Automobile-Restricted Zones

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The automobile-restricted zone, in which the free flow of traffic into a congested area is reduced, has been suggested as a potential solution to some of the problems of downtown business areas. This paper reports on a conference session that discussed problems, experiences, and opportunities of such zones. The following topics are considered: Recent experiences with automobile-restricted zones in Europe and in the United States are compared. The concepts, goals, and techniques for implementing automobile-restricted zones are discussed. A series of disaggregate, behavioral travel-demand models that were used to estimate the impacts of various automobile-restrictive policies on downtown retail and employment centers are described. The planning and design opportunities available in automobile-restricted zones are discussed. The economic approach to congestion problems, i.e., roadway pricing, is introduced, and its implementation in Singapore is described.

Restricting the free flow of automobile and truck traffic on downtown city streets is considered by an increasing number of transportation planners to be a means to reduce congestion, revitalize central business districts (CBDs), improve urban environments, and encourage more efficient use of mass transit facilities. Concepts, problems, opportunities, and experiences with automobile-restricted zones (ARZs) were discussed by seven speakers in a conference session. Joseph Goodman compared recent experiences with ARZs in this country and in Europe. Marvin Overway discussed the concepts, goals, and techniques for implementing ARZs. William Loudon discussed a series of disaggregate, behavioral travel-demand models that were adapted for the estimation of the impacts of various automobile-restrictive policies on travel demand to downtown retail and employment centers. Lajos Heder described the planning and design opportunities available in ARZs. Bert Arrillaga introduced the economic approach to congestion problems—roadway pricing and some of the factors affecting acceptance and implementation of the concept. Peter Watson and Edward Holland described the Singapore experience with congestion pricing.

EUROPEAN AND AMERICAN EXPERIENCES: RECENT COMPARISONS

Joseph Goodman, Urban Mass Transportation Administration

One of the major arguments in support of ARZs is the fact that the potential time savings of mass transit are lost in central business districts (CBDs) because of traffic congestion. In Europe, the immense growth in traffic on the narrow, medieval streets has become intolerable. In the United States, the motivations for ARZs are broader. Here, we are also trying to recapture some of the amenities of the cities and stem the decline in vitality of the CBDs. Decline in transit use and decline of downtown urban areas reinforce each other.

A 2-year study by the Urban Mass Transportation Administration (UMTA) has compared the European and American experiences and shown that there have been positive effects in Europe: ARZs have stimulated the use of downtown urban areas and increased business. The record in the United States, however, is uneven. Most of the experiences with ARZs in American cities have been with pedestrian malls, and the effects in terms of stimulating downtown retail businesses have been inconsistent.

In Europe, many of the ARZs are large and involve many downtown city blocks. They are also relatively clean and simple in design. In the United States, with the exception of one in Memphis, Tennessee, ARZs usually involve only a few blocks or a single street. We have relied heavily on street furniture, such as planters and benches, which are very expensive. On both continents, the placement of utilities underground can be very expensive.

AUTOMOBILE-RESTRICTED ZONES: CONCEPTS, GOALS, AND TECHNIQUES

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In the past year or so, the idea of the ARZ has become increasingly prominent. The term is commonly used to cover a rather wide variety of situations, depending on the perspective involved, but the concept that is emerging may have significant potential for some existing city centers.

What Is an ARZ?

To begin with, it may be helpful to understand what an ARZ is or can be. Some examples of areas where automobiles are restricted (although not necessarily prohibited) include commercial superblock redevelopments, suburban shopping malls, new-town residential areas, recreation and amusement parks, and college campuses. The obvious benefits ARZs offer in terms of environmental quality and overall attractiveness are increasingly evident, particularly when they are compared to areas where the automobile continues to be dominant. The current interest in ARZ planning is an effort to achieve similar benefits within existing city centers by reducing the impacts of the automobile.

The concept of restricting traffic is not new. Traffic has always been subjected to a variety of controls, which have become increasingly restrictive with time. The degree of restriction that can be instituted varies. The measures used can be grouped into four basic categories: physical, operational, regulatory, and economic.

Objectives of ARZs

In the highly automobile-oriented society in which we all function, increasing the restrictions on automobile traffic is viable only if there are corresponding benefits. These benefits serve as trade-offs with the things that people perceive as the disbenefits, both real and imaginary, associated with the change.

The goals and objectives of ARZ concepts are distinct for different types of areas. For existing city centers, the goals are the vitality of the urban center, its environmental quality, and the stimulation of other travel modes. Specific objectives for realizing these general goals have been identified in four categories: transportation factors, economic factors, social factors, and functional and physical factors.

Clearly, the degree to which ARZ policies can attain these objectives is subject to a number of factors, some of which are only indirectly related to the ARZ concept. An ARZ can be a catalyst to give impetus to a direction and a commitment to the maintenance and enhancement

of the city center by changing a situation of congestion and conflict to one of separation of function.

ARZ Techniques

While the actual design and implementation of an ARZ is closely related to the specific characteristics of the area, observation of a variety of existing ARZs suggests that there are a number of general techniques that are commonly used. These are

1. Traffic restriction—higher degrees of automobile restriction are realized through circulation controls with only limited interference to basic access;
2. Traffic circulation—through traffic is diverted out of the area, and local traffic is diverted around the area;
3. Transit service—a high level of transit service is provided to the area to serve as an attractive alternative mode;
4. Pedestrian orientation—pedestrian facilities are upgraded and linkages between facilities are provided;
5. Urban activity—existing spaces are reused for pedestrian-scale activities and to stimulate human interaction opportunities; and
6. Environmental quality—the area is made a nice place to be, with cleaner air, less noise, and improved urban design features.

The manner in which these issues are related to a specific site and the degree of their emphasis is tailored to the unique requirements of each local situation.

The following elements of an ARZ are interrelated to define a comprehensive ARZ scheme: the basic street element, the outer diversion element, the initial core element, the innercirculation element, the expanded core element, and the reinforcing element.

While the nature of the end product and the emphasis placed on particular elements are subject to substantial variation, the issues addressed and the techniques used are conceptually representative of most ARZ applications. Beginning with a basic grid system, four district ARZ plans might reflect, in turn, a pedestrian emphasis, a transit emphasis, an arterial-preference emphasis, and a traffic-operations emphasis. ARZs tend to be shaped over a period of time by the continuous implementation of specific measures that favorably accommodate pedestrian and transit functions and provide increasing disincentives to the use of the private automobile.

Existing Experience

At present, more than 70 cities of varying sizes in the United States have instituted some form of automobile restriction. The most commonly used technique has been the closure of a downtown shopping street and its conversion to a pedestrian area in which there is a high degree of emphasis on improved urban-design features.

An alternative scheme that is receiving increasing emphasis is the conversion of a downtown shopping street to a transit mall. Recently, a number of cities have moved toward a more comprehensive approach to traffic reorganization, transit emphasis, and environmental improvements. Boston, for example, has a number of completed projects that, when considered individually, have limited local impacts. But, as their number increases and linkages between the individual elements are formed, a comprehensive picture begins to emerge.

The concept of ARZs takes on an added dimension in the European context. Over 130 cities there have some form of automobile restriction. However, there are significant differences between European and U.S. cities in terms of the roles of public transit, land-use controls, and the importance of the CBD. The following highlights a number of relevant factors in the pattern of development of ARZs in Europe.

1. Most European programs are phased in over time.
2. Automobiles have not been totally eliminated from the restricted areas. Circulation within the area is severely restricted, but basic access by automobile to areas within walking and shuttle-bus distances of most destinations is generally maintained.
3. There has been a high degree of accommodation and compromise in most cities. Goods deliveries, service and emergency vehicles, and access to certain facilities have been suitably accommodated in a number of ways that are appropriate to the particular situation.
4. The pedestrian linkages that are created within the restricted areas serve the movement of people and create a pleasing shopping environment.
5. The severe opposition and the reservations that initially confronted these programs in most cities have generally been replaced with strong support after an initial 6 to 12-month period of adjustment.

Automobile restriction and environmental improvements cannot by themselves reverse the decay of downtown areas that are no longer viable centers for functions that have relocated elsewhere. However, they are an effective tool in protecting and enhancing downtown areas that are reasonably viable and serve as an impetus toward changing the image of the city center and the development of transit services that can compete more effectively with the automobile as a means of transport. This experience is common in both the United States and Europe.

Implementation Issues

The key issues related to implementing an ARZ are the following:

1. Urban activity—the area must possess some basic vitality and strength in its activity pattern;
2. Urban design—the purpose of automobile restriction is not simply to eliminate automobiles from city streets, but to create functional pedestrian and transit-preference networks;
3. Accessibility—the most critical factor in determining the success or failure of an ARZ is accessibility (if accessibility to and within an ARZ is not maintained, in the short term, there will be a decrease in the number of discretionary trips such as shoping and entertainment to the ARZ, and in the long run, many activities will relocate to more accessible sites);
4. Size of the ARZ—city size is only indirectly related to the success or failure of an ARZ, and the extent to which travel patterns will change is dependent on the size of the area subjected to automobile restriction;
5. Transportation policy—there is a wide range of options for automobile disincentives and for improvements in other transportation elements to maintain ARZ accessibility; and
6. Institutional and legal factors—institutional issues are the single most important factor, local leadership is of primary importance in the process of consensus building, and interagency cooperation is essential.

Conclusions

ARZs are not a concept that can be clearly categorized into a representative group of appropriate units to be conveniently matched to existing real-life situations.

Urban centers have many unique characteristics and constitute a conglomeration of special situations that must be dealt with on a site-specific, condition-specific basis. Automobile-restrictive policies must be tailored to local conditions.

Implementation of ARZ policies is not appropriate for all situations. Whether or not an ARZ is appropriate for a specific locality and what it might be like depends entirely on local conditions. An ARZ is not a cure-all: it is a means of encouraging and enhancing basic attributes that are already present.

MODELING THE TRAVEL-DEMAND IMPACTS OF AN AUTOMOBILE-RESTRICTED ZONE

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A series of disaggregate, behavioral, travel-demand models was used to estimate the impacts of various automobile-restrictive policies on travel demand to downtown retail and employment centers.

The models were used to predict the change in the following two major categories of travel demand for each policy:

1. Regional travel demand: work (mode choice among automobile drive alone, shared ride, and transit) and nonwork (frequency of travel, destination choice, and mode choice) and
2. Intra-CBD travel demand: worker (frequency of travel, destination choice, and mode choice) and nonworker (destination choice and mode choice).

The models predict changes in demand (frequency, destination, and mode choice) by using estimated changes in travel time and cost because of automobile-restrictive policies. They differentiate between trips made for work and nonwork purposes and also between regional trips—those into or out of the CBD—and intra-CBD trips—those having their origin and destination both within the CBD, such as trips made by shoppers, business people, and workers, during the day. The category of intra-CBD trips includes trips made in the morning and evening peak travel periods between parking lots or transit stops and places of employment, but the majority of intra-CBD trips occur during the midday (10 a.m. to 3 p.m.). Unlike the regional trips, the majority of intra-CBD trips are made on foot, and there are very few data available to aid in the analysis of the impact of automobile-restrictive or transit-improvement policies on them. A modeling approach developed recently is capable of simulating trips of this type from a very limited amount of data. These intra-CBD travel-choice models can also forecast the demand for new circulation modes, such as a shuttle bus service (either with or without a fare), which was recommended as a part of a number of ARZ projects.

The conclusions of the analysis of the travel-choice impacts of automobile-restrictive policies in a prototypical city and in Boston; Providence; Memphis; Tucson, Arizona; and Burlington, Vermont, are summarized below.

1. CBD trip patterns, both regional and intra-CBD, are diverse and complex, but a number of specialized travel-choice models can be used in an inexpensive and efficient manner to properly simulate each type of trip.
2. Because of the disaggregate and behavioral nature of the travel-choice models used in this analysis and because only changes in travel from existing patterns are being estimated, the models can be transferred, with only minor adjustments, to cities other than the one in which they were estimated.
3. The impact of automobile-restrictive policies depends on the extent of automobile restriction and the degree to which accessibility is maintained through other measures, such as transit and pedestrian improvements.
4. When implemented in conjunction with nontransportation policies, such as new construction, physical-design improvements, increased marketing, and improved maintenance, automobile-restrictive policies can induce travelers to change from automobile use to public transit and can increase the total number of shopping trips to the area.

PLANNING AND DESIGN OPPORTUNITIES IN AUTOMOBILE-RESTRICTED ZONES

Lajos Heder, Moore-Heder Urban Designers

Consider a familiar situation: A downtown shopping street becomes heavily congested and can no longer handle the automobile traffic. The conventional response has been to look for ways to improve the traffic flow. The moment a transportation planner decides to look instead for ways to eliminate or reduce the traffic and improve the street environment, he or she has entered a new world of planning concepts and working styles. The mechanistic ideas that relate to achieving the most movement for the least money must give way to complex ecological concepts of environmental capacity and the simple concept of the need to make places more attractive.

Those on a planning project team must constantly negotiate a balance among different disciplines. In the cities, they must look not only for solutions, but also for new opportunities. They must look about and walk the streets, because analytical studies do not reveal most of the opportunities. Urban designers must be able to invent new ideas for reusing older parts of cities.

The evidence from the automobile-restricted streets and zones that have been built in Europe and the United States shows that they do, in fact, help to bring new life into downtown areas. The indicators of pedestrian activity, retail sales, and building reconstruction all show major improvements. These places show a life that is in contrast to many dead downtowns. But it is also clear that to be successful, automobile restriction must be combined with improved streets for people, alternative transportation modes, imaginative promotion and management, and joint action with private developers. The following examples are drawn from five very different cities to illustrate the range of opportunities available in an ARZ.

1. Bringing the working population into the retail district is one of the opportunities available in Boston. Recent office construction has increased the number of workers in the downtown area to over 150 000, but it has also shifted much of this population just out of easy walking range of the old retail district. By shifting automobile traffic to the periphery of the retail area, the streets can become pedestrian-oriented and serve as connectors between the working population in Government Center and the financial district and improved shopping places. The upper floors of older buildings that are now vacant in spite of the intense business activity nearby could then become attractive again as living lofts or small specialty offices.
2. Keeping an old shopping street competitive with new developments is one of the opportunities in Burlington, Vermont. Creating a pedestrian orientation and providing shelters, heat in the winter, consolidated

parking, and other activities will help to maintain shopping on Church Street.

3. Building a city bus terminal and pedestrian arcades connecting the old downtown area to a renewal area is one of the proposals for Tucson. The terminal will provide convenient bus service and be the end point of a pedestrian-arcade system.

4. Building bus and pedestrian arcades along a declining shopping street in Tucson will accommodate waiting bus passengers, who will become pedestrians and customers. At present, the bus stops on the peripheral streets are crowded with people huddled on narrow sidewalks. The few pedestrians walk in 43°C (110°F) sun. The new arcades will provide continuous shade, occasional patios, seating areas, and evaporative cooling. The image of bus service will be improved.

5. A pedestrian-oriented downtown street as a stage for promotion and programmed entertainment is also proposed in Tucson.

6. A central place for city activities can be created in Providence by clearing away the traffic in front of the city hall and building a plaza and a sheltered transit terminal. The old Westminster Mall and proposed redevelopment of the Biltmore Hotel and Union Station can be tied together by a phased program of pedestrian improvements and bus facilities.

7. Locating a new transit center in a vacant building next to the main downtown bus stop is proposed for Memphis. Leasing the ground floor and opening it to the sidewalk and providing information, supervision, food vendors, shelter, and heat all become possible and may help to alter the image of buses as the transportation of last resort.

8. Creating pedestrian alleys and recycling buildings could be combined as a joint development program in the Cotton Row area of Memphis. The conversion of attractive, but run down and vacant, warehouses to apartments, restaurants, and specialty shops has begun and will be encouraged by the public contribution of repaving and lighting the alleys for pedestrian use.

The examples shown all concentrate on making the most of what the city already has and not on expensive reconstruction. The capital costs of the recommended improvement programs were in the range of $3 to 5 million for each city. While the issues may be typical, the solutions depend on the ability to discover the unique and often-neglected resources of the particular city. This is a discovery and design process that must go beyond quantitative analysis and requires the partnership of transportation planners and urban designers.

PRICING APPROACH TO AUTOMOBILE RESTRICTION: SUMMARY OF ACTIVITIES

Bert Arrillaga, Urban Mass Transportation Administration

Roadway-Pricing Concept

In roadway pricing, a fee is charged to low-occupancy vehicles that wish to use a designated area during highly congested periods, such as the morning peak hours. The fee is charged by selling a windshield license sticker on a daily, weekly, or monthly basis. The extent of the charge depends on the desired reduction in congestion and the needed revenue. High-occupancy vehicles, police, and emergency vehicles are exempt.

A collateral element is the implementation of significant transportation improvements in the months prior to implementation of the pricing scheme. These improvements may include the addition of conventional fixed-route buses or small vans. Service on these would be very low in price or free, and their headways would be 10 min or less. Park-and-ride lots could be strategically located around the restricted area so that automobile users could easily park and take a free shuttle bus to their destinations. Car pools, van pools, and shared-ride taxis would be encouraged. The reduction of traffic in some areas may free space in which to provide pedestrian amenities or physical improvements, such as sidewalk widening for cafes and shops.

Preliminary Analysis

Six cities expressed interest in a demonstration program, but only three (Berkeley, California; Madison, Wisconsin; and Honolulu) were willing to perform a preliminary analysis of alternative pricing schemes. A preliminary sketch design provided an opportunity to interact with local people and inform them about the concept and its possible impacts, and after this, a 6-month study dealt with the following key issues: public information, transit planning, project operators, cost estimates, and the development of an advisory group.

The table below summarizes the alternative pricing schemes studied for Madison. These schemes included a morning parking charge, several areawide charges on the downtown core area, and an urban-area permit for the entire city. The time of automobile restriction is the peak hours from 7:00 a.m. to 10:00 p.m.

Alternative	Fee ($)	Automobile Reduction	New Transit Riders	Annual Net Revenues ($000)
Parking surcharge	2.00	1 000	1350	-864
Core-area permit				
Drive alone	2.00	8 000	3300	-187
All automobiles	2.00	12 000	4500	+4 097
All automobiles	1.50	11 000	3500	+2 242
All automobiles	1.00	10 000	2930	+617
All automobiles	0.50	10 000	2475	-1 408
Urban-area permit	2.00	1 000	1100	+15 729

The alternative providing the greatest amounts of automobile reduction and transit increase is the $2.00 areawide license permit applied to all automobiles. This alternative results in an annual net revenue of over $4 million (the revenues from the license fees and the transit fares minus the costs of administration, enforcement, and transit operations). Care must be exercised in the selection of the charges because, in some cases, the costs of administration and operations are not covered by the revenues generated.

In Madison, the preferred strategy was a $1.00 core-area permit for all automobiles, which was close to break-even. The transportation improvements proposed for this alternative were 113 new buses running at a 7.5-min peak headway on all major transit routes and six or seven park-and-ride lots with shuttle service at 15 min or less headway.

Similar analyses for Berkeley and Honolulu led to similar results. In Berkeley, the initial reactions were positive, and a formal resolution to proceed with the more detailed study was passed. However, a press release on this action caused an unfavorable reaction from the public, which forced the study to be stopped.

In Honolulu, there was general interest, but business groups were concerned that the concept might be perceived as a tourist tax.

Additional Study Sites

Preliminary analyses are also being considered in Lake Tahoe, California, and Traverse City, Michigan, which have shown interest in the application of pricing schemes.

Lake Tahoe, where visitors outnumber residents four to one, has proposed a parking pricing scheme to restrict trip ends but allow through traffic. Parking permits would be sold at the rates shown below.

Time	Cost ($)
3 d	5
10 d	10
1 year	20

The major purpose of this scheme is to raise revenue to pay for the numerous transportation improvements planned for the area. It is expected that the parking charge would generate $13.8 million for fiscal year 1978.

At present, UMTA is studying the impact of the proposed Lake Tahoe plan on revenues and traffic congestion as compared to parking differential rates and areawide charges. The legal issues are also being studied, and an enabling legislation permitting the regional authority to enact a variety of pricing schemes is hoped for.

Factors Affecting Concept Acceptance and Implementation

The use of pricing schemes to control travel behavior in favor of high-occupancy vehicles is not a readily acceptable concept. Numerous factors affecting the implementation of the concept were perceived through personal contacts and visits made to the selected cities. These include the following:

1. The realism of a daily use fee;
2. Disbelief in proposed transportation improvements and their success in providing good mobility;
3. The inconvenience of obtaining a permit;
4. Effects on business;
5. Association of the concept with a commuter tax or a tourist tax;
6. Effects on low-income groups; and
7. Legal issues such as (a) whether the charge is a toll and whether it can be implemented on federal-aid roads, (b) the right to travel and the right to equal protection under law, (c) the availability of local enabling legislation, and (d) enforcement problems.

Future Directions

The experience gained by the initial interactions with city officials and local transportation planners and engineers convinced the UMTA study team that new directions must be taken to provide a better basis for the acceptability of the concept and its future implementation. These are

1. Ensure that the detailed feasibility-study phase is quite broad and considers not only the application of areawide charges but also parking strategies;
2. Deal fully with existing and planned transportation improvements;
3. Include other amenities, such as closing streets or lanes for expanded sidewalks for restaurants and shops;
4. Provide financial support for developing a comprehensive community-interaction program;
5. Develop an informative package to be used in citizen workshops or public hearings and for press conferences;
6. Be ready to accept a case-study site for performing detailed studies; and
7. Have a larger and more widely publicized site-selection process so that many cities will become acquainted with the program and have an opportunity to express their interest.

CONGESTION PRICING: EXAMPLE OF SINGAPORE

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The concept of road pricing and the details of its implementation in Singapore in the form of the area license scheme have been described previously. In this paper, the explanation of the design of the scheme is limited to a brief summary; the main purpose is to report the impacts of the scheme as measured in an extensive monitoring program.

Area License Scheme

The government of Singapore, having decided to take preventive action before traffic congestion grew to serious levels, instituted the world's first area license scheme in June 1975. The essence of the scheme is that a special supplementary license must be purchased and displayed on any automobile entering a designated restricted area during the peak commuting period in the morning. The license scheme is supplemented by increased downtown parking charges, and a park-and-ride service is provided as an alternative to driving downtown or using the standard bus service all the way.

The restricted zone was designed to include areas with congestion problems, leave diversion routes for motorists who do not have destinations in the zone, minimize the number of entry points that must be monitored, and take advantage of existing facilities for use as fringe car parks. The zone has an area of about 5 km^2 (2 $miles^2$) and has 22 entry points. The license fee was set at S$60/month (S$1 = U.S. $0.43) or S$3/day.

To focus the impact on peak commuting traffic, the license was initially required only for vehicles entering the restricted zone between 7:30 and 9:30 a.m., but later the period was extended to 10:15 a.m. to eliminate a peak that developed just after 9:30 a.m. It was thought that applying restrictions during the morning peak would significantly reduce traffic both then and in the evening peak, but the latter reduction has proved much smaller than desired. However, the scheme has not been modified to deal with the evening peak.

The license is not required for buses or commercial vehicles, to favor public transportation and maintain commercial activity. To encourage higher vehicle occupancy and more efficient use of road space, car pools (defined as automobiles carrying at least four persons) are also exempt from the license requirements, as are motorcycles. These exemptions also counter the objection that driving into the center would become a luxury that only the rich could afford; others can also do so if they form car pools or ride motorcycles. Taxis are not exempt.

Park-and-Ride Scheme

A park-and-ride scheme was designed to complement the area license scheme. Ten thousand spaces in parking lots around the periphery of the restricted zone were opened to commuters, and special shuttle buses were introduced to carry commuters from these lots to the central area. The combined monthly cost of parking and using the shuttle bus was set at S$30. This service attracted very few patrons.

Parking Policy

Parking charges were sharply increased at public parking lots within the restricted zone. Previously, there had generally been a flat rate of S$0.40/h. The new rates are designed to favor short-term, as opposed to all-day parking. The rates for the most congested part of the restricted zone are shown below.

Time	Cost (S$)
First hour	0.50
Second hour	1.00
Each subsequent half hour	1.00

The monthly rate for all-day parking in the central area has been increased from S$40 to 60 to S$50 to 80.

Monitoring Impacts on Travel

The World Bank, in cooperation with the government of Singapore, and with support from the United Nations Environmental Program, the U.S. Department of Transportation, and the U.S. Environmental Protection Agency, set up an extensive monitoring program that consisted of traffic counts, household interviews, speed versus flow measurements, interviews with businessmen, observations of pedestrian and parking behavior, and pollution measurements. The monitoring was begun more than 6 months before the scheme was implemented, so that before-and-after comparisons would be possible. The scheme was implemented during the middle of 1975. The implementation was carried out very smoothly, and no serious problems were observed.

The most visible impact was a decrease of 44 percent in the number of vehicles of all types entering the restricted zone during the restricted period. This was primarily the result of a 73 percent decrease in the number of automobiles entering during those hours. Of those automobiles that did enter, about 40 percent qualified as car pools (this can be compared to about 7 percent before the scheme was implemented and from 5 to 10 percent during unrestricted hours after implementation).

With these reductions in flow, one would expect to find increases in average traffic speeds, at least within the restricted zone. Technical problems prevented a direct before-and-after comparison, but by comparing speeds during the congested evening peak with those during the restricted hours, it can be inferred that speeds during the restricted hours have increased about 20 percent inside the restricted zone and from 10 to 20 percent on various inbound radial roads. Increased congestion on some parts of the ring road, however, may have reduced speeds as much as 20 percent in those locations.

From the household surveys, changes in travel behavior were analyzed in detail. The principal impacts, of course, were on people making trips to work in the restricted zone, especially those who had formerly driven automobiles. For these people, the monthly cost of commuting by automobile during the restricted hours increased from S$153 to S$228. Because of this, the proportion of trips that members of vehicle-owning households made as automobile drivers decreased from 34 to 27 percent, and the proportion that these persons made as bus riders increased from 33 to 46 percent. In addition, the proportion of work trips that were begun before 7:30 increased from 27 to 40 percent for automobile drivers and from 17 to 28 percent for automobile passengers. About the same numbers of persons from vehicle-owning households chose the options of changing to the bus, joining or forming car pools, and making the trip at a different time. People from non-vehicle-owning households did not change their behavior—90 percent of them traveled by bus both before and after the introduction of the area license scheme. The changes in travel time reported by travelers who did not change mode were very small. The only categories for which the average reported time changed more than about a minute were automobile drivers who changed to the bus and bus riders who changed to the automobile (mostly as passengers). The former lost an average of 9 min, and the latter gained the same amount.

The second group to be significantly affected were workers who traveled to work through the restricted zone to destinations on the other side of the city. Among these persons, the proportion of trips made by automobile decreased from 53.5 to 50 percent, but the proportion of automobile trips made in car pools increased from 9 to 28 percent. The proportion of trips begun before 7:30 a.m. increased from 50 to 60 percent. These travelers also had the option of detouring around the restricted zone. Before the introduction of the scheme, 88 percent of their trips had passed through the zone, but afterward only 66 percent of them drove through the zone, and of these, only 13 percent drove through during the restricted hours. The remainder changed time to avoid the fee.

Impact on Business

Many persons have expressed concern that a scheme such as that in Singapore could hurt business in the central area of the city. In-depth interviews with selected leaders in the business community, including store managers, bankers, wholesalers, and property agents, showed a consensus that the area license scheme has not had a serious adverse impact on the business climate. It is believed that the increased parking charges have further depressed retail sales in the central area but that these were already suffering from recession and decentralization. It is also believed that the restrictions on automobile travel to the center are accelerating the existing trend toward decentralization. In both cases, the area license scheme and the increase in parking charges are viewed as adding slightly to existing problems, but not as creating new ones.

Effects on Pedestrians

Before and after implementation of the scheme, time-lapse photographs were made at various times of day at different locations within the restricted zone to study the conditions for pedestrians. In general, there were more pedestrians at most locations after institution of the scheme, and they had less difficulty crossing the streets.

Air Quality

Although air pollution had not been considered as a problem, measurements made by the antipollution unit indicated an improvement, with changes in carbon monoxide levels that closely corresponded to changes in traffic flows.

Administration and Finance

Enforcement of the scheme has not been difficult. Distribution of licenses has gone smoothly. Revenues from license sales have exceeded operating costs (including the special police for enforcement) by a margin that was sufficient to pay off all the capital costs, including a gross overinvestment in fringe parking lots, in a little more than a year.

Evaluation

An opinion survey showed that residents of Singapore believe that the area license scheme has relieved congestion and improved conditions in central Singapore. Pedestrians, bus riders, taxi riders, and motorcyclists believe that they personally are better-off as a result of the scheme. Central area residents report that it is easier and safer to cross the streets, that general conditions in the restricted zone have improved, and that the amount of fumes has been reduced. Motorists report that they are worse-off, but not greatly so. All, including the motorists, believe that the effect on Singapore as a city is favorable.

In terms of the general objective of forestalling future congestion problems by forcing people to change their attitudes toward the use of automobiles for commuting, the area license scheme appears to be a success. Major modifications in travel behavior have taken place.

Whether these are simply short-term modifications or whether they represent fundamental changes in the attitudes of motorists cannot be determined at this point. It seems likely, however, that the continued use of such measures will result in a more widespread acceptance (rather than mere tolerance) of public transportation and car pooling.

Analyzing Indirect Impacts of Alternative Automated-Guideway-Transit Systems

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A computer methodology is described for analyzing at a sketch-planning level five types of indirect impact of automated guideway transit: right-of-way land consumption, community disruption, household and business displacements, aesthetics, and noise disruption. Application of the technique in a recent case study of dual-mode transit planning in Milwaukee is discussed. The methodology is also applicable to the preliminary analysis of other automated-guideway-transit systems. The procedures used in the inventory of potential link and station characteristics and in the analysis of network and corridor alternatives are reviewed. It is concluded that such analyses of neighborhood and environmental factors should be coordinated with other demand-and-supply-oriented, sketch-planning methodologies.

In the last 10 years, transportation planners have been introduced to a variety of new and proposed transportation technologies. Many of these technologies represent generic modes of travel for which there is no previous operational experience. Personal rapid transit and automated dual-mode transit are two examples of new transportation modes that, when viewed from the perspective of the traveler, offer performance characteristics that are significantly different from the more traditional, urban transportation modes. New planning methodologies and techniques are required to effectively analyze and determine the most appropriate role for a new transit technology within an existing mix of multimodal, urban transportation services. For simplicity, those new transit technologies that require some form of fixed facility or guideway are generally categorized as automated-guideway transit (AGT).

The Urban Transportation Planning System (UTPS) package of computer programs can represent the physical extent and operational characteristics of current and new transit technologies, for purposes of multimodal transportation-system, demand-and-supply analysis (13). The UTPS package can also be used for sketch-planning analysis—a procedure that can be used to rapidly iterate through alternative multimodal transportation systems and delineate feasible combinations of modes and service philosophies for more detailed, implementation-oriented studies. Sketch-planning has received increasing emphasis in urban travel-demand forecasting (1, 4, 11, 12), because it provides the following advances over the traditional urban-transportation planning process:

1. The ability to examine a much wider range and number of alternative systems to screen out concepts that can be shown to be less workable and delineate other designs for further, more detailed analysis;
2. The ability to analyze these alternatives relatively quickly and at low cost;
3. A selective focusing on major consequences and performance characteristics; and
4. The ability to perform parametric analyses that examine changes in these consequences because of variations in other system characteristics.

Sketch-planning programs are particularly useful at the system-planning level and may also be useful at more detailed levels, such as corridor planning (3, 9). They can be used in the planning and evaluation of both highway and transit systems, on a multimodal basis, and include the consideration of alternative transit technologies.

Much effort has been devoted to the development of sketch-planning procedures for analyzing travel demand and the related system-performance characteristics, but it is also important to develop methods for analyzing other, more indirect impacts of transportation-system alternatives (6, 7, 8, 10, 14). All too often, indirect impacts are not considered at the stage of alternative-