The program offers a centralized information center for prospective car poolers and maintains a file of organized car pools on an origin and destination basis. In addition, the program works closely with businesses and industries in organizing car-pool efforts within private firms. Approximately 4000 car pools are organized and operating throughout the program.

Actions to Improve Transit Service

The list of activities that have been undertaken to improve transit service in the Portland region is lengthy, but the important and productive changes are discussed below.

Flat Fare

In an effort to encourage transit ridership from an economic standpoint and to simplify the pricing system, Tri-Met adopted a flat fare for the entire three-county service area. This change from the previous zone fare system established a flat 35-cent fare, since changed to 40 cents, and provided for free transfer. An important objective in this decision was to increase the level of suburban area ridership, particularly during peak hours, in order to reduce the reliance on the automobile and thus diminish highway congestion. The change has resulted in significant increases in ridership from suburban areas and has worked in concert with the interim park-and-ride lots and the establishment of several express routes to the Portland downtown.

Monthly Pass

Also a part of the pricing changes, Tri-Met initiated monthly passes, which are sold throughout the service area, are transferrable, and represent a cash savings for the daily rider. The passes cost $14 and currently approximately 15 000 are sold monthly.

Free Fare Zone

Tri-Met also established a free fare zone in the Portland downtown. Accomplished primarily to simplify and diminish the cost of downtown distribution from line-haul routes, the free zone has also resulted in diminished use of the automobile for trips within the downtown.

Other

A great many other transit improvements have been realized within the past several years, including the placement of shelters throughout the service area (a vital improvement in light of Portland's climate), a much improved marketing program to inform the public of service, and significant improvements to service through better headways and many new routings, including a number of crosstown routes and service to suburban shopping centers. These changes have resulted in ridership increases of approximately 60 percent during the last 3 years.

TSM PROBLEMS AND OPPORTUNITIES

These project descriptions generally represent past experience in TSM. As was noted earlier, the basic change in the policy direction of the region several years ago and the thinking and analyses of transportation problems concomitant with that change provided a basis for TSM projects, programs, and policies.

In this context, the Portland region's reaction to the formal requirements calling for a TSM element in the annual transportation improvement plan earlier this year was straightforward and, predictably, was probably not too much different from the reactions and responses of many other regions throughout the country. The metropolitan planning organization simply compiled a list of TSM projects that had been completed or were currently programmed throughout the region and submitted the list as the TSM element. As for the second year's TSM submission, the Portland region is currently following essentially the same procedure.

TSM IN THE REGIONAL PLAN

One initial conclusion, which in fact may be a problem

inherent in the TSM approach, was reached in the process followed in the Portland region in complying with the federal TSM requirements. The process revealed an initial reaction by planners, traffic engineers, and others that strongly implied that TSM projects have an intrinsic value that either individually or collectively makes them priority projects. Consequently, when a list of TSM projects was compiled for the Portland region, an attitude observed was that the region was doing an above-average job in terms of TSM because it appeared that many TSM projects had been or were about to be undertaken. However, it has become clear that this is not necessarily the case. The city's perspective on this situation provides a good illustration of the problem.

From the city's standpoint, one of the more important elements in the regional transportation plan is the commitment of new capital resources to transit investments, pursuant to the objective of nearly tripling regional transit usage within the next 15 years. As explained previously, this objective is extremely important to the city because of the direct relation between higher transit ridership and related city goals, including the preservation of neighborhood environments and the continued health of the downtown.

One of the major threats to these purposes is the continued reliance on the automobile as the predominant mode of transportation between the suburbs and the central city areas. From the city's perspective, the arterial system is perfectly adequate to handle the travel needs—both automobile and transit—of city residents, but is not adequate to handle the additional demands of suburban commuters.

TSM projects are in large part aimed at improving the efficiency of operation of the transportation system. But in light of the initial perception of the apparent importance and priority of TSM projects, a dilemma presents itself. A perusal of the list of TSM projects in the region reveals a large number of projects that are intended to improve the efficiency of traffic movement. It also reveals that many of these projects are not located within the city of Portland, but rather in suburban areas. What is the effect of these projects? It is quite likely that improvements in the efficiency of automobile traffic movement will result in the inducement of additional automobile traffic—a result that is inconsistent with one important goal of the regional plan and that aggravates the city's problems within the regional system.

What conclusion can be drawn from this? At least from the city's standpoint, it demonstrates quite clearly that there is no inherent value in TSM projects simply because they are TSM projects. Moreover, it appears to demonstrate that TSM projects and the TSM approach are in themselves of little value unless directly related to, or consistent with, a broader policy direction or program strategy. It appears that many of the TSM projects undertaken in the Portland region, including nearly all of those previously identified here, are in fact generally consistent with the objectives of TSM as well as with the goals of the regional plan and the interests of the city. However, there are exceptions and it is with these that there is concern. Should projects be denied that improve the operating efficiency of the transportation system but that, when viewed in a broader context, do not contribute positively to the basic goals in the transportation plan and planning process? Discussion in Portland seems to be heading in the direction of a careful evaluation of all projects, including TSM projects, to discriminate more closely between those that are consistent with the basic goals of the regional plan and those that are not.

TSM AS AN ALTERNATIVE

As noted, merely compiling a list of TSM projects is not necessarily meaningful if the projects are not consistent with broader objectives. On the other hand, compiling the other parts of the transportation improvement program without any consideration of the TSM element also represents an ineffective application of TSM.

Given the many reasons behind TSM, but particularly singling out the fiscal problems facing most transportation investment programs, it has become apparent to a number of Portland area planners and engineers that we have not yet applied the TSM approach as fully as possible. Although many projects are listed under TSM, a much larger list of conventional highway and transit projects make up the rest of the region's transportation improvement program. Most of these found their way onto the list through a conventional process—problem identification and design of an appropriate solution—and, consequently, are implemented as fairly conventional projects. In fact, and unfortunately, it is unusual for anything but a highway project to be considered for application to a problem defined as a highway problem; rarely is consideration given to solving the problem through a transit investment or some other broader programmatic approach.

This situation represents an attractive opportunity to more fully employ the TSM approach, and this opportunity is currently being explored in Portland. More specifically, what might be done is to impose a requirement that all projects submitted for inclusion in the transportation improvement program be reviewed on a project basis to ascertain whether any possible TSM project solution could accomplish the same objective. In short, the region could require that TSM alternatives be considered in all project activities and resultant project submissions.

In many cases such a review would not be rigorous, and in some cases (for example, rural projects) the review might be quite rudimentary. But, in numerous instances such a requirement might lead to helpful, cost-saving modifications to a project. If nothing else, such a requirement would maintain an awareness among those responsible for project development that there exist alternative, although perhaps unconventional, approaches to problem solving and project design.

TSM SUCCESS

One of the more interesting aspects of the TSM approach and generally of TSM projects—at least in the Portland area—is the basic sensibility and logic of TSM and its appeal to a diverse group of professionals. The reference here is specifically to many of the more innovative TSM projects, particularly those aimed at providing greater efficiencies for transit and car-pool operations. Indeed, in Portland, projects such as signal preemption for buses, contraflow bus lanes, high-occupancy vehicle lanes, park-and-ride lots, and the mall itself have found almost total appeal among transportation planners, transit operators, traffic engineers, and highway engineers. Many of the projects that have been completed in Portland were in fact developed and initiated by the Oregon Highway Division or the Office of the City Engineer rather than by the transit agency or planning offices. Although this might be surprising and perhaps unique to Portland, what has not been surprising or unique has been the public reaction to many of these kinds of projects. The public reaction has often been in sharp contrast to that of the professional staffs developing the projects. The experience in Portland perhaps can provide some useful commentary on developing

the acceptability of TSM projects. A good project example, for purposes of illustration, is the Banfield high-occupancy vehicle lane.

The first point with respect to public acceptance is the importance of proper and adequate marketing of the project. In the case of the Banfield project, a major marketing, or information, effort was undertaken well in advance of the actual construction. Although this was an Oregon Highway Division project, the marketing effort was under the direction of the transit agency, upon whom it was felt would fall the primary burden of demonstrating the project to be successful. In advance of construction, a complete marketing strategy was developed that included the following important elements.

1. Development and design of leaflets (flyers) to be handed out to motorists entering the freeway. Leaflets were designed for several stages in the project, including before the initiation of construction, at the initiation of construction, and at the opening of the completed facility. The literature attempted to describe not only the specifics of the project in terms of design and operation but also the benefits of the project to both users and nonusers and the rationale behind the project.
2. Explanation and solicitation of support for the project from policy level boards, including the Portland City Council and the Tri-Met Board of Directors. These presentations were further reinforced with press releases providing explanations of both the project and the (supportive) actions of the boards.
3. Ongoing series of press releases was developed jointly by Tri-Met and the Oregon Highway Division, coinciding with various stages in the project development and aimed at keeping the public fully informed on project progress.
4. Establishment of both technical and citizen advisory committees for the project, which met weekly before and during the project implementation. (These committees continue to meet monthly to monitor the progress on the project and consider modifications to its operation.) The citizen committee was composed of representatives from business and residential interests located along the project route as well as any other special interest groups who wished to be involved. The technical committee was composed of highway engineers, planners, traffic engineers, law enforcement officials, transit operators, and other technical persons as well as representatives from the citizen committee.
5. Public hearings were held in advance of the project for the purposes of both providing a project explanation and soliciting comments on the project.

The second important consideration in the public acceptance of TSM projects has to do with their flexibility after completion. In many cases, innovative projects such as the high-occupancy vehicle lane are somewhat unproven and there is limited confidence in the forecasts made regarding their use. The most apparent way to deal with this problem is to first test the project through temporary measures, which can be easily modified or removed if success is not forthcoming. However, in the case of a project such as the new high-occupancy vehicle lane, this was not possible, so instead as much flexibility was retained in the project as possible. Although TSM projects are intended to be modifications in the operation of the transportation system, they themselves can be modified. This was done in the case of the high-occupancy vehicle lane.

The project was designated as "experimental" in which operational changes would continually be considered. If necessary, the lane could be reverted to full automobile use. Although this has not been done, the continued monitoring of the project has resulted in a number of operational changes, which were decided on basically through the technical review process. These changes included altering the enforcement period of the lane from all day to only during peak hours in the peak direction and adjusting the level of transit service provided especially for the project—in response to the demand for such service. Other adjustments that have been considered, but not implemented, include a redefinition of a car pool from the current three persons to two persons and the allowance of special carriers, such as taxis, into the lane regardless of whether they meet the three-person occupancy requirement. It is clear that the changes that have been made, although technically justified, have also helped to respond to the many public criticisms of the project. A key to this process was the initial decision to open the project with what were viewed as relatively rigid, or maximum, operational characteristics—characteristics that could be altered without resulting in the complete termination of the project.

Another important consideration in the development of TSM projects is the opportunity for simultaneously developing several TSM projects. In many cases, TSM projects are mutually supportive, and considerable thought should be given to their simultaneous development and implementation. For example, park-and-ride lots are obviously consistent with, and supportive of, express transit routes. In the case of the high-occupancy vehicle lane, many such related projects were considered and several were implemented. Tri-Met quickly purchased 10 additional buses, which were used on the express routes. These express routes were reinforced by the expeditious development of two park-and-ride lots at locations near the outer terminus of the lane. In addition, the region's car-pool program seized the opportunity offered by the project and developed an information program aimed specifically at users of the freeway segment. This program included leaflets that were distributed to motorists and, subsequently, road signs posted along the route describing the car-pool service and providing the telephone number to call for information and assistance. Other TSM project opportunities considered but not instituted included reduced transit fares for the express bus service and the initiation of reduced parking prices in the downtown for car-pool users. (The latter concept is currently being developed for implementation.)

It is clear from the high-occupancy vehicle lane experience, as well as other experience in Portland, that it is important not to disassociate the TSM projects from the rest of the transportation system, but instead to capitalize on the TSM projects by supporting them whenever possible with other TSM projects. The major transit station currently under construction in Portland will be linked to the downtown with a contraflow bus lane, and express service will be developed from the station to downtown. TSM success and resultant public acceptance are highest where a comprehensive approach to TSM is accomplished and where all agencies involved in the management of the transportation system are integrally involved in the process.

POLICY CONTEXT

The most important and fundamental conclusion with regard to the TSM success in Portland concerns the necessity of having a strong transportation policy direction that is conducive to TSM projects and programs. Although problems and discord still exist in Portland, there is widespread agreement among professional staffs and nearly all policy level boards that the direction

of regional transportation planning and implementation must be that which is stipulated in the regional plan. There is a recognition that much better use must be made of the existing transportation system, that the existing transportation system must and can be operated more efficiently, and that much greater reliance on transit must be selected in future transportation capital and operational investments. The level of understanding of these conclusions varies throughout the region, but the variety of strong rationales that support such conclusions have already been shown to be effective.

From the city's standpoint, broader objectives pertaining to neighborhoods, the downtown, and economic development plans clearly point in the direction of TSM, and the focus brought on the basic nature of the transportation problem facing the city by the deliberation over a freeway withdrawal has done much to educate not only city staff and council members, but also staffs and policy boards throughout the region and the public. For others, such as regional organizations, the rationale for TSM is probably less refined, but specific policy concerns and objectives on problems such as air quality provide essentially the same direction. An important rationale that is instrumental in directing efforts to TSM is the fiscal situation, which has resulted in an acute awareness on the part of many that a new direction must be taken in the development of the transportation system and that an important element in that direction is TSM. Although some problems with TSM remain unresolved, or perhaps even unidentified, it is clear that in Portland the experience to date has been quite positive and that there is an awareness on the part of many that the city and the region as well are only beginning to understand the potential that exists.

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MADISON, WISCONSIN

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The city of Madison is located in Dane County, Wisconsin, in the south central part of the state. It is roughly midway between Lake Michigan and the Mississippi River, some 130 km (80 miles) west of Milwaukee and 240 km (150 miles) northwest of Chicago. The city is the state capital, county seat, and home of the University of Wisconsin. As such, its economy is service oriented although there is some industry. The central business district, the Capitol, and almost all of the downtown area are located on a narrow isthmus, approximately 1 km (0.6 mile) at its narrowest, between two lakes (Figure 1). The university campus is located approximately 2 km (1.2 miles) to the west of the Capitol and is connected to the CBD by State Street, an intensively used commercial thoroughfare.

The 1970 population of the Madison SMSA was just under 300 000, and about two-thirds of this population (205 000) is located within the Madison urbanized area. The Madison SMSA is coterminous with Dane County. The county, in addition to the city of Madison, contains four smaller cities: Sun Prairie, 1970 population of 9935; Middleton, 1970 population of 8286; Monona, 1970 population of 10 420; and Stoughton, 1970 population of 6096. Middleton and Monona are part of the Madison urbanized area. The county also contains 28 villages.

Madison's downtown has a residential area where students, young professional workers, and families with children live. In 1970 more than 55 000 people lived in the isthmus area, approximately 4.5 km (2.8 miles) east and west of the Capitol. This area also contains over 50 percent of the region's employment. Suburban shopping malls have attracted much recent retail activity, and the Capitol Square-State Street area, the former retail core, has experienced a decline. The city, however, has become involved in a number of projects including a new civic center on State Street and an extensive mall effort to reverse this trend.

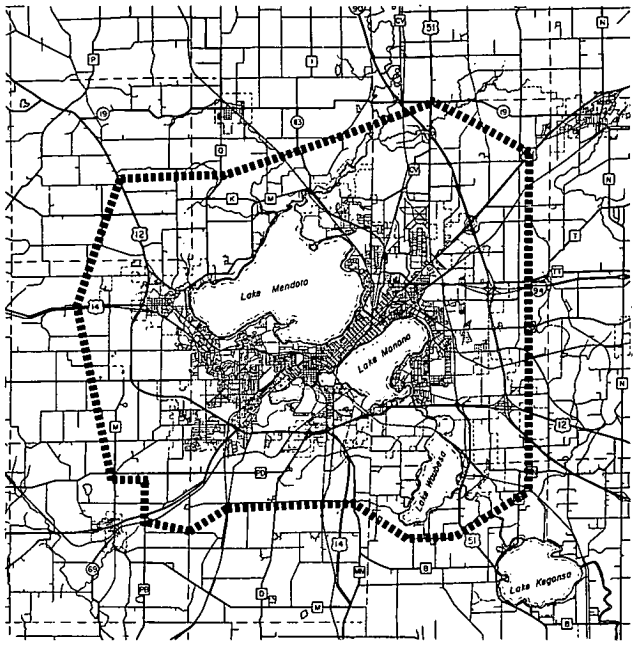
In the past the Madison area has grown quite rapidly, but at present the rate of growth has slowed considerably. Transportation planning efforts have been and are being reviewed and revised, where necessary, to reflect this change.

COMMUNITY GOALS AND OBJECTIVES

Because of the existence of active comprehensive planning programs at both county and city levels, community goals are well articulated. In addition, the Madison Department of Transportation and the Dane County Regional Planning Commission have undertaken extensive public attitude surveys related to transportation objectives.

At a general level Dane County has an adopted land use plan, which sets out policy guidelines for future growth of the area (5). The policy of the Dane County Transportation Study is to plan and direct the extension and expansion of transportation services and facilities in a manner consistent with that plan. In particular the county land use plan designates urban service areas, that is, areas intended to receive the bulk of urban growth during the next 10 to 20 years; and it is desired to confine the extension of urban transportation services to these areas. The city of Madison itself has a developed set of transportation objectives and policies (9, 15), among which are the following:

Figure 1. Dane County-Madison urban area.



1. To recognize public bus service as a public expenditure as justifiable as maintenance of the public street system;
2. To minimize the need to use private automobiles and maximize the availability and encourage the use of public transportation and alternative forms of private transportation, such as taxis and bicycles, particularly for commuter travel;
3. To coordinate implementation of the various transportation and parking policies so that disincentives to low-occupancy vehicle use are accompanied by improved transit service and incentives to high-occupancy vehicle use;
4. To provide most city residents with access to the public transportation system within reasonable walking distance of their homes;
5. To use noncapital programs, such as staggered work hours and car pooling, to reduce automobile traffic congestion;
6. To improve the operating efficiency and safety of the existing highway network to maximize fuel economy and minimize air pollution while at the same time implementing programs to minimize the need to bring commuter automobiles into the isthmus area;
7. To discourage through automobile traffic from traveling through the interior of residential neighborhoods.
8. To discourage automobile traffic from traveling through the central area; and
9. To discourage low-occupancy commuter automobile traffic to the central area.

The Madison Department of Transportation is currently engaged in developing a municipal transportation policy intended to provide a policy base for the city in its dealings with the legislative bodies of the county, state, and federal governments as well as their respective administrative branches. This municipal transportation policy will be a statement of goals, policies, and program objectives, which (as recommendations to the various public entities) represent the consensus of judgment of the Madison policy leaders.

INVENTORY OF THE EXISTING SITUATION

Travel Patterns

In 1962, an estimated 600 000 daily person trips were made in the Madison urbanized area; by 1970, 992 000 were made each day. The private automobile was the dominant travel mode although transit usage was higher than in most cities of comparable size. In 1970 4.9 percent of the trips that began and ended within the urbanized area and 7.7 percent of the home-to-work trips were made by transit. The latter percentage increased to 9 percent by 1976.

Street Volumes

Madison has a grid street pattern oriented northeast-southwest east of the Capitol and north-south west of the Capitol. The narrow width of the isthmus, however, works as a funnel restricting the number of major streets into the central business district. In 1975 the average annual daily traffic on major approach streets was almost 85 000 from the east, 55 000 from the south, and 72 000 from the west. Traffic volumes are nearing capacity, particularly during the peak periods, although there is room for some additional flow. Vehicle travel through the isthmus has stabilized around an average daily traffic of 115 000 for the last 6 years.

There is little possibility of additional vehicular capacity in the isthmus area because of physical constraints and local policy. A new arterial along a railroad right-of-way is a possibility, but it would probably replace existing capacity rather than add to it. The reason for this is that in recent years there has been increasing local support for removing traffic from arterials that pass through residential areas.

Core Area Parking

Governmental agencies are the major providers of parking space in central Madison. The city and county provide more than 4400 off-street spaces, which when added to on-street meters account for more than half of the available spaces. These spaces are well located with reference to shopping and major employment centers.

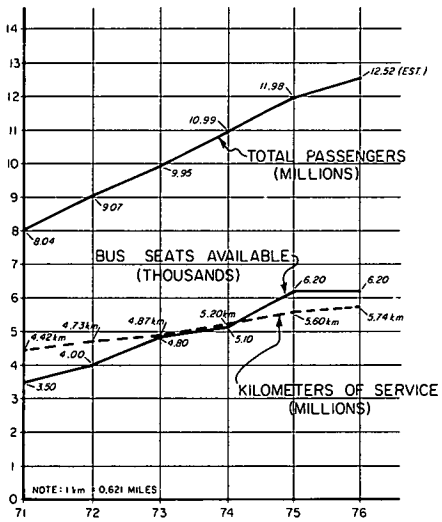
Public actions have tried to encourage short-term use of available space by restricting the number of long-term spaces and by having a rate differential (20 cents versus 10 cents) that favors short-term use. This, however, has not been successful since drivers are willing to make one or more extra trips back to the parking facility to feed the meters during the day.

Privately provided off-street parking is relatively limited, and most is directly associated with a specific building. Madison, in contrast with many areas, has limited the amount of parking space that new development can provide and, in some cases, has forced reductions in developer requests. The city intends to continue policies that encourage parking for short-term shopping and service trips.

Transit System

Mass transportation in the Dane County area has had a recovery during the past few years. Threats of service cutbacks or curtailment during the late 1960s have been overcome. Substantial improvements to a declining system—including acquisition of new vehicles, improvement of service and initiation of innovative programs, and expansion of marketing efforts—have been followed by reversal of declining ridership trends as given below and shown in Figure 2 (14).

Figure 2. Transit trends in the Madison urbanized area 1971 to 1976.



Year	Passengers	Increase (%)	Rides per Person in Service Area
1971	8 043 000		38.1
1972	9 070 000	11.3	42.8
1973	9 950 000	8.8	46.7
1974	10 992 000	9.5	51.4
1975	11 975 000	8.2	55.7
1976	12 515 000	4.5	61.0

In addition to the actions taken at all levels of government, a variety of indicators of recent local public opinion suggest that there is broad support for continued and expanded transit improvement and that there is a public willingness to make greater use of transit if appropriate improvements are made.

In spite of this, the recent growth in urban area automobile travel appears to be about as rapid as the growth in transit ridership. It is estimated that, during the past decade, the proportion of urban area travel made by transit (in terms of person trips or person kilometers traveled) has actually decreased; and current ridership, although about 38 percent higher than at this time 4 years ago, is just now approaching its 1955 level. Hence, although survival of transit in Dane County is now ensured, establishment and preservation of its role as a major element in a multimodal transportation system will require continued vigorous effort to maintain, improve, and expand service. A detailed assessment of the existing transit system, in light of these needs and opportunities, is presented below.

Within Dane County, the following bus operators compose the transit system: Madison Metro, owned by the city of Madison and the predominant system operating a fleet of 162 buses within the Madison urban area, and Commuters Service, Inc., privately owned and operating three buses during weekday peak periods between Madison and several communities in the south and southeast portions of the county. The University of Wisconsin also operates a daily campus shuttle service by contract with Madison Metro. In addition four private charter operators provide yellow bus service to Madison area elementary schools. A number of organizations operate special demand-responsive transit services for the elderly. Most notable are Independent Living, a quasi-public nonprofit group that operates two urban area and two outer area minibuses; the Colonial Club of Sun Prairie, a local service club, which operates one outer area minibus; and the Monona Community Center, which also operates one minibus within Monona. Quite recently the city has also become directly involved in the provision of these services by contracting with a private nonprofit corporation, which operates three demand-responsive buses for service to the elderly and handicapped.

Routes and Service Areas

At present, most of the urban area population (including about 90 percent of the population of the city of Madison) lives within 0.4 km (0.25 mile) of an existing route; in addition, almost all of the area's apartment complexes lie within 0.4 km (0.25 mile) of such routes. The major activity centers within the Madison urban service area are all served by existing routes. In particular, central Madison—the area's largest employment center, a major commercial center, and the home of the University of Wisconsin and the Madison Area Technical College—is conveniently accessible by transit for an overwhelming majority of urban area residents. However, other activity centers and corridors, including several existing or emerging employment concentrations, are comparatively inaccessible on existing routes from many parts of the urban area because of indirect routing and the need to transfer between routes.

Shuttle services are available within the two most intense activity centers in the county—the University of Wisconsin campus and the Madison CBD—where substantial internal vehicular movements would be both logistically difficult and environmentally disruptive. The university system is linked to a campus peripheral parking lot at the west end of the campus and connects with the areawide transit system, including Madison Metro's State Street (CBD) shuttle, at key points. The State Street shuttle provides a convenient link between the University and Capitol Square office-retail-residential areas and makes State Street, an intensely active business street, more easily negotiable.

Urban area households that have no automobiles have tended to establish themselves in the older and more centrally located neighborhoods and so have comparatively convenient access, by existing transit services, to most sections. All urban area elderly housing developments are located within the 0.4-km (0.25-mile) service area. All of the most popular destinations associated with transit-dependent groups (e.g., the elderly, young, and handicapped) lie within the 0.4-km (0.25-mile) service area. However, many of these are not easily accessible to these groups by transit because of the absence of direct routing and the need to transfer. Some are not accessible during evenings or weekends.

Levels of Service

The level of transit service in the Madison area was reduced by about 50 percent from 1950 to 1970, but this trend has been dramatically reversed as shown by Figgure 2. Currently available service levels vary by area served, travel origin and destination, time of day, and day of week. Spatial variation in peak-hour service available to urban area residents reflects the fact that transit services are generally available on a more frequent basis to central Madison residents than to suburban area residents. Service is generally less frequent during evening and weekend off-peak periods, especially in suburban areas, some of which have no evening or weekend service.

Recent local experiments with varying service levels suggest that, where latent demands for transit service

exist, increasing levels of service can stimulate increased transit use. For example, when service frequencies were increased on the Sherman Plaza Flyer and State Street shuttle, ridership substantially increased. Portions of this report point to areas and groups that present, or are expected to present by 1980, significant increased ridership opportunities.

Fare Structure

The basic (adult) transit fare structure in the Madison area reflects both a long-standing, stabilized fare (the basic fare on the Madison Metro system has increased by only 5 cents—from 20 to 25 cents—since April 1962) and a community willingness to provide necessary operating subsidies to maintain this program.

An array of special fares are also part of the structure, including youth fares, elderly fares, and a shopper's pass. In addition, there is mounting evidence from local experiments that a judicious program of reduced fares can stimulate substantial ridership increases and alter travel habits.

Capital Facilities and Equipment

Substantial improvements to facilities and equipment, especially those of Madison Metro, have occurred within the past few years. These have included the acquisition of new buses, installation of a two-way radio communications system for the Metro fleet, and installation of new passenger shelters in the city and the university campus area. In addition, approvals have been granted for the acquisition of additional new buses, bus shelters, and various support facilities. Improvements to transit system support facilities and equipment are under way as outlined above. Additional needs include spare parts; shop equipment; office equipment; supervisor cars; repair and renovation of maintenance, operations, and office areas; land acquisition for additional storage space; and bus storage and service building in the central Madison area to replace the current outdated transit maintenance facility.

TRANSPORTATION PLANNING IN THE MADISON AREA

Comprehensive planning and transportation planning have been going on in the Madison area for a long time. The Madison Department of Transportation has been considering transit and a wide variety of other transportation activities as part of its program for more than 20 years. For example, bus ridership surveys have been conducted since 1955, and a comprehensive central area parking plan was first developed in 1955. Early institutional activities were also important, and the Madison Common Council inaugurated a comprehensive transportation planning process before the Federal-Aid Highway Act of 1962 was passed. The council's action is interesting because of the degree of importance it assigns to the planning process. The resolution adopted by the council May 26, 1960, stated:

> Resolved, that the City of Madison embark on a four-step program to improve the local transit system and made it an integral and permanent part of a comprehensive transportation plan for the City. The four steps would be:
>
> 1. That the Common Council encourage greater use of the transit system as it exists today by taking those actions which are now available to improve traffic conditions through the activities of the Traffic Engineering, Police, Engineering and Street Departments.
> 2. That the Traffic Engineering Department cooperate with and assist the Madison Bus Company in making comprehensive studies of routes and coverage, route inventory, passenger load data, service frequency and regularity, transit running time, transit speed and delays, general operating data and passenger riding habits to determine the need for further improvements according to recommended standards, warrants and objectives for transit services and facilities. Procedures used successfully in other cities should be made a part of these studies.
> 3. That the ordinances be amended to effect a reorganization of the Traffic Commission and assign to it the additional responsibility of reviewing the plans for traffic, transit and parking activities and facilities for the purpose of advising the Common Council on an overall transportation policy.
> 4. That the Traffic Engineer and Plan Director develop and submit to the Traffic Commission, Plan Commission and to the Common Council for consideration a comprehensive transportation plan for the city with the improved transit system being integrated and made a permanent part of this overall plan.

This early recognition of the need to plan for the whole transportation system was undoubtedly helpful in bringing the city to its present high level of involvement in transportation. In 1974, a unified City Transportation Commission was established to further develop, coordinate, and guide policy.

Areawide transportation planning has been in progress since 1961. The initial agreements of the Madison Area Transportation Study (MATS) recognized that sound transportation planning should be integrated with the other elements of areawide comprehensive planning, especially the land use element. In 1970, the long-range Madison Area Transportation Plan was approved by the participating governmental units (16). The transportation study was then reorganized as a part of the Dane County Regional Planning Commission activities and became the Dane County Transportation Study (DCTS); the study boundaries were expanded outward to the county boundaries. This reorganization provided for (a) refining and updating the earlier prepared Madison Area Transportation Plan through a major plan reappraisal effort; (b) expanding the plan from the Madison urbanized area to be a countywide transportation plan; (c) providing a stronger all-mode, or multimodal, orientation to the transportation planning efforts; (d) providing staff for a continuing, cooperative, comprehensive transportation planning process to further develop and maintain current transportation plans; and (e) integrating transportation planning efforts more closely with comprehensive planning for the realization of overall objectives and goals.

Long-Range Plan

The Madison Area Transportation Plan, adopted in 1970, serves as the long-range plan for the Madison urbanized area. The plan has had about 30 specific facility amendments since 1970, and other possible amendments have been identified for study. Other major changes have also been made: (a) The forecast year is now 2000 rather than 1985, (b) the small-area forecasts of development within the urbanizing area have been reviewed and adjusted as necessary, and (c) the reliability of the computer forecasting models has been checked and verified against an independent data base. An overall transportation plan reappraisal is currently under way and is expected to be in 1977 (3). It will include a broad public discussion of plan alternatives and the testing of goals and objectives and will lead to a single long-range transportation plan for all of Dane County.

Transportation Improvement Program

An annually updated listing of transportation improvements anticipated to be undertaken during the next few years has been developed and approved (6). The pro-

gramming of transportation improvements includes major capital facilities as well as low- and non-capital improvements related to all modes of surface transportation. Further, this document includes major improvements throughout Dane County, regardless of the unit of government undertaking a particular project or improvement. The most recently adopted program was approved by the Dane County Regional Planning Commission in January 1976 and covers the period from 1976 through 1980.

Related Transportation Plans and Studies

Other past and current transportation planning efforts that are pertinent to transportation system management efforts include the following.

1. Work of the Madison Area Transportation Study from 1961 through 1970, which included studies on traffic control devices, parking, and transit;
2. The Madison Traffic Operation Program to Increase Capacity and Safety in 1971, which included minor improvements to be made throughout Madison's transportation system to improve efficiency and safety (13);
3. A governmental employee staggered work-hour study and implementation program undertaken in 1971 and 1972;
4. Periodic car-pooling studies and implementation efforts since 1972 to present, which include a computer name-matching program for employees of a new state office building, a computer matching program for more than 30 000 state and university employees in the Madison area, development of an organizational structure and program for an areawide car-pool matching program (not implemented), and numerous other governmental office and private efforts to encourage car pooling;
5. Study of potential commuter parking facilities and connecting transit services to the central Madison area (2);
6. Study of transit services and development opportunities through 1980, including transit operating and capital improvements (10);
7. A short-range and long-range bikeway plan for the Madison urban area (12);
8. An intergovernmental pass program in 1972 to achieve increased transit usage through an integrated program of disincentives and incentives, including reduced-rate bus passes made available to employees (not fully implemented);
9. Studies related to policies and issues of intercity travel through Dane County, including noncapital improvement recommendations (4);
10. Various special corridor and area studies that recommended noncapital and capital improvements;
11. A study and report in 1974 on transportation energy conservation (1);
12. Various studies of parking supply, pedestrian needs, taxicabs, elderly and handicapped transportation needs, and traffic engineering.

Relation of TSM and Other Plans

Although all of the above transportation plans are related to the TSM planning, the relation to the long-range plan is the most important and fundamental. The long-range plan establishes the basic transportation policy framework for the various TSM elements. Although the long-range plan is currently undergoing a major reappraisal, it is still the foundation on which TSM activities are structured.

TSM PLANNING

The management of the existing transportation system is vested with the governing bodies of the 61 local units of government within this area and the Wisconsin Highway Commission. Coordination efforts are achieved through the Dane County Transportation Study organizational structure, through the annually prepared transportation improvement program, and other means. Coordination in the city of Madison is by the Transportation Commission, which has responsibility for transit, parking, bikeway, and pedestrian facilities; taxicabs; and traffic engineering activities (Figure 3). Staff support in Madison comes from the city Department of Transportation. Currently this department addresses a full range of transportation activities through its Traffic Engineering, Transit, and Parking divisions. Coordination in the other Dane County cities is by their appropriate planning commissions, public works committees, and transportation committees. Coordination within the governmental structure of Dane County is through the County Highway and Transportation Committee, which in turn coordinates many of the town government transportation improvements.

The Dane County Transportation Study (DCTS) provides the coordination among modes and among agencies (Figure 4). The DCTS Technical Coordinating Committee members include representatives of the comprehensive planning agency, transit operators, local governmental units, University of Wisconsin, state transporta-

Figure 3. Madison Transportation Commission.

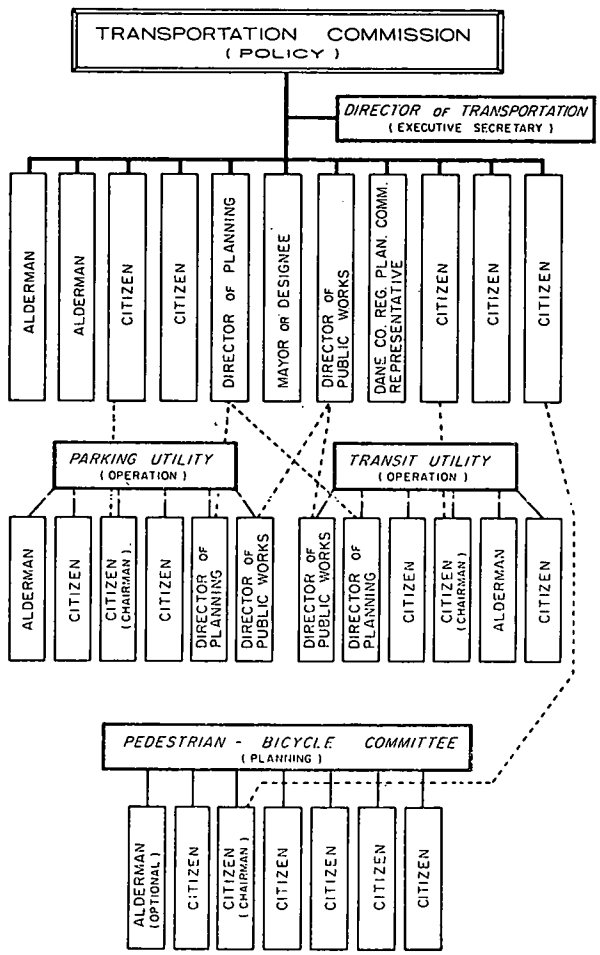
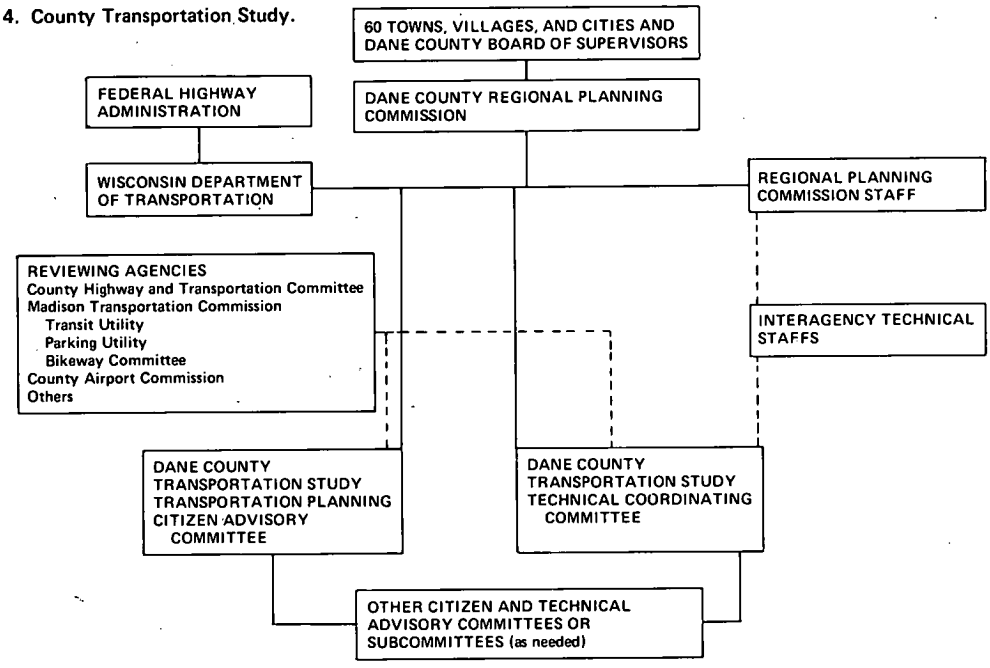


Figure 4. County Transportation Study.



tion and other agencies, and the Federal Highway Administration. The Transportation Planning Citizen Advisory Committee advises the Regional Planning Commission on transportation planning matters, helps to form new transportation policies in view of public comment, provides liaison with public groups and individuals, reports citizen reactions to transportation matters that might suggest possible future shifts in transportation policies, and initially aids in developing and refining the all-mode transportation plan (plan reappraisal efforts).

Coordination of transportation planning and improvements within Dane County is the responsibility of the Dane County Regional Planning Commission through the Dane County Transportation Study activities. The commission serves as the advisory areawide transportation planning policy body for this area. The commission integrates transportation with comprehensive planning in a manner that provides for its maximum compatibility with other functional areas. The organizational structure provides for a direct channel of communication and responsibility between the commission and the Technical Coordinating Committee and the Citizen Advisory Committee.

The general DCTS organizational structure provides for appropriate coordination and liaison activities for conducting areawide transportation planning. The following activities of the Dane County Transportation Study are examples of how this works to tie the long-range transportation planning functions to the TSM functions:

1. Inventory of local unit programs and analysis of these in relation to past and ongoing planning activities in Dane County;
2. Analysis of indications of local policy and public opinion related to planning and implementation of transportation facilities;
3. Review of perceived areas of growth and development to 1980 and analysis of these in relation to the transportation needs;
4. Review and analysis of accident information and possible transportation improvements; and
5. Review of existing transportation system operating characteristics.

Further insight into the TSM process can be gained by examining how specific project-oriented issues have been addressed. One issue was the South Madison Beltline Freeway. The development of plans for this highway had been under way since the mid-1960s. In 1973 public dissatisfaction with the original plan became apparent, and in April 1973 further planning for the facility halted. In May 1973, a contract to replace the Nob Hill Railroad bridge, part of the beltline project, was not signed by the governor, and the overall plans for the highway were "shelved" by the State Highway Commission. The intention was to have a citizen committee review the plans and suggest solutions. At this point the Dane County Regional Planning Commission became involved and acted to both maintain the integrity of the area's transportation planning process and solve the specific problems. The commission formed a citizen committee, which included appointments by the chief executives of the cities of Madison and Monona and Dane County and by the Regional Planning Commission. The committee was staffed by an interagency group consisting of personnel from the Wisconsin Division of Highways, the Dane County Highway Department, the cities of Madison and Monona, and the Regional Planning Commission. Thus both the committee and the staff represented the diverse interests of all parties involved in the issue.

The committee first examined long-range plans and forecasts and then immediate or short-range actions, including

1. Alternative transit levels of service,
2. Multiple land use opportunities along this corridor,
3. Alternative roadway cross sections and staging of construction for resultant needed roadway improvements,
4. Multiple-mode approach to travel considerations in this corridor,
5. Proximity of the ultimate facility as planned to the Waunona Way neighborhood,
6. Impact of the facility on the Upper Mud Lake wetlands,
7. Compatibility of the facility with future transit potentials, and
8. Concerns of the Dane County Coliseum manage-

ment over coliseum access and traffic backup.

Some of the committee recommendations were capital intensive, such as the purchase of additional buses and the construction of some freeway segments, but many were integrated into the TSM element, including improved transit service through the use of express routes and peripheral parking lots and the designation of bicycle trails.

Because the DCTS structure provides for these coordination and liaison activities, it was not necessary to form any new committees or groups for the TSM process. The existing groups will continue to incorporate transportation system management efforts into their ongoing transportation planning activities. Those efforts will be reflected in the periodic updatings of the transportation system management element; the long-range areawide transportation plan, including the current plan reevaluation activities; and the transportation improvement program actions.

Identification of Needs and Improvement Activities

This section presents the main substance of the transportation system management element (1). The needs are listed, and the proposed activities to meet those needs are discussed. Many of these actions were begun prior to the TSM process and have already been incorporated into the transportation system.

Improve Traffic Operations by Managing and Controlling Flow of Motor Vehicles

In 1967 the Federal Highway Administration initiated a program providing funds for the Traffic Operations Program to Increase Capacity and Safety (TOPICS). Projects of this type have been carried out in Madison since the 1950s and were the subject of a special TOPICS study in 1971. This study surveyed problem locations that needed improvements. Specific projects that have been and will continue to be implemented, even though the TOPICS funding program has changed, include improvements along short segments of roadways, eliminating jogs, improving traffic control measures, improving intersection geometrics, and improving intersection street lighting.

Othe traffic operation techniques being used include access control, progressive timing of traffic signals and computerized traffic control on major arterials, accident monitoring and safety improvements, and temporary signs and barricades to direct traffic onto major streets from residential streets.

Provide Preferential Treatment for Transit and Other High-Occupancy Vehicles

One objective of traffic engineering activities is to aid the free flow of transit traffic. These activities include removal of on-street parking when it interferes with transit movement, signal timing, bus pullout bays, bus stop location, and signing and marking.

A central area bus lane has been in operation for 10 years between Campus Drive and Bassett Street on University Avenue. Originally for buses only, the lane was later opened to bicycles and other special vehicles. Two special lanes are designed to be included when this segment of University Avenue is reconstructed: a contraflow bus and bicycle lane on the south side of the street and a lane for buses, bicycles, and right-turning vehicles on the north side of the street. The north lane will be tried on an experimental basis in 1976.

Other variations of the bus lane are also scheduled for construction in the central area and will require various accompanying traffic engineering improvements. When the Capitol Concourse, bordering the Capitol Square, is converted to transit and limited automobile use, changes to the outer ring of streets and access streets to Capitol Square will make access to the Capitol and stores and offices on the square more convenient for transit patrons (8). State Street, which connects Capitol Square with the University of Wisconsin campus, will be converted to a transit way for most of its length. The transit way will be open to emergency vehicles and taxicabs serving patrons on the street. Traffic engineering improvements are necessary to coordinate the transit way with automobile traffic on cross streets.

A device for bus preemption of traffic signals can be considered for selective sites in the future, especially in connection with exclusive bus lanes. In addition, related traffic engineering improvements, such as intersection modifications, special signing, and perhaps exemption for buses from turn restrictions, will be incorporated into all bus lane projects as necessary.

Provide Appropriate Improvements for Bicycles and Pedestrians

The need for improvements to bicycle and pedestrian traffic flow is increasingly being recognized. The 120 000 bicycles in Madison outnumber cars three to two. Nearly 10 000 pedestrians were counted on one block of State Street during a summer day. An increasing number of plans are being made to improve facilities for pedestrians and bicycles.

A bikeway program including route signing and intersection curb ramps was undertaken in the early 1970s. A more extensive long-range bikeway program was developed for the entire urban area in 1974 and adopted in 1975, together with the short-range improvement program within the city of Madison (12). Other portions of the urban area have also scheduled bikeway improvements. The system is coordinated with the university campus routes and plans and with county bikeway routes. A Madison resolution directs that bikeway facilities be considered for inclusion in all street projects. Planned bikeway facilities will be a part of several major improvement plans including University Avenue (Bassett to Babcock), John Nolen Drive Causeway, South Madison Beltline Freeway corridor, Capitol Concourse, and Mineral Point Road. A bicycle system is planned as part of the transportation system for the University of Wisconsin Center for Health Sciences, and additional bicycle ways are scheduled for construction on the University of Wisconsin campus. Using the railroad corridor from central Madison to Middleton as a bicycle way is also being studied. Large apartment complexes are asked to provide secure bicycle storage, and storage facilities will be a part of the Capitol Concourse-State Street Mall projects.

Facilities for bicycle travel are being provided in other jurisdictions as well. Dane County promotes safer and more convenient bicycle travel through two programs: a shoulder paving program for county roads and a program for cooperative financing of bikeways, sharing the cost on a 50-50 basis with local units of government.

Since trips beginning and ending in the CBD or campus areas are relatively short, a higher proportion of them can be made on foot. Walking can be encouraged by providing more carefully designed facilities. Pedestrian facilities will be stressed in the Capitol Concourse-State Street Mall projects and will be extended when the

Murray Pedestrian Mall on the lower campus is completed. A pedestrian circulation system is also planned as part of the University of Wisconsin Center for Health Sciences. A Campus Drive pedestrian overpass is scheduled for construction in 1976. Stoughton Road, where a study is being conducted, and the South Madison Beltline Freeway are other possible locations. Capitol Square has all-way walk lights. Traffic signalization improvements for pedestrians are part of continuing traffic engineering considerations.

Increase and Improve Management and Control of Parking Facilities

The general trend of parking policy in the Madison CBD and campus areas, where competition has been more intense and the impact of stored cars more severe, has been toward favoring short-term parkers through changes in public parking space allocation and parking rates. Long-term spaces in city-owned facilities are being converted to short-term spaces at the rate of 8 to 10 percent per year and long-term meter rates have been raised to 20 cents/hour. Parking on Madison CBD streets is being phased out. Fines and towing enforce these restrictions.

The amount of private parking is influenced in the city of Madison by zoning ordinances, which do not require parking to be provided in the central area, and by building permit regulations. There is no government regulation of private parking pricing.

Adjustments in the amount and price of parking in the central city must be handled in a way that preserves a difficult balance, maintaining and enhancing the central city as an employment-retail-institutional-cultural center of the area and as a desirable place to live. Favoring short-term parking can encourage visitors to the central area, maximize the use of space by a large number of people, and reduce the need for additional capital investment in parking facilities. Reduction of on-street parking can improve the flow of personal travel, whether by automobile, transit, bicycle, or foot. Reduction of all-day parking must be balanced against parking revenue needs and against the availability of transportation alternatives for those who work in the downtown area, such as attractive transit service combined with peripheral parking facilities. Parking will continue to be studied as an important factor in managing the transportation system.

Peripheral parking and express transit service to the downtown area well established (2). The Sherman Plaza Flyer and local buses serve the Sherman Plaza. Express and local bus service to a Copps peripheral lot on the South Madison Beltline Freeway at Stoughton Road began in 1976. Efforts will continue to secure other peripheral parking lots in the Middleton area, the Nakoma Plaza area, and other areas.

Continue Efforts to Reduce Peak-Hour Travel and Encourage Off-Peak Use of Transportation Facilities and Services

Staggered work and school hours are currently in force for state of Wisconsin and city of Madison employees and for the city of Madison students. Efforts will continue to extend staggered work hours to other groups of employees. Reduced transit fares are available to elderly and handicapped transit riders during off-peak hours. In addition, a shopper's pass for riding transit offers unlimited rides during the nonpeak period for the 55-cent price of a single round-trip ride.

Continue Action to Reduce Vehicle Use in Congested Areas

Actions to reduce vehicle use in congested areas have already been discussed in the previous paragraphs, and the following comments supplement rather than repeat previous comments.

In 1974, the Dane County Transportation Study developed a program to coordinate and expand car-pooling efforts already begun by state agencies and the city of Madison. The program envisioned focusing on regular travel to and from significant activity centers in the Madison urban area and using computer matching and extensive marketing. Although there was some initial disappointment at lack of response to some of the programs implemented, a recent spot check showed that an increasing number of employees of state agencies car pool to work. Car poolers at these agencies have high priority in obtaining on-site parking spaces. Future efforts will include further car-pool monitoring and assistance in car-pooling efforts including possible use of Dane County funds earmarked for car-pool promotion. Increased automobile occupancy, or car pooling, is a key element of the Dane County Transportation Study Plan Reevaluation (3).

Continue Action to Improve Transit Service

Significant improvements to the transit services provided in this area have resulted in substantial ridership increases, particularly during the past 5 years. A detailed study of transit services and improvements to services during the next 5 years was prepared and adopted in early 1975 (10). Recent actions taken to promote efficient use of the existing transit system include

1. Route changes to improve efficiency, give better service, and expand the area covered;
2. Combined express routes for more direct service;
3. Contractual agreements to provide service to surrounding areas;
4. Headways of the shuttle service linking the University of Wisconsin campus and the Capitol Square reduced from 10 to 7 min from 11 a.m. to 2 p.m.;
5. Coordinated Madison Metro system service, including transfer arrangements, and its contracted service with the university campus system;
6. Service by the university campus system to campus peripheral lots;
7. Scheduled start-up of special demand-responsive service for the institutionalized and handicapped elderly to be provided by three specially equipped buses;
8. Convenient 20-ride tickets;
9. Fares during the off-peak hours reduced to 10 cents for the elderly and handicapped;
10. Continuing program to provide bus shelters at transfer points and other high-use bus stops; and
11. Downtown Transit Information Center to answer bus service questions.

Improvements undertaken in the Madison urban area during 1975 included

1. For areas already served, improved peak-hour frequency, experiments with off-peak-hour fare structures, increased frequency of State Street shuttle, and experiments with improved weekend service frequencies and reduced weekend fares; and
2. For currently unserved areas, peak-hour service to newly developing parts of the urban area, staggering

of middle and high school hours and possibly updating central Madison staggered work-hour program, direct financial incentives to increase transit usage (including 20-ride ticket and token packs, reduced fares for handicapped, and possible reduced off-peak fares for all), expanded marketing program, continued gradual conversion of long-term central area parking supply to short-term and regulated parking rates coordinated with transit service improvements, limited-use lanes for transit, continued coordination with traffic engineering activities related to transit, and Downtown Transit Information Center to improve the quality and dissemination of transit information to the public.

Improvements planned in the Madison urban area for 1976-1980 include

1. For areas already served, improved routing to allow for connections between east side routes and campus bus system, increased levels of service in the South Madison Beltline Freeway corridor, peak-hour headways reduced to 10 min on main-line routes, peak-hour headways reduced as required by areawide employee bus-pass program, and improved service to far west campus area, including possible Highland Avenue shuttle; and
2. For currently unserved areas, peak-hour service to newly developed areas, peripheral parking, and commuter service to outlying county areas.

In addition basic transit system routing will be restructured to reflect proposed 1980 system structure, including possible increased express service availability in suburban neighborhoods, expanded (north-south) crosstown route system, extension of central Madison area shuttle service, improved directness of service to East Towne area, and limited-use lane for transit along University Avenue.

Transportation for the elderly and handicapped is being provided by the Madison Department of Transportation, by taxicab companies, and by private nonprofit agencies. The private nonprofit agencies will be able to expand their services with vans and buses acquired by UMTA grants. The Wisconsin Department of Transportation will help monitor how these private agency vehicles are used and how services are coordinated. A Wisconsin Department of Transportation survey of elderly and handicapped services in the state will also aid in planning future services.

Continue Actions to Increase Transit Management Efficiency

Continuing efforts to improve transit management efficiency include the following:

1. Market research effort to identify expanded ridership opportunities;
2. Two-way radio equipment for scheduling, equipment breakdown, and emergency information;
3. Bicentennial bus to provide more than 1000 hours of free riding time in 1976;
4. Driver training programs and school safety programs;
5. Expanded transit services to University Center for Health Sciences; and
6. Paratransit ordinance regulating vehicles carrying persons commercially.

Problems in Implementation

The main problem in TSM implementation involves conflict between different policies or objectives. Sometimes two transportation policies may be incompatible, and often a transportation policy will clash with some other community objective. In addition there is the continuing problem of trying to use an orderly, rational process in a dynamic, changing political environment.

An example of conflicts between different transportation objectives is the case of the Madison central business district. One goal is to limit automobile access to this area to alleviate congestion, minimize pedestrian-automobile conflict, encourage transit use, and so on. Another goal is to facilitate automobile access to the area to maintain the economic vitality of the retail core. Part of the solution, of course, involves strategies that segregate automobile trips by purpose, but the basic conflict remains.

A second major conflict involves efficient use of streets: maximizing existing street capacity versus removing through traffic from residential neighborhoods. In the Madison isthmus, where there are a limited number of existing arterials, where street volumes are near capacity, and where the public would probably view any major new facility with disapproval, the options are limited (11).

A more general problem is balancing vehicle efficiency in terms of fuel costs, depreciation, time, and driver stress against public demands to slow down and ban automobiles. In dealing with this problem, the transportation planner must address mutually inconsistent goals, some of which may well have significant negative effects on transportation but may nonetheless be desirable from a community standpoint.

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RESPONSE

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The first question that I find myself struck by is, What are the problems to which TSM is addressed? I think that I understand the background from which TSM has emerged. I think the causes have to do with the constraints on facility and service expansion in the late 1960s and early 1970s. The highway expansion ran into a variety of constraints largely of a nonfiscal nature. In the mid-1970s, transit is also running into serious constraints on service expansion mainly of a fiscal nature. There is concern as well about lack of integration of the costs of the system. But I think that there is still a lack of clarity about the problems of urban transportation that transportation policy may be trying to alleviate or to solve.

The case studies suggested that congestion is the primary problem and that TSM is the new traffic engineering strategy for alleviating congestion. But in the discussion of urban transportation more generally, one often has the sense that the primary objectives today have to do with increased equity, increased amenity in the urban area generally, air quality improvement, energy conservation, and so on. It is not always clear the extent to which TSM is addressed explicitly to these other issues or the extent to which it is an instrument for dealing with them.

Traffic engineering has been the historic strategy during most of our history for dealing with congestion. In the late 1950s through the early 1970s we had a brief burst of a construction orientation associated with the Interstate program in urban areas, but it was unprecedented and appears to have been a relatively brief episode. And now we are returning to a traffic engineering orientation under a new name. In a sense, I think, we have rediscovered the wheel. We now call it system management, but it bears a great deal of resemblance to the enthusiasm of the late 1940s and early 1950s over things such as one-way street systems, staggered traffic lights, and so on. The question is, What else will TSM be besides the new traffic engineering? Will it incorporate new objectives in important ways and new conceptions to the urban transportation problem? Will it focus on the management of institutions, transit institutions for example, and on cost control as well as on the management of urban street systems?

The second question that I find myself pondering is, How great is the challenge of integrating the new planning requirements that have been imposed, largely at federal initiative, on urban areas for the past several years? First there was the thrust to integrate highway and transit planning, and increasingly paratransit planning is being added to that. Paratransit, of course, incorporates a great many things under a single title, and it involves the integration of many parts of the system that are under different ownership and management, that is, dial-a-ride systems that may be under public transit management, van-pool and car-pool systems that may be under private management, and taxicab systems that are also privately regulated management. Then, there is the integration of long- and short-term planning. That may be the most difficult form of integration of all. How does one integrate the 6-month to 1-year perspective with the 20-year perspective, which has guided transportation planning during most of the postwar period? And there is the capital and operating integration. The idea of integrating the forms of operating planning with capital planning seems particularly difficult because the coordination of operations involves day-to-day coordination of action, not just the coordination of the intellectual activity of planning, and then the delegation to individual modal agencies to carry out those plans.

If one takes those various types of planning—highway, transit, paratransit, long- and short-term capital and operating—and builds a matrix, there would be 12 cells in that matrix; but of course it is much more complicated than that. The question that I would like to have addressed is, To what extent is this proving to be a nearly insuperable burden or one that in fact is proving to be quite manageable in urban areas?

A related question is, Does it matter if the TSM projects are not closely integrated and not all built into a comprehensive plan if TSM is essentially ad hoc and opportunistic in its orientation and requires only that major conflicts be ironed out and major priorities be set in some regional form? In that context, does it matter whether the region has a major capital agenda? A casual observation of my own has been that, in those regions that still have major highway, transit, and capital-intensive transit projects on their agendas, key policy makers and even planners are finding it difficult to focus on TSM and paratransit kinds of issues. It is in those areas that do not have rail rapid transit on their agendas and that do not have major expressway issues on their agendas that TSM is proving to be highly used. This I say in spite of the Boston case study. My own observation is that in spite of this imaginative project in downtown Boston, which is a very special case, major policy makers in Boston have found it difficult to focus on TSM because of their continuing preoccupation with major capital projects, which, of course, stems from a long and reasonable history in that region.

The third question involves the issue of the constituencies for TSM. Every major initiative, if it is going to have much of an impact on urban America, has to have political constituencies associated with it. At the moment, I think that I perceive that TSM is a professional initiative that has emerged out of the transportation professions, particularly those professionals who sit in Washington, but has received a favorable response from those who operate out of the states and regions and

localities around the country. But it is also an initiative that has only succeeded insofar as it has pursued modest objectives that have not inconvenienced significant numbers of drivers or voters and have not changed the basic patterns by which the urban transportation system has operated over the years. And it may be that as long as it continues to do that it will be undisturbed by the larger political process, but will also have a trivial impact on the overall nature of the urban transportation system. This gets back to the comment that TSM may be a minor initiative, although a commendable initiative.

Who are the potential constituencies of TSM who may over time eventually enable it to try some bolder initiatives and to become more pervasive with respect to the nature of the urban transportation system? I think of some constituencies that can be identified right now, both for conventional policies and not so conventional policies. It is the downtown business initiative or constituency that wants downtown malls. The highway programs had major constituents, who were concerned about the construction of the highways and about building the automobiles to be driven on the highways. It is more difficult to see exactly where the constituency for conventional transit has come from, but there are major institutions both in the central city governments and in transit authorities that have carried the ball politically on that one. There may also be TSM initiatives waiting to be tapped that are not so instantly visible right now. So perhaps the first question is, What has been the evolutionary development of constituencies in this area and how will they develop over time?

LLOYD: It seems to me that one of the big problems with TSM is that it is an economy of sorts, and the projects that tend to have enormous support are expensive projects because they bring big benefits to the business community and support from the unions. A project that is economical by nature is limited in terms of lobbying. For the Park Plaza development in Boston, a major redevelopment in the downtown, it was the unions who organized around building the project because of the kinds of jobs it would yield. Many decisions are made for profits because of the jobs they bring and against projects if jobs are lost.

A problem for TSM, then, is that it does not create jobs because it does not cost a lot of money. Therefore, its virtues are its vices. Are there environmental constituencies or other kinds of constituencies who have significantly become supporters of TSM strategies, perhaps as an alternative to something else?

WRIGHT: With regard to the Banfield project, we explained to the policy boards that the project was consistent with several regional policy objectives including those relating to the environment. The policy boards made a commitment to those objectives and are now adhering to them and attempting to provide an opportunity for its ultimate success. It has not been easy, however.

SOMERFELD: Our TSM projects require little capital and, therefore, have few opponents. We are having some difficulty in balancing the goals and objectives. As soon as we start reducing traffic through neighborhoods, we are, of course, downgrading the automobile efficiency and movement, and that is controversial.

Is it feasible or necessary to integrate the many types of planning: long-term, short-term, capital, operating, highway, transit, paratransit?

ALDERSON: The initial proposal for Nicolet Mall was made in 1956; the first skyway was built in 1962, and there are still skyways to be built. An effort like that cannot be carried out without long-term planning. Some have suggested that TSM planning, or short-range planning, will replace long-range planning. I think long-range plans and short-range TSM actions must be integrated, and people who suggest that they need not be miss the point of what planning is about. Once one has moved into the 3 to 5-year time frame and is trying to decide which things to do with next year's budget, one is in programming anyway and not in planning.

How great are the communication and coordination costs of doing that? Clearly, one of the arguments critics of the comprehensive planning thrusts of recent years have made is that everything now takes so long because so many people have to get into the act, so many clearances have to be made, and so many points have to be dealt with in the analyses. To what extent are the intellectual demand and the communication demand becoming more than it is humanly possible to do? Or is it manageable?

ALDERSON: In our metropolitan area, our transportation system management policies are simply extracted from our long-range plan. We did not make any new TSM policies because the policies that were in the 1990 transportation plan had enough about effective use of the system to give us what we needed for TSM. So, there was not any added communication. We do spend time in committee work dealing with priorities when we come to funding.

LLOYD: One problem we have that pertains specifically to MPOs is that we have such a detailed and extensive process of review in terms of transportation planning that by the time a project gets distilled to the final decision point so many people have seen it and signed off on it that it is almost irreversible. Sometimes at the last moment the timing or the exact extent of the project may not seem wise, but it is hard to take another couple of weeks or another 3 or 4 months because so many people have already seen it and are outraged to think that their effort may have gone in vain if there is going to be a last-minute change.

ALDERSON: We have a very detailed set of policies and objectives that were reviewed by major segments of the community. However, when we begin implementation, for example, in the central part of the city where our objective is to maximize existing roadways and transit, then we must talk about automobile-restrictive zones and pricing mechanisms to reduce the flow of traffic. The merchants are, of course, the first ones to oppose it even though they were involved in setting the policies and objectives.

So, it is easier to get consensus on the general strategy than on the specific tactic.

WORKSHOP A DISCUSSION

G. J. Fielding
University of California, Irvine

The following conclusions were reached in workshop A.

1. TSM has been an effective means for conveying to transportation officials that federal funds are limited and that programs seeking to achieve use of existing facilities are essential if congestion is to be relieved and energy conserved.
2. The federal policy statements are not in line with

practice in two areas. In the first area, federal agencies can only use "discretionary" programs to leverage TSM actions. Congress does not desire obstructions to the flow of formula grant funds. Future amendments to the Clean Air Act of 1970 will likely delegate enforcement of standards to state and regional agencies. In the second area, local agencies reported that, when conflict arose as a result of the implementation of policies required by the Environmental Protection Agency and the U.S. Department of Transportation, federal agencies failed to support the local officials. This was a problem for major metropolitan areas. Smaller cities were able to develop a support constituency for TSM. However, apart from professional planners, there is no constituency for TSM in large metropolitan centers. In these cities, TSM is only successful when it does not affect too many drivers.

3. Because TSM proposals are highly controversial, state and local agencies should budget funds for citizen participation during the development of the alternatives and for the marketing of projects after implementation.

4. TSM elements are too frequently regarded as project plans rather than programs for transportation improvement. There are two options: (a) TSM ought to be a programmatic aspect within the transportation improvement program so that competing transportation agencies have an opportunity to resolve issues and to change attitudes toward transportation improvements or (b) TSM should be a required assessment for each capital project like the requirements for environmental assessment.

5. Success cities are those in which TSM is regarded as an extension of regional transportation improvements and where the capital agenda is satisfied. That is, the region has sufficient highways and rapid transit or there is a policy decision not to develop through transportation capital improvements.

WORKSHOP B DISCUSSION

Harvey R. Joyner
Barton-Aschman Associates, Inc.

The first question raised was, Why does TSM seem to have been more successful in some cities than in others? The case studies seemed to suggest that TSM has been most active and successful in regions with a strong metropolitan planning organization and a tradition of an active regional planning program. These programs were also characterized by clearly defined regional development goals and policies that provide a context for TSM and long-range transportation planning. The basic 15-year plan of the Twin Cities was done in a pre-TSM environment and was simply comprehensive and realistic enough to see opportunities for system improvement outside of major capital facilities.

The more successful TSM programs also seem to be in regions that had resolved the issue of major capital projects in their regions. For example, Portland's TSM program has been in strong response to policy decisions to halt further freeway construction in the city. A similar situation exists in Boston. Additional urban freeways do not seem to be a major concern in the Twin Cities region (perhaps because the region has a reasonably complete system in place).

Other comments from the group suggested that TSM projects might be easier to implement in newer midwest and western cities than in the older eastern cities. Comparison of the orderly grid pattern of relatively wide streets in central Minneapolis with the narrow streets and disjointed pattern in downtown Boston suggests that there are greater opportunities for, and more flexibility in, devoting exclusive lanes to buses, creating automobile-free zones, and making other adjustments to the street system in Minneapolis than in Boston.

Finally, there were some who thought that TSM programs might be more popular and successful in smaller cities where the solution to local traffic problems is more likely to lie in low-capital improvements rather than major capital projects such as freeways or rail transit systems.

Workshop participants also expressed considerable concern over the documentation of the TSM plan. There is uncertainty in how to select and assign priorities to projects for inclusion in the plan and how to evaluate candidate projects and make trade-offs between projects in the same area. Some people expressed the opinion that UMTA and FHWA have not been helpful in defining documentation requirements, but seemed to be saying, "Submit what you think is needed, and we will tell you if we agree with that." Most local agencies expect the federal agencies to be considerably more explicit in the content and extent of documentation expected for TSM projects.

Another major area of discussion concerned the review of TSM projects for technical competency. In effect, the question was, Who catches poorly conceived projects? In some areas, local staffs may not be technically equipped to develop competent plans. At the same time, the MPO staffs whose responsibility it is to assemble and package individual projects from local agencies may be trained for the review of long-range traffic engineering and transit projects. This, in turn, raised the question of how much of the MPO's review of TSM projects is technical versus political (i.e., achieving some balance politically in the distribution of projects throughout the region and in some relation to a realistic allocation of available funds). In terms of the technical review of TSM projects at the MPO level, there is no easy answer to that question since it is unlikely that MPOs will be competently staffed in all of the technical areas that might be included in TSM projects. Probably the best mechanism is through local technical committees composed of technical representatives from all local and regional agencies in the hope that some of the people in these committees will have sufficient skills to catch ill-advised or poorly designed projects. In effect, at least one of the local jurisdictions represented is likely to have a competent traffic engineer or transit planner who can meet this need.

Finally, several workshop participants expressed a general lack of information and understanding of the energy implications of alternative TSM strategies. Although some data on this subject have been generated

by studies at the federal level, this information has apparently not filtered down to many of the local people actually involved in planning and evaluating TSM projects. In line with this, there was a general need expressed for more research on the development of better means for evaluating alternative TSM projects, for quantifying and measuring trade-offs between alternative strategies, and for assessing the effectiveness of various types of TSM improvements.

CONFERENCE REACTIONS AND PERSPECTIVES

Carlton C. Robinson
Highway Users Federation for Safety and Mobility

One conference spokesman said that the purpose of TSM was to conserve—to conserve energy, to conserve money, to conserve the time of urban residents, to conserve environmental quality. I think that we all grant considerable merit to that purpose. Let me suggest a broader definition of the purpose of TSM: to improve—to improve the contribution of transportation to urban life. One part of this broader definition must be to conserve, but it also suggests a more important criterion for selecting projects and measuring accomplishments: Will things get better for the urban dweller?

There was an implication in many remarks during the conference that TSM can supplant a capital improvement program. I was thus happy to hear California Transportation Director Gianturco say that new facility solutions continue to be considered in her state and continue to be built. They are not stopping the building of urban freeways, and I presume that they are not stopping consideration of high-capital transit. They recognize that capital replenishment in any society is an important consideration.

The urban transportation field has a legacy of capital investment, and we cannot live indefinitely off of that past capital. Those past investments depreciate physically and functionally.

The highway plant that this country put together during a 50-year span is depreciating at the rate of about $7 billion a year. I am sure that there are comparable figures for transit facilities. We have to reinvest in that capital plant. We may not reinvest in exactly the same things or in exactly the same places because this is a changing society and a growing society in numbers of citizens and in wealth. We must divide our resources between making best use of what we have, reinvesting in what we are depreciating, and meeting inevitable change and growth. And this is a difficult kind of question for a city or a business or a family. How many of the available dollars will be put into annual consumption? How many will be invested in longer term durables? Traditionally the problem has been to get enough dollars together to do some of the big, long-term things; and traditionally this has been one of the principal roles of the federal government. The federal role now seems to be changing; and perhaps that is the most important change represented by the TSM concept—a shift of federal dollars from long-term to short-term objectives. There is the obvious danger that, if the federal source of long-term investment is eroded away because it is being spent in some of the shorter term areas, the cities and counties and states are not necessarily going to be in a position to pick up the burden of the needed long-term investment. And we really must do both.

Another significant change associated with TSM is the role of the metropolitan planning organizations. Are they to form a new layer of government between local and state governments, or are they a coordinating mechanism only? Clearly, this question complicates the development of a federally acceptable TSM plan in many communities. However, let me emphasize that our real objective is not to develop a plan, not to meet federal rules per se. Our job is to improve transportation, to improve its contribution to urban living, and to improve the transportation system that is available to our people. That is a great goal, and that goal can be reached under lots of different jurisdictional systems.

And that brings me to the criteria for selecting projects and measuring accomplishments. A successful TSM effort has to have specific objectives, a set of priorities, and ways to handle the trade-offs among conflicting objectives. Some of the conference papers discuss setting of these objectives. I would like to add, in emphasis rather than in disagreement, that these must be the community's objectives. Objectives set by technicians or bureaucrats—federal or local—are not going to be persuasive. More discussion on how best to arrive at community consensus on objectives would have enriched the conference. After objectives, we have to have yardsticks that say this is really what we are trying to do and this is the scale on which we are going to measure. And then we have to measure the things that we are doing

and the effects of the things we are doing.

There are some quiet revolutions going on in this country. We do not know about most of them because we do not measure them. Half of the people in the United States now get to work in some kind of multiple-occupancy vehicle. Some TSM proposals may be aimed at solving a problem that is taking care of itself. Another quiet revolution that is already happening is the trend toward flexible work hours. This, too, is helping solve peak-hour transportation problems. Urban destination patterns are changing as well, and points of stress in our transport system may not always be where we think they are. Mark Twain once said: "It isn't what you don't know that gets you into trouble in this world, it's what you know that isn't true." And there are some things that we may think we know about energy efficiency, cost efficiency, and when and where and how people get to work that may not be true. So let us be sure that we address TSM projects to real problems and to the right problems. And that means doing some measurement of the problem before we jump to the solutions.

I was, therefore, surprised that the conference discussions seemed to be predominantly about getting downtown. Downtown is an important place in our cities, but it is not the only place in our cities. I was further surprised by a statement made that the TSM concept is not applicable to the suburbs and that TSM actions that improve the quality of transportation in the suburbs are counterproductive to the city's goals. I hope that such a position represents only a few cities because I do not think that we want to reduce mobility. I do not think that we want to reduce the freedom of choice of people or coerce them to live and work in ways or in places that fit our plan but not their plans. There is a theory, and not a bad one, that the sum of a series of individual optimizations is going to be a total optimization for the group. Plans that are designed to let people optimize their situations, their mobility, and their travel will produce a better city.

And finally, if we are going to have the right objectives and be able to implement the right solutions, we need to communicate. We need to hear as much as if not more than we say. And if we do not hear, we are not going to have an answer to the question that was mentioned in one of the first conference panels on Monday morning, "Who is the council of governments to tell me how I have to live?" If the answer is not convincing or if the public's attitude toward what we are doing is negative, we can not succeed. We will have wasted a great deal of effort and lost a great opportunity to improve the contribution of transportation to urban life.

Thomas B. Deen
Alan M. Voorhees and Associates

One wishes that, after having heard so many thousands of well-chosen words about TSM, that one could produce an eloquent and creative concluding statement. Failing that, I will instead observe from three different perspectives what I think we heard at the conference and perhaps should remember.

FEDERAL PERSPECTIVE

Federal government officials at the conference were indeed sponsors of it, and there were some messages there for them. The first one is that TSM is accepted. Six months ago I am not so sure that was true. I did not hear anyone at the conference say that TSM is a bad idea and we ought to forget it. We heard many quotations from learned sources saying that conservation and the things that TSM is aiming for are worthy, are in the national interest, and are in fact essential.

The second message is that it will be a long time before the impacts are seen. As Americans, we have two sacred notions: We can solve all problems in 1 year or less, and we can solve anything if we have enough money.

TSM runs counter to both of those notions. I think those at the federal level have to accept the fact that TSM actions are longer term and are not necessarily a quick fix to troublesome situations. The Minneapolis Skyway that we saw during the conference is an example. I was impressed with how long ago it had been started on the one hand, and how effective and really quite impressive it is on the other.

TSM solutions are not highly visible. You cannot see car-pool programs. You cannot see staggered hours. A computerized signal system looks like any other signal system. We may, therefore, feel we have not done anything even if we have been successful. And the public may feel the same way. For that reason, we may need more of the kinds of things that were suggested by the conference panel than we have been used to in other programs—more citizen participation, more public relations, and maybe some funds for that sort of thing.

The third message is that the federal agencies are going to have to be gentle in their application of TSM regulations. TSM action agencies have to be concerned with the combination of all the modes, the long-range and short-range aspects, the operational planning, and long-term capital planning all at once. And there is no methodology to pursue. As a result, at the end we are left with whoever it is who reviews the program at our local level and decides whether we made it or not. This is an extremely exposed position.

The top-level federal officials at the conference said that they intended to apply the regulations gently, and I believe they intend to do that. But sometimes something happens to top-level intentions before they reach the lower levels, and therein lies some danger.

LOCAL PERSPECTIVE

What were some messages with regard to the local level, which is the action level? First the diversity of local institutional arrangements and the essentialness of that diversity were stressed. A number of the case studies indicated that communities that have a history of successful intergovernmental relations will be able to accommodate TSM with no difficulty. On the other hand, those that have a history of tension and struggle for a variety of reasons may have great difficulty in instituting TSM actions. We must therefore have a variety and a diversity of ways to handle TSM. And I am not so sure that I see that metropolitan planning organizations (MPOs)

present such a problem. MPOs have been in operation for some time; some of them work, some of them do not. The amount of state influence in the way an MPO works varies. In some communities, the state influence predominates; in others, local influence is heavily dominant. In each case, the MPO can plan but has limited or no implementation power. It has some control on money flows. And all of that is true with TSM. A few more agencies are involved, and fewer federal "carrots" are available to lead the action along, but otherwise not much has changed and the initiative still lies largely with the local government.

We heard a lot about bottom-up planning, and if that is to be effective then the local professionals—the traffic engineers and the transit operators—are going to have to move quickly into TSM planning. The MPOs may move more heavily into it than need be (although I think that they have a role) because of the vacuum created by inaction on the part of the local agencies themselves.

And the other message is that many TSM elements may satisfy some objectives but hurt others, and we do not have many good tools for trading these things off. And even if our tools were perfect and we had a perfect model that measured to the last decimal place the impact of all potential actions, the issue is still mobility versus other social values such as the environment and energy conservation, and public attitudes and choices will differ at any given time. That is why we need community participation and involvement of officials and the media. As technicians, we can only display and measure and show what the options are.

PROFESSIONAL PERSPECTIVE

Finally, what are the messages to the profession? And I mean a profession of transportation officials, whether planners, engineers, transit operators, or whatever. We have been finely honed as a group to be expert at deciding how best to expand our transportation system and, although there is some more expansion yet to happen, that is not our main goal these days.

We have heard that the government cannot be smarter than the people, and neither can transportation professionals. We cannot move too far ahead of public expectations. Some TSM elements can have dramatic effects; in Singapore peak-hour travel was reduced 50 percent within 2 weeks after a pricing scheme was instituted. On the other hand, one conference speaker told about the problems that you can get with big, bold solutions that have not been well planned. And a lack of success with some of these big, bold moves may keep us from being prepared when conditions and constituencies change so that those kinds of solutions are wanted. In other words, we cannot be smarter than the people, but we should not be dumber than the people either. And we should be aware that constituencies change and be prepared for that change. In San Francisco, for example, a constituency formed and heavily taxed itself to build a modern rail rapid transit system. I suspect that we can have only marginal influence in forming these constituencies, but we had better be ready to do the bold things when they become practical. What is practical one year may be impractical the next and vice versa. Pricing strategy seems impractical now, although we are beginning to get into it a little bit with parking and so on. Our energy situation is such that people may agree that certain things are practical next year that are not this year. Like the airline in its commercial, we had better be in a position to say, "We're ready when they are."