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-