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

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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 km² (3000 miles²) within which about 2,000,000 people reside. About 1200 km² (460 miles²) 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 sub-regional 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 pre-emption 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 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 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 one suburb, 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-
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.
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
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, protecting 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 campaign 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 $28. 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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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