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Automobile Diversion: A Strategy for Reducing Traffic in Sensitive Areas

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In recent years awareness of the negative impacts of motor-vehicle travel has increased. One approach to those impacts is automobile diversion, a strategy for reducing vehicle use in congested areas. This paper reports on a recent study directed toward developing and evaluating the potential for automobile diversion in Denver. General traffic problems are identified and a potential yardstick for locating affected areas—the environmental capacity of city streets approach—is discussed. Benefits and problems of notable U.S. background experience in automobile diversion are summarized. A detailed breakdown is given of the various transportation system management strategy-formation elements applicable to automobile diversion, and several implementation techniques are described. Advantages and disadvantages are also presented to demonstrate the use of automobile diversion as a community-improvement tool. Finally, the study determines that the potential for automobile diversion in Denver relies on the degree of citizen interest, the identification and resolution of issues and problems, and sound decision making in the political forum.

In the fall of 1975, the Urban Mass Transportation Administration (UMTA) and the Federal Highway Administration (FHWA) jointly issued urban transportation planning regulations directing appropriate local agencies to develop transportation system management (TSM) plans for their respective urban areas (1). TSM plans are intended to document local strategies for improving air quality, conserving energy, and improving transportation efficiency and mobility through management of existing transportation systems. TSM strategies deal with low-capital, short-range, or policy-oriented urban transportation improvements.

Although many TSM strategies have been implemented in the Denver transportation system, only recently has emphasis been placed on directly identifying and pursuing those strategies in an organized and coordinated manner. For instance, Denver now has computerized traffic control and operations, transit operations, carpooling, and various preference and restraint programs. These management concepts and control strategies, and their respective action elements, were developed and implemented only when the need became obvious.

Because of federal emphasis on TSM and the techniques already in use in Denver, the Denver Planning

Office (DPO) has developed and evaluated the potential of selected TSM strategies to complement midterm and long-term transportation development activities such as downtown pedestrian and bicycle facilities and automobile-diversion practices.

PURPOSE

The automobile-diversion strategy has been identified as one possible means of reducing vehicle use in congested areas (2) or in areas particularly sensitive to traffic impacts on land use and social conditions. This strategy limits the movement of traffic in sensitive land-use areas by diverting traffic around rather than through them. The purpose of this report is to evaluate the potential for automobile diversion as a TSM strategy in Denver.

APPROACH AND STUDY ORGANIZATION

First, land-use and traffic-related changes in Denver and the region are summarized and the general problems and impacts of traffic in sensitive areas are identified. The environmental-capacity philosophy of city streets is examined for appropriateness of application in Denver. Automobile-diversion objectives are formulated to provide a basis for further application and evaluation of the strategy.

A brief summary of U.S. experience with automobile diversion is presented and strategy elements, including a general description of implementation techniques, are discussed. The potential for automobile diversion in Denver is then evaluated by identifying its effectiveness and related advantages and disadvantages as a TSM strategy. Finally, conclusions and recommendations are presented.

PROBLEMS AND ISSUES

Growth

Since World War II, population growth in the Denver region, coupled with increased mobility provided by the automobile and an extensive road network, has resulted in an urban pattern characterized by relatively low-density development extending outward in all directions from the city center. By 1975, the region had a population of 1 500 000 and an employment base of 650 000. During the past 35 years population and employment have more than tripled, and the amount of urbanized land has increased more than sixfold. These figures indicate predominantly low-density peripheral sprawl.

Denver's rate of growth, however, has been much slower than that of the rest of the region. From 1940 to 1975, Denver's population less than doubled and its employment less than tripled. Thus, despite its absolute growth, Denver's share of the region's total population and employment has been decreasing since 1960, which suggests that the city's role in the region is changing from that of a well-balanced residential community to that of a maturing service core for the entire region (3).

The number of motor vehicles in Denver has also increased. From 1965 to 1975 the total increase in motor vehicles registered in Denver was 94 866, while the population increased by only 23 900. This fourfold increase in vehicles over population may be accounted for by greater economic affluence, increased numbers of driving-age individuals, and the transition of the city from a predominantly residential area to a core service area.

The growth of population, employment, and motor vehicles has resulted in increased travel activity in the region and therefore more demand on the highways and transit. For example, in the same 10 years from 1965 to 1975, average motor-vehicle traffic into and out of Denver every 24 hours increased more than 80 percent, from 586 320 to 1 062 540 each day, while Denver's population increased by only 5 percent. Because Denver is the crossroads of the state's two Interstate highways, I-25 and I-70, a substantial amount of the increase can be attributed to the ballooning volume of statewide commercial and recreational travel. Interstate traffic into and out of Denver has increased by about 220 percent.

Ever-increasing vehicle traffic in urban Denver has heavily loaded most major streets and highways, probably because they usually provide the quickest, most direct routes. But many existing streets are congested because of limited capacities, restricted expansion space in older areas, and limited improvement funds. Transit and carpooling can accommodate a small proportion of all metropolitan person trips, but many drivers avoid the congested streets and highways by seeking alternate routes, for example, by using residential streets as shortcuts. Heavy through traffic and occasional speeding vehicles on otherwise quiet streets have thus become increasingly annoying and disruptive to many good residential neighborhood environments.

In addition to the obvious transportation service provided by motor vehicles, there are direct and indirect problems and impacts associated with heavy through traffic. The universally recognized, direct, negative impacts of traffic are

1. Potential street-crossing hazards for pedestrians, especially children and the elderly;
2. Air, noise, and dirt pollution;
3. Vibration; and
4. Inconvenience in parking operations and in driveway entry and exit movements.

These direct problems and impacts within a neighborhood generate real or perceived indirect problems such as social or neighborhood barriers, declining property values relative to areas with light traffic, declining pride in the neighborhood, decreased home and yard maintenance, increased renter occupancy and resident transiency, and additional resident flight to the suburbs.

Environmental Capacity of City Streets

It is usually not an individual motor vehicle that offends residential sensitivity, but rather the cumulative effect of a quantity of vehicles. Thus, consideration must be given to the number of vehicles that may affect adjacent land uses. Some efforts have been made to determine environmental capacities of streets by analysis of field surveys and questionnaires, but results have varied.

A study conducted in Louisville, Kentucky, determined that the maximum daily number of vehicles that should be permitted along street types with various land uses ranges from 14 000 on four-lane (some two-lane), single-family residential streets to 15 000 on four-lane single- and multi-family residential streets to 35 700 on four-lane, commercial, recreational, and industrial streets. A recent study in London, England, set street capacity limits at about 12 000 vehicles for 24 h (4).

In contrast, a report on San Luis Obispo, California, found average daily residential area traffic volumes as high as 4000/day acceptable, while a comprehensive study in San Francisco recommended that traffic volumes should not exceed 2000 vehicles/day on streets where the adjacent land uses include families with children (5). This wide range of acceptability values is indicative of the individuality of various communities and the relative priorities they assign to land use or transportation when these considerations conflict.

If the environmental capacity of streets is to be considered as a factor in determining traffic management in sensitive Denver residential areas, impact studies and attitude surveys of local tolerance levels of traffic volumes will be necessary.

STRATEGY OBJECTIVES

Objectives central to defining TSM strategies and to developing effective methodologies may conflict with each other. The ultimate decision might then be based on satisfying disparate points of view among users, operators, and the general public.

Planning and developing an automobile-diversion strategy needs four general categories of factors: transportation factors, social factors, economic factors, and functional and physical factors (6). Within each are specific objectives:

1. Transportation factors:
   a. Reduce street congestion,
   b. Maintain accessibility,
   c. Improve transit services,
   d. Maintain service to goods movement,
   e. Maintain emergency service,
   f. Encourage shift to nonautomobile travel modes,
   g. Reduce accidents,
   h. Reduce energy consumption,
   i. Reduce parking requirements,
   j. Prevent excessive through traffic in neighborhoods, and
   k. Achieve the functional designation of the transportation system;
2. Social factors:
   a. Increase opportunities for community interaction,
   b. Improve perception of personal security,
   c. Increase use of public areas,
   d. Create perceptible improvements in the environment, and
   e. Stimulate community cohesion;
3. Economic factors:
   a. Encourage private investment,
   b. Stimulate market potential,
   c. Enhance tax base,
   d. Reduce street construction and maintenance costs,
   e. Minimize adverse economic impacts caused by urban traffic, and
   f. Maximize effectiveness of public transit investments; and
4. Functional and physical factors:
   a. Improve air, noise, and aesthetic qualities,
   b. Enhance pedestrian space,
   c. Improve the physical environment to strengthen and support the desired types and patterns of local land use,
   d. Provide separation of motor-vehicle and nonmotor-vehicle traffic movement,
   e. Restore human scale, and
   f. Complement urban land-use goals and objectives.

Beyond these general objectives, which are applicable to most automobile-diversion strategies, other objectives related to specific proposals must be identified by planning or implementing agencies. In addition, the degree to which automobile-diversion projects can fulfill these objectives is subject to factors such as cost, space, and demand.

EXPERIENCE IN THE UNITED STATES

To date, relatively few cities or towns have implemented automobile diversion to any great extent. The techniques most used have been cul-de-sacs, diagonal intersection barriers, and narrowings that prohibit or discourage through traffic. The majority of the cities involved in significant automobile-diversion programs are on the West Coast—Seattle, Portland, San Francisco, and Berkeley (7, 8). In the Midwest, a program has been developed for the community of Oak Park, a suburb of Chicago (9). Although the experience survey is not exhaustive, notable applications are highlighted.

In most instances, automobile-diversion techniques were applied in response to citizen concern about traffic in residential areas. Public works and planning agencies then developed diversion strategies and implementation programs to address the problems identified. In some of the cities, though, planners recognized the conflict between neighborhoods and traffic, held public meetings to discuss problems and possible solutions, and sought citizen support for implementation. Some of the projects began by providing landscaping and increased resident parking and later evolved into constructing traffic controls to prohibit through traffic.

Many cities installed traffic-diversion devices in older areas, in which the typical street pattern is a grid. As long as traffic volumes were low on residential streets, community concern was small or even nonexistent. But, as areas around the older locations developed and generated more traffic, the philosophy of changing street use from traffic to people gathered support. Thus the approach in areas that had grid-system streets was to change traffic-movement patterns to reflect the manner in which modern subdivisions were developed with curvilinear and nonthrough streets (5).

Some automobile-diversion projects have been provided at spot locations such as in Oak Park (9). The typical approach, however, has been to install traffic restrictions on a citywide or neighborhood basis as part of an overall improvement program. For example, San Francisco and Seattle have constructed diversion projects in those neighborhoods where community support was greatest and, in some instances, where current urban renewal or residential improvement programs were under way.

Experience in San Francisco was focused on neighborhood and district installations. Initial emphasis was on townscaping (landscaping and urban design treatments) that shared equal importance with traffic management. Further interest was demonstrated in discouraging heavy, fast, and through traffic, so more stringent controls at intersection necks, stars, and one-way entrances to two-way streets were installed (5). Subsequently, citizen outcry brought a ballot that resulted in traffic-diversion installation removal (10), although the townscaping efforts have in large part remained.

Experience with traffic diversion in Seattle neighborhoods has shown that, while the targeted streets experienced a reduction in accidents, no discernible changes in traffic volume or accidents have been seen on adjacent arterial streets. Emergency vehicles also did not encounter major inconveniences. Neighborhoods have developed stronger identities, and the environment has been enhanced in the areas of safety (primarily for children) and a general feeling of relative serenity (11).

The city of Berkeley, a university suburb of San Francisco, has a population of 110 000 and has moved toward an overall residential traffic-restraint program after an intensive citizen-participation process. There, traffic-restraint devices have been placed throughout the city. To guide their programs, Berkeley citizens set a rollback goal of 25 percent in total vehicle travel and put great emphasis on transit (12). It is a comprehensive strategy, but the overall consequences are not clearly known to most in the community. Some of the initial findings of Berkeley's program were the following (13):

1. Changes in traffic volumes have occurred generally as expected;
2. Traffic increases on arterial and collector streets have not caused serious increases in congestion;
3. Overall travel times along the city's designated circulation system have not changed significantly from pre-program conditions;
4. Traffic accidents and fatalities decreased over the period the traffic management project was in effect, although injury accidents were up slightly; and
5. There was considerable driver disobedience of all traffic-management device types.

Citizen reaction in Berkeley has been substantial. Groups were formed to protest the barricade installations. Twice the issue of removing or reducing the number of diverters went to the voters and was twice rejected. Concurrently, the protesters took action in Alameda County Superior Court that resulted in a ruling that the diverters must be removed. The Berkeley traffic-management installations are still in place pending an appeal (10).

Overall, citizen reaction has ranged from resident delight over having street traffic decreased to automobile drivers' anger about their street-use privileges being denied. Residents along streets experiencing increased traffic have also complained that traffic problems have not been resolved but only shifted to other locations. At the initiation of traffic-diversion programs, there has usually been an immediate public outcry that tapers off after six months of operation.

These experiences suggest that diversion projects should be installed on a low-cost, temporary basis to gauge community acceptance and interest. After a trial period and modifications, physical devices can then be permanently installed in an attractive manner (5).

These experiences also suggest that a comprehensive approach should be taken to planning and implementing automobile-diversion programs in specific areas. This means considering traffic improvements for those streets to which traffic is to be diverted, as well as developing programs to encourage increased use of transit, carpooling, and nonvehicle modes as part of overall area-improvement programs.

Automobile-diversion experience in Denver has been minimal. Several recent Denver neighborhood plans have recommended traffic diverters, but the background analyses were not substantial and citizen interest in implementation was weak. Those proposals have not been carried out.

The Ellis community organization in the Virginia Village area considered the closing of some streets to through traffic to reduce commercial traffic from Writer's Manor to the west (14, 15). The neighborhood was polled by the organization, but in general the residents seemed unwilling to support the effort. The end result was no change.

STRATEGY-FORMATION ELEMENTS

A traffic-diversion strategy is composed of various elements, from which application features can be identified and guidelines on how to address those features can be formed. These elements (16) are

1. Target population,
2. Travel-behavior effects,
3. Scale of application and zone of influence,
4. Strategy interrelationships,
5. Control degree and mechanism,
6. Institutional and legal factors,
7. Area selection, and
8. Public acceptance.

Target Population

The primary targets of diversion are automobile drivers. Secondary targets are truck drivers who travel on sensitive streets to bypass congested streets or to reduce travel time.

Travel-Behavior Effects

Fundamental traffic-management concepts specify intended effects on targets and the periods of time during which impacts can be expected to be felt after strategy programs have been started. The basic traffic and travel-behavior effects of automobile diversion programs are

1. Changes in traffic-flow operations,
2. Changes in choice of streets,
3. Changes in time of day of trips taken,
4. Changes in modes,
5. Changes in amount of traffic on the various routes, and
6. Changes in number of trips.

The primary travel-behavior impact of automobile diversion is generally on the choice of streets, because the actions imposed make target streets unattractive and alternate paths attractive. Secondary effects normally occur on travel flow, because trips may be made longer and on fewer routes. Concentration of travel demand requires increased use of alternate highways and major streets, which may cause congestion and slower travel times. These effects would be expected to last a short time and to dissipate as driver habits change.

Other travel behavior may be affected only marginally, unless the alternate traffic paths fail to meet demand. On the other hand, traffic redistribution by mode or time of day as part of a comprehensive approach to traffic management may result in secondary impacts on mode choice or even on the times at which people choose to travel.

Scale of Application and Zone of Influence

The spatial areas that can be affected, primarily or secondarily, by automobile-diversion applications include (a) spot (intersection), (b) facility (street, highway), (c) corridor (several parallel facilities), (d) subarea (central business district, activity center, neighborhood, preservation area, historic district, or park location), (e) urban area (city), and (f) region (urban area plus suburbs).

Applied at a spot location, diversion would require a change in path at a specific location. For instance, installation of diverters at a through-street location could change the traffic function to that of a local street. On a smaller scale, automobile-diversion techniques could maintain the function of a designated collector-street function and increase traffic volumes. A sub-area application would be possible for a neighborhood or residential area. Even an entire city may be a site for automobile diversion.

If automobile-diversion programs were applied to a Denver neighborhood, the primary zone of influence would be that area itself. The secondary zone of influence would be the urban area, or even the region if the target area were sensitive enough or the magnitude of vehicle diversion such that regional trips would be affected.

Strategy Interrelationships

Interrelationships between the automobile-diversion strategy and other strategies can be classified as synergistic, independent, overlapped, equivalent, or counterproductive.

If a major effort is made on a diversion project, combinations of several diversion strategies may produce a synergistic effect; i.e., their combined total effect may be greater than the sum of their separate effects. For example, drawing from the strategies cited in the joint FHWA-UMTA regulations (1), a synergistic effect might result from the combined application of (a) through-traffic restrictions in sensitive areas, (b) traffic-operations improvements to facilities designated for concentrated major traffic movement, (c) preferential treatment of high-occupancy vehicles, (d) pedestrian- and bicycle-facility improvements, and (e) transit-service improvements.

Induced TSM strategies that are equivalent to automobile diversion (at least in the intent to reduce vehicle use in congested areas) include encouragement of carpooling and other forms of ride sharing, automobile-restricted zones, and area parking surcharges. In Denver, automobile diversion without the use of induced strategies would in all likelihood be counterproductive to eliminating bottlenecks or reducing major street congestion, because more strain would be placed on those major facilities. Thus, induced disincentives would probably have to be offset by positive improvements.

Control Degree and Mechanism

The degree of control exercised in automobile diversion would be mandatory in the restrictions applied, but voluntary in the choice of alternate streets used by drivers. The mechanism of control for this strategy would be both physical and operational, i.e., through traffic restrictions such as physical barriers or simply sign control.

The following types of management techniques can be used to divert traffic to more appropriate streets or to control vehicle movement: diverters, semi-diverters, street closures, median barriers, traffic circles, "chokers" (street narrowing), traffic signals, stop signs, one-way exit streets, and cul-de-sacs (17). Figure 1 presents several conceptual examples of these techniques, and Figure 2 (18) illustrates a more detailed set with landscaping. Most cities experienced in automobile diversion began with a pilot program and temporary diverters. As problems were resolved and as the program became more acceptable and successful, permanent and attractively landscaped changes were made.

Further, these techniques can be applied to effect the strategy objectives for a given area. Figure 3 shows a street grid before and after that conversion to a protected area with curvilinear flows. Note that traffic is not completely prohibited, but rather redirected to the peripheral routes by diagonal diverters.

Finally, there are many additional measures that can and often must be taken to divert traffic and open up neighborhood space, while allowing emergency vehicles and local access. These include installation of new curbs, realignment of existing curbs, relocation of drainage inlets, adjustment of castings and manhole covers, sidewalk construction and reconstruction, street lighting and signing, accommodation for emergency vehicle crossings, additional fire hydrants, and other nontraffic improvements such as special lighting, landscaping, street furniture, and other urban design treatments.

Institutional and Legal Factors

The primary issue of the automobile-diversion strategy is that the basic decision to implement a specific program is a government one and that the decision makers must consider the concerns of automobile-oriented interests.

Because automobile diversion represents a restraint to through traffic, it results in regulation and restriction of the flow of vehicle traffic. The needs of a sensitive area are thereby elevated to a more prominent position with respect to the dominant automobile. This realignment of planning objectives is certain to result in substantial concern by firmly established automobile-oriented interests in a community, city, and region.

To be successful, the approach to diversion must involve different government agencies in planning and implementation, especially if a synergistic combination of positive TSM strategies is to be achieved. The ability of these agencies to work together is essential to success, and agency cooperation is a function of the extent to which local leadership is willing to pursue innovative and controversial approaches to solving small-area problems. The agencies cover a broad spectrum of municipal affairs and their accepting that automobile diversion will achieve multiple objectives will be determined by how the strategy will affect their own areas of concern.

Legal factors can also be of primary importance in implementing automobile-diversion programs. Legal questions can arise as to the ordinances needed to change the control of streets, e.g., improperly installing stop signs to slow down traffic in an area rather than to stop vehicles purely for an intersection safety problem. If time restraints are installed in a designated area, they also may result in legal action. Finally, changes in traffic control would necessitate enforcement to maintain safety and orderly movement.

Area Selection

Various factors could be considered in selecting an area for a traffic-diversion application. Generally, the choice of area is based on the following criteria: amount of citizen interest, significance of the area's problems, feasibility of the methods to be applied, existence of an on-going neighborhood organization to support the concept, and land uses compatible with access limitations.

Based on other cities' experiences, it would also seem important to select an area, noted for its stability, low-density character, relatively high percentage of children, and transitional nature, that could benefit from a decrease in traffic or better traffic control.

Public Acceptance

The private sector would certainly be a key factor in automobile-diversion success. Like any major urban policy change, planning for this strategy must be conducted with full public participation. Public support and participation will be the most decisive factor in the realization of maximum benefits.

Experience in Berkeley has shown that, because of the very visual nature and potential broad-scale effects of diversions, support of the majority of the public is necessary (5). Large-scale automobile-diversion efforts will not succeed if promoted by a minority or a special-interest group with a single objective.

If government agencies follow a course of action that is negative in nature (restricting traffic), this could alienate most of the interests involved. Positive actions, such as providing incentives to use other paths or modes, must be taken as part of a comprehensive small-area revitalization process founded on strategy goals and objectives.

Figure 1. Types of suggested automobile-diversion techniques.

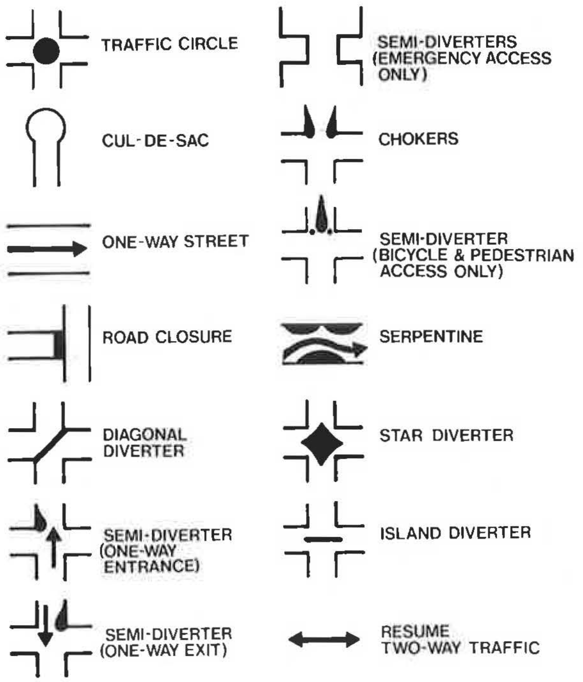
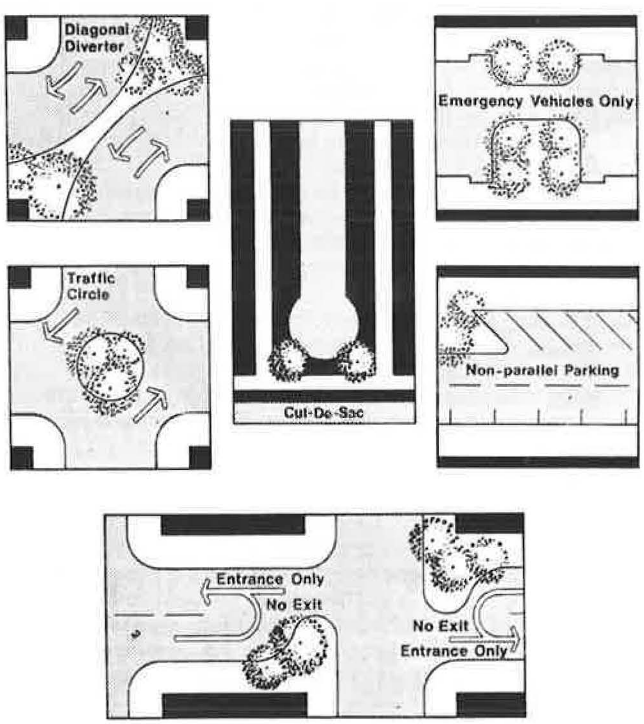


Figure 2. Details of some automobile-diversion techniques.



EVALUATION

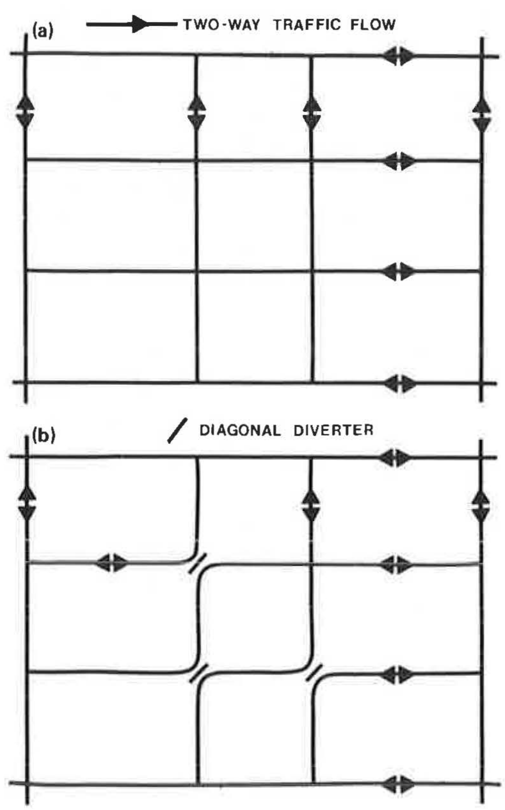
TSM Strategy Effectiveness

It is difficult to judge automobile-diversion strategy effectiveness specifically. Before-and-after studies of a specific case would have to be conducted to determine automobile occupancy, delay, volume, and accident changes and to measure economic, social, and environmental changes. Automobile diversion may require increased efficiency on the major routes to which the traffic might be diverted and would influence more travelers to use transit.

Advantages and Disadvantages

The various major advantages and disadvantages of automobile-diversion programs are described below (5, 11).

Figure 3. Automobile-diversion application.



Advantages

1. Improvement of a small area could be an incentive for middle-class families with children to move back into the area.
2. Diversion can help keep the occasional high-speed vehicle from using primarily residential, local streets as thoroughfares.
3. Selective street closures and the use of cul-de-sacs can provide additional green space, play areas, pedestrian malls, or parking areas for residents or businesses.
4. Closing streets or diverting vehicle traffic may foster a stronger sense of neighborhood or community identity.
5. Crime may be reduced because of increased neighborhood use and surveillance of residential streets and lack of easy vehicle access and escape.
6. Within an affected area, traffic diversion may reduce noise and air pollution, vibration, and perceived or physical crossing of barriers and may make the streets safer for children and other pedestrians.
7. Controlling traffic can act as a catalyst that spurs neighborhood revitalization.
8. Improvements in the public streetscape could provide impetus for rehabilitation of private property.
9. Selective street closures, cul-de-sacs, and traffic-direction controls at local and arterial street intersections can reduce access conflicts and thereby improve traffic flow and safety on arterial streets.

Disadvantages

1. Residents on streets in the vicinity of vehicle diverters may experience higher levels of traffic volume and associated environmental and safety impacts.
2. Diversion may give children or other residents a false sense of safety from motor vehicles.
3. Some cities have found that cul-de-sacs may heighten racial segregation: Closed-off, tightly knit streets may discourage minority families from moving in.
4. Traffic diverted from residential streets may exceed the capacity of adjacent arterial and collector streets and require their upgrading or improvement.
5. Automobile-diversion installations (barriers, signs, islands, and pavement markings) would require additional maintenance by city agencies.
6. Additional right-of-way acquisitions may be necessary for both the target and alternative streets; for instance, diagonal diverters and cul-de-sac construction could be restrained by insufficient existing right-of-way.
7. Diversion may result in access problems and inconvenience for residents and visitors on the affected streets and in the vicinity of the diverters.
8. Access for police, fire, and other emergency vehicles may be hampered and response times may be increased unless adequate provisions are made to ensure access for such vehicles.
9. Application of traffic restrictions without positive and compatible strategies may result in negative reactions from agencies and the public.
10. Traffic may not be eliminated but rather only redistributed.
11. Not all residential streets can have heavy traffic removed by traffic diversion; where traffic impacts on residential streets cannot be reduced through street or transit improvements, those impacts should be offset by public trade-offs such as street landscaping and noise buffers.

CONCLUSIONS AND RECOMMENDATIONS

This study of automobile diversion led to the following conclusions and recommendations pertaining to potential planning and implementation in Denver.

Conclusions

1. Denver's role in the region is changing from that of a well-balanced residential community to that of a maturing service core for the entire region. As the region grows, Denver will experience traffic increases that will affect sensitive areas.
2. Motor-vehicle traffic has direct negative effects on crossing hazards; on air, noise, and dirt pollution; on vibration; and on parking-operation inconvenience.
3. Environmental street-capacity studies have been conducted in various cities; results have varied. To establish the environmental capacity of any one particular area, impact studies and attitude surveys would have to be conducted to determine tolerance to traffic volumes.
4. Several cities, most of them on the West Coast, have applied automobile-diversion techniques with varying degrees of success.
5. Citizens in an affected area may place more value on traffic control and access than on traffic impediments.
6. Automobile diversion can induce more efficient use of major streets around affected areas.
7. The installation of traffic-management devices can modify established neighborhood traffic patterns so that they resemble the curvilinear and non-through-street patterns of modern subdivisions.
8. An automobile-diversion program in a specific area should be part of an overall improvement effort that is approached in a comprehensive and positive manner and should include other compatible TSM strategies such as increased transit, carpooling, and nonvehicle modes.
9. Automobile-diversion techniques can be used to achieve functional designations. For instance, traffic diverters installed at a spot location can change a through-street traffic function to that of a local street or can maintain the designated function of a collector street and prevent arterial-street function and increased traffic volumes.
10. Substantial public support is necessary if an automobile diversion program is to be successful.
11. Improperly installed diversion devices may increase safety hazards, e.g., a diagonal diverter that does not allow the proper sight distance for the posted speed limit may cause accidents.
12. Limited right-of-way in the established portions of the city may prevent some automobile-diversion installations, unless the expected benefits justify property acquisition.
13. Application of automobile diversion in Denver has potential, but implementation at any scale must result from full identification of the problems and issues involved, sound technical and policy analysis of all available alternatives and impacts, and substantial support from all parties interested in the effort.

Recommendations

1. If major public interest is expressed in automobile diversion, the city should prepare and distribute newsletters that explain negative aspects of local traffic, identify the potential benefits of diversion, and suggest a process by which to initiate projects.
2. Further considerations should be given to mea-

suring traffic impacts on residential streets in Denver, possibly by use of environmental capacity studies, involving traffic, noise, safety, and attitude surveys.

3. The automobile-diversion strategy goals, objectives, and techniques contained in this report should be applicable to a specific area in Denver, if potential benefits that outweigh potential detriments can be determined and if support is evidenced by all involved interests and decision-making groups.

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Development and Application of a Freeway Priority-Lane Model

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This report describes the status of freeway priority lanes in the United States, the development of a freeway priority-lane simulation model (FREQ6PL), and the application of the model to a real-life situation. Of the five feasible types of priority lanes, normal-flow exclusive lanes that reserve one or more lanes for priority vehicles are the most prevalent. FREQ6PL can simulate one or more lanes used exclusively by priority vehicles (buses only or vehicles of either three or more or two or more occupants). Three points in time are simulated: the before situation (no exclusive lane), the short-term after situation (the first day of operations with no traveler demand responses), and the longer-term after situation (3-6 months later, after spatial and modal shifts). Performance is measured by an integrated measure of effectiveness that includes costs of travel time, fuel consumption, and vehicle emissions and facility operating and maintenance costs. The model was applied to the Santa Monica Freeway in two parts: (a) to the priority cut-off limit, number of reserved lanes, and length of the exclusive lane and (b) to different parallel arterial speeds, different levels of arterial spare capacity, and different hypothetical mode shifts. It was concluded that reserving an existing or added freeway lane on such a freeway will at best make its performance as good as before and at worst significantly poorer in both the short- and longer-term situations.

In recent years the emphasis in transportation planning has shifted from long-term, capital-intensive, capacity-