NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
SYNTHESIS OF HIGHWAY PRACTICE

93

COORDINATION OF TRANSPORTATION SYSTEM MANAGEMENT AND LAND USE MANAGEMENT

TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL

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TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL
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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

In recognition of these needs, the highway administrators of the American Association of State Highway and Transportation Officials initiated in 1962 an objective national highway research program employing modern scientific techniques. This program is supported on a continuing basis by funds from participating member states of the Association and it receives the full cooperation and support of the Federal Highway Administration, United States Department of Transportation.

The Transportation Research Board of the National Research Council was requested by the Association to administer the research program because of the Board's recognized objectivity and understanding of modern research practices. The Board is uniquely suited for this purpose as: it maintains an extensive committee structure from which authorities on any highway transportation subject may be drawn; it possesses avenues of communications and cooperation with federal, state, and local governmental agencies, universities, and industry; its relationship to its parent organization, the National Academy of Sciences, a private, nonprofit institution, is an insurance of objectivity; it maintains a full-time research correlation staff of specialists in highway transportation matters to bring the findings of research directly to those who are in a position to use them.

The program is developed on the basis of research needs identified by chief administrators of the highway and transportation departments and by committees of AASHTO. Each year, specific areas of research needs to be included in the program are proposed to the Academy and the Board by the American Association of State Highway and Transportation Officials. Research projects to fulfill these needs are defined by the Board, and qualified research agencies are selected from those that have submitted proposals. Administration and surveillance of research contracts are the responsibilities of the Academy and its Transportation Research Board.

The needs for highway research are many, and the National Cooperative Highway Research Program can make significant contributions to the solution of highway transportation problems of mutual concern to many responsible groups. The program, however, is intended to complement rather than to substitute for or duplicate other highway research programs.

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The members of the technical committee selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and, while they have been accepted as appropriate by the technical committee, they are not necessarily those of the Transportation Research Board, the National Research Council, the National Academy of Sciences, or the program sponsors.

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The Transportation Research Board evolved from the 54-year-old Highway Research Board. The TRB incorporates all former HRB activities and also performs additional functions under a broader scope involving all modes of transportation and the interactions of transportation with society.

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PREFACE

A vast storehouse of information exists on nearly every subject of concern to highway administrators and engineers. Much of this information has resulted from both research and the successful application of solutions to the problems faced by practitioners in their daily work. Because previously there has been no systematic means for compiling such useful information and making it available to the entire highway community, the American Association of State Highway and Transportation Officials has, through the mechanism of the National Cooperative Highway Research Program, authorized the Transportation Research Board to undertake a continuing project to search out and synthesize useful knowledge from all available sources and to prepare documented reports on current practices in the subject areas of concern.

This synthesis series reports on various practices, making specific recommendations where appropriate but without the detailed directions usually found in handbooks or design manuals. Nonetheless, these documents can serve similar purposes, for each is a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems. The extent to which these reports are useful will be tempered by the user's knowledge and experience in the particular problem area.

FOREWORD

By Staff
Transportation
Research Board

This synthesis will be of particular interest to transportation planners, administrators, traffic engineers, and others concerned with the relationship between transportation facilities and land use. The interaction of transportation systems management and land use management techniques is analyzed for various environments and applications.

Administrators, engineers, and researchers are continually faced with highway problems on which much information exists, either in the form of reports or in terms of undocumented experience and practice. Unfortunately, this information often is scattered and unevaluated, and, as a consequence, in seeking solutions, full information on what has been learned about a problem frequently is not assembled. Costly research findings may go unused, valuable experience may be overlooked, and full consideration may not be given to available practices for solving or alleviating the problem. In an effort to correct this situation, a continuing NCHRP project, carried out by the Transportation Research Board as the research agency, has the objective of reporting on common highway problems and synthesizing available information. The synthesis reports from this endeavor constitute an NCHRP publication series in which various forms of relevant informa-

tion are assembled into single, concise documents pertaining to specific highway problems or sets of closely related problems.

Because increased emphasis is being placed on more efficient use of existing transportation facilities, it is important to understand how the interaction of land use management techniques and transportation system management can be used to achieve desired development and transportation objectives. This report of the Transportation Research Board contains a review of the application of currently used techniques in various operating environments and includes a discussion of research needs.

To develop this synthesis in a comprehensive manner and to ensure inclusion of significant knowledge, the Board analyzed available information assembled from numerous sources, including a large number of state highway and transportation departments. A topic panel of experts in the subject area was established to guide the researcher in organizing and evaluating the collected data, and to review the final synthesis report.

This synthesis is an immediately useful document that records practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As the processes of advancement continue, new knowledge can be expected to be added to that now at hand.

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Coordination of Transportation System Management and Land Use Management

SUMMARY

The coordination of transportation system management (TSM) and land use management (LUM) can take place in individual projects, for an area or along a route, or at the program level where continuous efforts are made to assure compatibility in the relationships between transportation and land use. Much coordination takes place in communities with comprehensive planning programs where land use and streets are planned to complement one another and zoning and other regulations are designed to implement plans and protect transportation. However, there is little documentation of this coordination or of the coordination at the area or route levels.

It has long been recognized that there are strong relationships between transportation and land use. The coordination of transportation and land use is a primary objective of comprehensive planning; many zoning controls and land use regulations are designed to match land use to transportation or to serve transportation objectives. The decline in financial resources available for transportation and the increased emphasis on the management of existing facilities have increased the need to avoid conflicts between traffic and land use.

The type and number of actions that might be taken to meet the objectives of TSM or LUM are limited only by imagination and by the nature of the problem to be resolved. The actions fall into four categories: (a) control/develop land, (b) control access to transportation, (c) control physical features of transportation, and (d) control or influence transportation system use.

Possible applications for coordination of TSM and LUM, with specific examples of current practice where available, for each of nine operating environments (major employment sites, major activity centers, outlying commercial centers, neighborhoods, central business districts, regions, arterial corridors, freeway corridors, and modal transfer points) are discussed in this synthesis.

The advantages of coordinating TSM and LUM have been recognized for years; many of the concepts and principles built into zoning and subdivision regulations are based on this recognition, although the concepts and principles are not always applied. One of the major factors standing in the way of coordination is lack of understanding of the economic benefits, particularly in developed areas. Another factor is the separation of funds used for transportation and land development. To overcome these obstacles, research is needed to demonstrate the importance and value of the benefits of coordination. In addition, funding mechanisms are needed for equitable distribution of costs in relation to benefits.

CHAPTER ONE

INTRODUCTION

PURPOSE OF SYNTHESIS

This report presents the results of a survey of current practice in the coordination of transportation system management (TSM) and land use management (LUM).

In undertaking this study, emphasis was placed on the "state-of-the-art" in the coordination of transportation and land use actions at the level of "operating environments." For purposes of this synthesis, TSM is defined not as the individual projects and actions being undertaken, but rather the work of planning and coordinating such actions for areas or corridors that constitute "operating environments." Although this definition may appear to overlook the solid experience and research that has been accomplished at the project level, it does focus on the area- or corridor-wide approach, which must be pursued if the objectives that have generated TSM and LUM are to be achieved.

Because there are few significant examples of the *formal* coordination of TSM and LUM, the examples discussed here are drawn from a wider area, including standard, or at least desirable, area and comprehensive planning practice.

To gather information for this report, a review of the relevant literature was supplemented with interviews of personnel involved in coordination of the two types of management and with visits to a small number of selected sites. Although the identification, classification, and analysis of TSM activities has been well documented in previous literature, there are few studies dealing with TSM-related land use actions and the coordination of TSM and LUM.

This synthesis will be useful in several ways. It will help to identify the research needed to generate improvements in TSM programs and practices, and to focus greater attention on the value of coordinating TSM and LUM. It is hoped that this study will encourage those involved in TSM and LUM to proceed toward greater coordination in the conduct of their programs. Generally, this will involve more coordinated planning on a corridor or "operating environment" basis.

THE CONTEXT FOR COORDINATION OF TSM AND LUM

The coordination of TSM and LUM can take place at several levels: (a) in individual projects, where mutually reinforcing land use, traffic engineering, or similar changes are made; (b) in an area or along a route where a number of complementary actions are planned, possibly to be implemented over time; and (c) at the program level, where continuing, deliberate, and consistent efforts to obtain coordination are made to assure compatibility between transportation and land use. These levels are depicted in Figure 1.

A distinction should be made between those TSM and LUM actions that are "generic" in the sense that they are considered to be ongoing, normal activities of local government (for the most part), and those that are undertaken as a formal response to federal requirements. In the generic sense, there is a substantial amount of coordination of TSM and LUM, particularly in communities with substantial and advanced comprehensive planning programs and where substantial new development is under way. Land use and streets are planned to complement one another, and zoning subdivision and other regulations and capital improvement programs are designed to implement plans, and to protect transportation facilities from unwise land use planning and land use from unwise transportation planning. Much of this coordination takes place in the form of negotiation in the land planning and development process, at the time zoning approvals are requested. Some coordination occurs in areas undergoing public redevelopment, where standards are imposed on the design of streets and the reuse of land as part of the redevelopment process. However, this coordination is not generally formally recorded, and there is little documentation of results.

Although there are many examples of coordination at the project level, there are relatively few examples of efforts to achieve coordination at the *area* (or *route*) or *program* levels, including those programs carried out pursuant to federal mandates. Although coordination at the project level is commendable and is ultimately the way in which improvements must be achieved, action on a project-by-project basis does not constitute *management* in the sense of organizing and mobilizing resources to achieve predetermined ends. The needs that have generated the concept of TSM require more than a project-by-project approach; they call for the concerted application of many individual and often small actions to achieve overall transportation objectives. Planning and *management* over time and space are the essence of

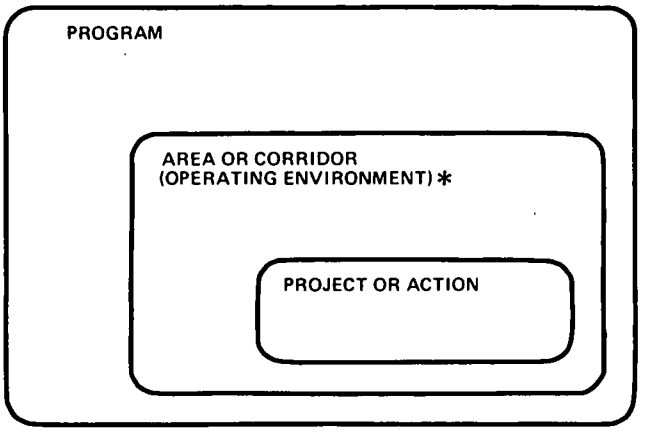

FIGURE 1 Levels of TSM-LUM coordination.

TSM and the aspects that need emphasis in the conduct of research.

Operating Environments

Roark (*1*) developed a useful framework for the study of TSM activities above the project level, which identifies "operating environments" in which both TSM and LUM planning should (and to some extent does) occur. These environments are the equivalent of "areas" (or "routes") that are usually associated with transportation or land use planning. They provide a context in which to identify objectives that are reasonably consistent and in which sets of complementary actions can be pursued. Planning and implementation often can proceed independently in these environments and can produce useful results. The operating environments include (*1*):

1. *Major employment sites.* Centers of employee concentrations outside the central business district (CBD), including industrial, research, and office locations.
2. *Major activity centers.* Locations of large public and/or private institutions or facilities outside the CBD, including universities, hospitals, sports stadiums, etc.
3. *Outlying commercial centers.* Concentrated retail merchandising locations outside the CBD (e.g., shopping centers).
4. *Neighborhoods.* Identifiable areas of residential development with which residents have a feeling of identity.
5. *Central business districts.* CBD's of central cities or outlying communities (however, most suburban business areas are activity centers).
6. *Regional environments.* Areas for which a metropolitan planning organization or other regional planning entity has been or might be designated.
7. *Arterial corridors.* Areas generating the "watershed of trips" using either a primary or minor arterial highway.
8. *Freeway (limited access) corridors.* Areas generating the "watershed of trips" using a limited access freeway or highway.
9. *Modal transfer points.* Facilities for mode changes in the urban transportation network, including transportation terminals and park-and-ride lots.

In addition to providing a focus for research and analysis, such areas or environments are frequently subjected to comprehensive planning or planning that may involve several related subjects. Often, these environments are the basis upon which citizen, business, or property-owner interests function, and they sometimes provide a funding base. Thus these areas serve as a logical and internally consistent basis for planning and implementing many types of TSM and land use actions.

Land use solutions to the transportation problems of several of these environments, especially items 1, 2, 3, 5, and 9 listed above, can be quite similar: they can include efforts to combine two or more functions into one area to permit more multipurpose trip-making, and they can be a stronger focus for transit operations, multipurpose parking, and other transportation efficiencies. As Roark (*1*) observed, many TSM actions also are likely to apply equally as well to several of these environments. In addition, many actions, such as the provision of parking or the development of a transportation terminal, can be characterized as being both "land use" and "transportation." Thus there can be substantial overlap in the actions taken in these areas in terms of land use and transportation.

Need for Coordination of TSM and LUM

It has long been recognized that there is a strong relationship between transportation and land use. The nature of this relationship was the basis for the establishment of the "3-C" planning process that guided much of the work of planning and transportation agencies throughout the 1960's and early 1970's. It also has been the basis for efforts to guide the development of land around highway interchanges, to promote joint development along highways and transit lines, to create auto-restricted zones, to provide or withhold access to freeways, and to restrict traffic movement through neighborhoods. Almost all these efforts have been directed toward achieving both transportation and land use objectives.

At a more basic level, the coordination of transportation and land use is a primary objective of comprehensive planning, whether for a region, a city, a neighborhood, or a project. Moreover, many of the provisions of zoning and subdivision controls are designed to match land use to transportation capacities and to preserve the effectiveness and value of transportation investments. Most of the specific design requirements in such regulations are closely related in scale to the types of improvements and actions categorized as TSM. The regulation of lot size, restrictions on access, and off-street parking and building setback requirements are all designed to serve transportation objectives. The effective administration of the traditional tools of land use planning is a virtual prerequisite to the development and maintenance of a viable transportation system. Thus, whether or not LUM is included, there is a strong relationship between LUM and the objectives and activities of TSM.

With the decline in financial resources available for major new transportation systems and the increased emphasis on "management" of existing transportation facilities, prospects for the coordination of transportation and land use may be less obvious and may appear less important. However, the reverse may be the case. With relatively less money available for building new facilities, it will become increasingly important to avoid conflicts between traffic and land use that will negatively affect traffic safety and reduce capacity; land use actions will be required to help in reducing or avoiding transportation problems and in reducing transportation expenditures. With traffic volumes increasing on a fixed roadway system, it will be important to find ways to protect neighborhoods and other areas from the negative effects of traffic movement. With increased emphasis on redevelopment of existing property and infill of vacant land as a way to accommodate urban growth, incremental improvements to existing streets and transit become key elements in encouraging and supporting new investments, new jobs, and the improvement of amenities.

Every indication is that in the era ahead the need for coordination of transportation and land use will be greater—not less. The required economy and efficiency can be achieved

only if land use plans support and protect the investments in transportation, and only if such investments are fully sensitive to land use needs.

TSM and LUM Objectives

On the basis of past efforts to coordinate transportation and land use as well as on more recent experience, *objectives* (or causes of action) that are common to both areas can be identified. These objectives and actions are characteristic of those associated with many TSM programs, where, although land use objectives may be involved, they often are not expressed. General objectives are listed below. (Specific causes of action are listed in Table 1.)

Transportation

- Reduce costs, congestion, etc., overall, by certain modes and at certain times.
- Increase efficiency in terms of space, dollars, and energy.
- Increase safety.
- Increase capacity.
- Assure equity.

Land Use

- Reduce or avoid negative impacts of transportation, such as noise, air, visual, safety, land use disruption, and pedestrian-vehicular conflicts.
- Stimulate/attract investment/development by means of access, visibility, adequate site size, and amenity.
- Limit development costs by reducing parking needs or access needs.
- Attract customers/employees by reducing travel costs, providing access options, and ensuring amenities.

Many of the objectives listed above can be associated with any given situation. However, their importance may vary greatly, and they may appear to be in conflict. For example, there may be a need to attract customers or employees as well as to reduce congestion and travel. In some cases, the achievement of one objective (e.g., increased efficiency) may be met by achieving a second (e.g., controlling or limiting demand). The particular mix of objectives and their relative importance will (or should) determine the type of TSM or land use action to be taken. In most instances, actions will be aimed at achieving several objectives, for this may be the only way in which the action can be justified.

Because many (perhaps most) TSM actions are undertaken in response to perceived needs and are not an outgrowth of a formal planning process, objectives are seldom set forth so comprehensively. Usually one or a few objectives are stated as a rationale for action. Compelling transportation problems of safety and congestion or the need to reduce air pollution are usually prominent. However, a goal-oriented approach that includes the full range of concerns would likely generate a broader range of solutions and, perhaps, better coordination.

Types of TSM and LUM Actions

The range of actions (either LUM or TSM) appears to be limited only by imagination and by the nature of the problem to be resolved. Where the concept of TSM is well understood, a number of new TSM techniques and approaches are being generated. Roark (*1*), for example, has identified over 150 types of TSM actions. Where concerns about congestion, cost, safety, or other impacts of transportation are great, additional techniques are likely to be developed and applied. However, because LUM has not generally been closely related to TSM, the number of land use actions tied to TSM is small. Obviously, there is much room for innovation in this area.

The types of actions can be grouped under the following categories:

1. Control/develop land, including type, mix, intensity, and timing of use, as well as site standards and facilities.
2. Control access to transportation, including location, design, amount or frequency, and mode.
3. Control physical features of transportation, such as street geometrics, landscape, buffer treatment, lighting, signs, separation of modes, and terminals and parking.
4. Control/influence system use by providing or discouraging specific modes, segregating modes in space or time, spreading or focusing time of use, effecting behavior change (education, information), and improving coordination and control.

Examples of TSM and LUM actions in each category, which should be considered in the coordinated application of TSM and LUM, are identified in Table 1, along with the operating environments where such actions might be most appropriate or useful. Also indicated are the problems that tend to generate the actions indicated.

TABLE 1

POTENTIAL TSM AND LUM ACTIONS: OBJECTIVES AND OPERATING ENVIRONMENTS

Actions Employed	Where Actions Might be Appropriate: Employment Center	Activity Center	Commercial District	Neighborhood	CBD	Region	Arterial Corridor	Limited Access Corridor	Mode Change	Causes of Action
1. Control/Develop Land										Land-use
a. Type of Use	X	X	X	X	X	X	-	-	X	-- Need to meet air quality standards.
b. Promote Mixed Use	-	X	X	-	X	-	0	0	-	-- Costs of providing additional parking.
c. Intensity of Use	X	X	X	X	X	-	X	-	X	-- Conflicts between parking and land-use.
Examples:										-- Costs of parking to employees.
-- Restrict types of use to reduce conflicts with traffic or parking.	X	-	X	X	-	0	X	X	X	-- Noise and related traffic impacts.
-- Increase densities to promote transit usage.	X	X	-	-	X	0	-	-	X	-- Difficulty of attracting employees/customers because of congestion/costs/conflicts/safety.
-- Restrict densities to avoid congestion.	-	-	-	X		0	X	-	-	
-- Promote mixed uses to reduce travel need.	-	X	X	-	X	0	0	0	X	Transportation
-- Promote mixed use to make better use of parking and other access facilities.	-	X	-	0	X	0	0	0	X	-- Congestion of vehicular movement and access because of amounts of activity.
-- Require TSM actions as a precondition to development.	-	X	X	0	X	0	-	0	X	-- Conflicts between traffic and land-use activities (usually pedestrian)(1)
-- Require contribution to street/transit improvements as a precondition to development.	X	X	X	-	0	0	X	0	X	-- Conflicts between types of vehicular movement, e.g.: autos, trucks, transit, etc.(1)
d. Site Standards	X	X	X	X	X	0	X	-	X	
Examples:										Land-use
-- Require setbacks from streets or other transportation facilities.	X	X	X	X	X	0	X	-	X	-- To reduce frictions between traffic and land-use.
-- Control access locations.	X	X	X	X	X	0	X	-	X	-- To provide for and encourage pedestrian movement.
-- Require minimum site size.	X	X	X	X	-	0	X	0	X	
-- Require special types of access e.g.: transit, pedestrian, cycle.	-	X	-	X	X	0	-	0	X	

(1) Can also be a land-use objective.

Key to Table:

X = Very Important Potential Action
- = Significant or Some Potential
0 = Minor or No Potential

TABLE 1 (*continued*)

Actions Employed	Where Actions Might be Appropriate: Employment Center	Activity Center	Commercial District	Neighborhood	CBD	Region	Arterial Corridor	Limited Access Corridor	Mode Change	Causes of Action
e. Site Facilities	X	X	X	X	X	0	X	0	X	Transportation
Examples:										-- To assure parking/storage for types of vehicles used/ preferred for access or to selected users.(1)
-- Require/prohibit parking.	X	X	X	X	X	0	X	-	X	-- To discourage auto usage or storage.(1)
-- Control parking use/charges.	-	-	-	X	X	-	-	-	X	-- To reduce vehicular and pedestrian conflicts.(1)
-- Require off-street loading.	X	X	X	-	X	0	X	0	X	-- To minimize number of access points required to streets.
-- Control buffer landscaping/ features.	X	X	X	X	-	0	X	X	X	-- To control points of access to streets.
-- Control/limit signs.	X	X	X	-	X	0	X	-	X	
-- Require on-site transit/ cycling facilities.										
... Cycle storage.	-	X	-	-	X	0	0	0	X	
... Transit terminal/ loading.	-	X	X	-	-	0	-	0	NA	
-- Require pedestrian facilities.										
... Arcades/property crossings.	-	X	X	X	X	0	-	-	X	
... Skyways/pedestrian bridges.	0	-	-	0	X	0	-	0	X	
	-	-	-	X	-	0	X	-	-	
2. Control Access to Transportation										Land-use
a. Location	X	X	X	X	X	0	X	X	X	-- Assure adequate and equitable access to property.
b. Design	X	X	X	-	X	0	X	X	X	-- Match access with land-use need and parking and modes provided.
c. Amount	-	X	X	0	X	0	X	X	X	-- Meet air quality standards.
d. Mode	-	-	-	-	X	0	X	X	X	-- Minimize conflicts between traffic and on-site activity.
Examples:										
-- Provide vehicular access to arterials and freeways at selected locations or intervals.	X	X	X	X	X	0	X	X	X	Transportation
-- Design and build or rebuild access points to meet safety/capacity.	X	X	X	X	X	0	X	-	-	-- Assure efficient operation of transportation facilities.
-- Restrict amounts of access through signal timing, metering, etc.	X	X	X	-	X	0	X	X	X	-- Minimize potentials for accidents.
-- Restrict access by mode (truck, transit, auto).	-	-	-	-	X	0	X	X	X	-- Assure access to preferential modes.
-- Restrict access by time or level of usage and/or by mode.	-	-	-	-	X	0	X	X	-	

(1) Can also be a land-use objective.

Key to Table:

X = Very Important Potential Action
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TABLE 1 (*continued*)

Actions Employed	Where Actions Might be Appropriate: Employment Center	Activity Center	Commercial District	Neighborhood	CBD	Region	Arterial Corridor	Limited Access Corridor	Mode Change	Causes of Action
3. Physical Improvements										Land-use
a. Street Geometrics	X	X	X	X	X	0	X	X	X	-- Improve amenities/setting for land-use activities.
b. Landscape/Buffer	X	X	X	X	-	0	X	X	X	-- Improve pedestrian access/ environment.
c. Lighting/Signage	-	-	X	-	X	0	X	X	X	-- Improve parking.
d. Separation of Modes	-	-	-	0	-	0	X	X	X	-- Reduce traffic conflicts.
e. Terminals, Parking	X	X	X	0	X	0	-	X	X	-- Buffer traffic noise, conflicts.
Examples:										-- Revitalize older commercial or neighborhood area.
										-- Support infill or new development.
-- Throat widening, channelization, intersection improvements.	-	-	-	-	-	0	X	-	-	Transportation
-- Improved signal systems.	-	-	-	0	X	0	X	X	-	
-- Improved lighting.	-	-	-	0	-	0	X	X	-	-- Improve efficiency, speed, safety of traffic flow.
-- Transit, bikeway lane separation.	-	-	-	-	X	0	X	X	X	-- Reduce vehicular-pedestrian conflicts.
-- Sidewalk, pedestrian areas redesign.	-	X	X	X	X	0	-	0	X	-- Improve transit operations.
-- Crosswalk improvements.	-	X	X	X	X	0	X	0	X	-- Improve transit environment.
-- Pedestrian/cycle grade separation.	0	0	0	0	X	0	X	X	X	-- Provide better parking.
-- Street widening.	-	-	-	0	-	0	X	-	-	-- Provide for cycling.
-- Noise barriers, berms, and landscape improvements.	-	-	-	X	-	0	X	X	-	-- Reduce energy use.
-- Traffic diverters.	-	-	-	X	-	0	-	0	X	-- Create better street continuity.
-- Cul-de-sac closures of intersections.	-	-	-	X	-	0	X	0	-	
-- Bus stop, passenger pick-up areas.	X	X	X	X	X	0	X	-	X	
-- Remove/redesign curb parking.	-	-	-	-	X	0	X	0	-	
-- Close street(s).	-	-	-	X	X	0	0	0	-	
-- Open new street connection.	-	-	-	-	-	0	-	-	-	

Key to Table:

X = Very Important Potential Action
- = Significant or Some Potential
0 = Minor or No Potential

TABLE 1 (*continued*)

Actions Employed	Where Actions Might be Appropriate: Employment Center	Activity Center	Commercial District	Neighborhood	CBD	Region	Arterial Corridor	Limited Access Corridor	Mode Change	Causes of Action
4. Control/Influence System Use										Land-use
a. Provide/Discourage Specific Modes.	X	X	X	-	X	X	-	-	X	-- Provide employees with alternate modes of access.
b. Segregate Modes.	-	-	-	-	X	0	-	X	X	-- Reduce employee transportation costs.
c. Spread/Focus Time of Use.	X	X	-	0	X	X	-	-	0	-- Hold down costs of providing parking.
d. Promote/Market/Coordinate Services.	X	X	-	X	X	X	-	-	-	-- Increase area for employee housing.
e. Improve Coordination and Control	-	-	-	0	X	-	X	-	-	-- Increase intensity/amount of development.
Examples:										-- Decrease employee travel time.
-- Provide passes, subscription, or other fare systems.	X	X	X	-	X	X	-	-	X	-- Meet air quality standards.
-- Provide transit subsidies.	X	X	X	-	X	X	0	0	X	-- Improve environmental conditions.
-- Provide vanpool fleet.	X	X	-	-	-	X	0	0	0	Transportation
-- Conduct carpooling program.	X	X	-	X	X	X	0	0	0	-- Reduce vehicular traffic volumes.
-- Install/train "brokers," managers.	X	X	-	-	X	-	-	0	-	-- Reduce levels of peak travel.
-- Provide specialized services for special markets/users.	X	X	X	-	X	X	-	-	0	-- Expedite transit/HOV movement.
-- Meter access to freeways.	0	0	0	0	0	X	-	X	-	-- Assure parking availability where needed.(1)
-- Restrict access to activity areas.	-	X	-	0	X	-	0	0	X	-- Discourage parking where not wanted.(1)
-- Differential tolls/parking rates by area, vehicle occupancy, or location.	X	X	X	-	X	X	-	X	X	
-- Provide HOV lanes/streets.	-	-	-	0	X	X	X	X	X	
-- Restrict street-parking use.	X	X	X	X	X	-	X	0	X	
-- Provide differential parking rates.	X	X	X	X	X	-	X	0	X	
-- Improve management/enforcement with personnel or equipment.	X	X	X	X	X	X	X	X	0	

(1) Can also be a land-use objective.

Key to Table:

X = Very Important Potential
- = Significant or Some Potential
0 = Minor or No Potential

CHAPTER TWO

ENVIRONMENTS AND APPLICATIONS

Current practice in TSM and LUM for each of the operating environments listed in Chapter 1 is reviewed in this chapter. Because a detailed discussion of TSM actions in these operating environments is provided in *NCHRP Synthesis of Highway Practice 81* (*1*), discussion of TSM is limited in this report. However, trends are indicated and land use and TSM actions in response to emerging problems are noted.

MAJOR EMPLOYMENT SITES

Major concentrations of office, industrial, research, or similar employment centers outside of CBD's are increasingly the focus of traffic and parking problems. Where areas consist of or are dominated by one major employer, planning to solve these problems frequently proceeds with little public policy involvement. Often the planning simply involves efforts to provide additional parking space, obtain better access to highways, or install traffic controls. Increasingly, van- and car-pool programs and various forms of "flextime" are also being included. Although there is little documented evidence of related or complementary land use actions, the "mixed-use" concept is being applied in some areas to provide greater convenience to employees and visitors through reducing the need for trip making. This concept also permits more efficient use of parking and access facilities by extending the number of hours in the day during which activities take place.

The most common land use actions (usually zoning) involve regulating the type and density of land use to provide a balance between transportation system capabilities and traffic generation. Good site planning with respect to streets is widely practiced (enforced), as are landscaping, sign control, and other measures designed to prevent conflicts with traffic movement.

One relatively new approach being applied in Portland, Oregon, is coordination of the development in several industrial areas and the establishment of a transportation center, with related transit service improvements (*3*). A major part of the rationale for the improvement of transit services is the limited accessibility of the specific industrial areas involved (i.e., island locations). Plans have been developed for the establishment of the center and for the improvement of services. However, no complementary land use actions have apparently been proposed, although it is presumed that the provision of good transit service would allow some relaxation of parking or other automobile oriented site requirements in the employment centers.

Increasingly, developers are being required to contribute to improvements in transportation facilities to meet the needs they are generating, and a growing number of employers are involved in sponsoring or cooperating in various forms of ride-sharing programs. However, again there is no evidence that land use actions are being planned in conjunction with or as a part of TSM actions in relation to employment centers or that the impacts of such actions on transportation are well understood.

MAJOR ACTIVITY CENTERS

Institutional, recreational, and entertainment areas are becoming more intensely developed, congestion is growing, and development and transportation problems in such areas are becoming more complex. In general, these areas tend to be more densely developed and have more restricted sites than many employment centers, and often attract users who have limited resources, such as students, handicapped persons, etc. In a few instances, the efforts being directed toward resolving these problems include TSM actions. Where joint transportation and land use planning is involved, there may be coordination of land use and transportation improvements. Most documented work focuses on TSM actions, with little or no mention of land use elements. However, many of the TSM actions are designed to help resolve land use problems, even where no land use action is involved.

One notable example is the San Francisco Joint Institutional Transportation Systems Management Program, which provided training and technical assistance to 14 employers (13 institutional) outside of the central area with respect to transportation "brokerage" or management (*2*). One impetus for this program was the desire to reduce conflicts between traffic and land use (principally neighborhoods). Although the program has been well received, no evidence is available regarding the impact on land use. However, based on the continuation of the activities by the institutions, which are utilizing their own resources, it can be assumed that the program has been beneficial.

Another example of coordinated TSM and LUM planning is provided by the Anaheim (California) Commercial/Recreation Area, which is a multipurpose area of approximately 10,000 acres containing Disneyland, the Anaheim Stadium, and a number of related traffic generators. A wide variety of TSM actions has been recommended to help meet present as well as projected transportation needs in this area (*4*). In addition, a number of major land development changes have been proposed and will obviously be served by the transportation actions, but it is not clear that any land use actions have been recommended specifically to help resolve transportation problems. However, the coordinated planning of land use and TSM in this area should produce beneficial results for transportation as well as for land use through the achievement of more effective use of various traffic routes and parking facilities.

Other examples involve individual hospitals, universities, stadiums, etc. For example, to resolve the problems of a limited site space and neighborhood conflicts, the Evanston

(Illinois) Hospital runs a shuttle bus to a remote parking facility connected with Northwestern University's Dyche Stadium, thereby making better use of stadium parking space while resolving its own parking problems. To reduce trip making by doctors, many hospitals have built medical office buildings adjacent to their facilities. At Baylor Hospital in Dallas, hotel, retail, and related services have been included to create a relatively self-contained, mixed-use area. Many examples of such planning exist, but they are not documented and may or may not be a part of a formal TSM program. If the results of such efforts are to be known and evaluated, substantial additional research will be required.

A more deliberate effort to coordinate transportation and land use is the plan for the Clackamas (suburban Portland) Town Center area in Oregon (*5*), which encompasses a number of intensive land uses, including Kaiser Hospital, schools, a shopping center, and various commercial and housing development. Plans for the area call for office space to be increased to 3.9 million ft^2, retail space to be increased to 3.8 million ft^2, and employment to increase to 9,000. Dwelling units (6,300) also are proposed for the area in "special high-density" categories. In addition to attempts to produce a mix and a balance of land uses, transit, pedestrian, and bicycle circulation facilities are included as central elements of transportation. An exclusive bus roadway will be provided to expedite transit movement. All transportation elements are integrated with each other and with land use to encourage maximum efficiency and safety of movement.

The development of such plans for outlying activity centers is becoming more common, and the potential for creating (or improving) additional multi-functional activity centers is substantial. Forty-seven centers (including five major CBD's for comparison) in the four regions of Los Angeles, Houston, Minneapolis/St. Paul, and Denver are listed in Table 2. Many of these centers are oriented to shopping centers and could thus be classed as outlying commercial centers. The listing in Table 2 provides an indication of the potential for developing and improving activity centers. This potential has been explored by Schneider (*6*) and Stuart (*7*). However, additional work is needed to demonstrate the coordination of TSM and LUM in such areas and the advantages of such coordination.

OUTLYING COMMERCIAL CENTERS (SHOPPING CENTERS)

Most outlying shopping centers are under single ownership, which should simplify the application of TSM or land use measures compared to multiple-ownership facilities. In order to meet air-quality standards, TSM measures have been applied in many locations (*1*). However, there is less evidence of parallel and complementary land use actions.

Although not necessarily related to TSM programs, several land use actions that affect vehicular and pedestrian travel are currently being undertaken. These actions involve increasing the variety of land uses in shopping centers through the addition of office and community service facilities (i.e., turning commercial centers into activity centers). In some instances, hotels and housing are included. The intended result is a mix of functions that will reduce the need for automobile travel, make more efficient use of parking space, and provide a focus for cost-effective transit service. For example, it has been shown that up to 20 percent of the parking space at major shopping centers can usually be allocated to the support of office activities without affecting overall parking requirements (*unpublished data*, Barton-Aschman Associates, Inc.). Theatres, restaurants, and other facilities that generate off-peak demand for parking space also can be added with the same result. Research on shared parking is now being conducted under the sponsorship of the Urban Land Institute to determine more precisely the benefits to be obtained through mixed-use development (*unpublished data*, Barton-Aschman Associates, Inc.).

Many of these actions are private. However, public agencies are becoming increasingly involved through the relaxation and adjustment of land use controls and through cooperation in the development of public facilities. Also emerging in some shopping centers is the transportation center, which has land use as well as transportation functions. Such centers focus transit, paratransit, and even park-and-ride services on outlying commercial centers, thus increasing accessibility. At the same time, the location of such facilities in shopping centers helps to connect systems and provides transit service to a larger area, making transit more convenient for patrons.

NEIGHBORHOODS

Concerns over traffic conditions in neighborhoods have always evoked TSM-type actions, ranging from the installation of simple traffic diverters or controls to the provision of special bus services (*1, 8–18*). Land use actions to achieve transportation objectives are less common at the neighborhood level. In redeveloping or newly developing areas, land use actions can involve the careful layout of lots and local streets and the requirement of off-street parking, etc., to protect and improve the efficiency of arterial streets, transit routes, and other key transportation facilities.

In developed areas that are not subject to significant change, the number and range of possible land use actions are restricted. In most instances, such actions consist of small changes to reduce conflicts between traffic and land use, such as the reorientation of property access driveways or the provision of off-street parking and recreation areas in key locations in order to reduce competition for street space. When comprehensive neighborhood improvement programs are undertaken with resources that can be applied to making land use changes, significant improvements can be accomplished by making adjustments that reduce or eliminate conflicts with arterial street functions or that improve transit (see Figures 2 and 3). In other situations, improvements must be made more slowly.

No current, organized attempts to coordinate land use and TSM actions in neighborhoods were identified in this study (although a number may be under way). However, some of the principal findings from several studies are listed below.

- Residential parking permit programs generally are beneficial to the neighborhoods in which they are implemented, but have no discernible impact at the regional level. However, the long-term impacts of such programs need further study (*17*).

TABLE 2

SELECTED CHARACTERISTICS OF MAJOR ACTIVITY CENTERS IN FOUR REGIONS (7)

Activity Center, Region	Type	Employment (000) (1)	Daily Shoppers, Visitors (000) (2)	Daily Population (000)	Land Area (sq. mi.)	Population Density (000 persons/ sq. mi.)	Parking Spaces (000)	Gross Leasable Area, Retail (000 sq. ft.)
Los Angeles CBD	CBD	129	186	315	2.55	124	94.5	8,000
Houston CBD	CBD	118	226	344	1.00	344	63.0	7,242
Minneapolis CBD	CBD	90	89	179	0.66	271	35.5	6,252
L.A. Airport	Airport	47	125	171				
Denver CBD	CBD	83	75	158	1.66	95	33.0	4,500 (est.)
St. Paul CBD	CBD	63	54	117	0.57	205	29.1	3,910
Wilshire	OBD	63	44 (est.)	107				
City Post Oak, Houston	MDC	34	64	98	0.78	126	26.0	2,035
Del Amo, Los Angeles	MDC	7	77	84	0.22	381	11.1	3,000
Texas Medical Center, Houston	MED	33	29	62	0.34	182	27.8	
University of Minnesota, Minneapolis	UNIV	6	55	61	0.80	76	15.0	
Lakewood Center, Los Angeles	RSC	5	51	56	0.26	215	12.5	2,300
Hollywood	OBD	12 (est.)	42 (est.)	54 (est.)			23.4	1,934
Century City, Los Angeles	MDC	25	25	50	0.28	146	21.3	895
Denver Airport	Airport	11	37	48	0.31	154	12.0	
Greenway Plaza, Houston	MDC	36	8	44	0.47	94	28.6	400
University of Houston/TSU, Houston	UNIV	2	40	42	0.81	52	15.5	
Westwood, Los Angeles	OBD	16	26 (est.)	42	0.12	350	7.7	1,200
Panorama City, Los Angeles	RSC	3	37	40	0.14	286	9.0	1,700
Minneapolis/ St. Paul Airport	Airport	16	24	40	0.26	154	10.9	
S. Coast Plaza, Los Angeles	RSC	3	36	39	0.32	122	8.5	1,625
Cinderella City, Denver	MDC	10	28	38	0.10	380	7.1	1,300
Long Beach CBD, Los Angeles	OBD	12	26 (est.)	38 (est.)	0.77	141	10.0	1,200
UCLA, Los Angeles	UNIV	2	33	35				
Almeda Mall, Houston	RSC	3	32	35	0.20	175	6.1	1,470
Disneyland, Los Angeles	REC	2 (est.)	32	34	0.31	110	11.0	
Fashion Island, Los Angeles	MDC	9	25	34	0.12	283	11.7	1,150 (3)
Memorial City, Houston	RSC	3	29	32	0.23	139	5.7	1,340
Northridge, Los Angeles	RSC	3	28	31	0.11	282	6.7	1,281
USC, Los Angeles	UNIV	2	28	30				
Ridgedale, Minneapolis/ St. Paul	RSC	2	27	29	0.15	193	6.1	1,225
Puente Hills Mall, Los Angeles	RSC	2	26	28	0.15	187	6.5	1,200
Los Cerritos, Los Angeles	RSC	2	26	28	0.15	187	6.5	1,175

TABLE 2 (*continued*)

Activity Center, Region	Type	Employment (000) (1)	Daily Shoppers, Visitors (000) (2)	Daily Population (000)	Land Area (sq. mi.)	Population Density (000 persons/ sq. mi.)	Parking Spaces (000)	Gross Leasable Area, Retail (000 sq. ft.)
Southdale, Minneapolis/ St. Paul	MDC[4]	2	25	27	0.12	225	6.5	1,150
Sharpstown, Houston	RSC	2	25	27	0.16	169	6.3	1,130
Houston Airport	Airport	5	22	27	0.08	338	11.0	
Topanga Plaza, Los Angeles	RSC	2	24	26	0.16	162	6.3	1,088
Westminster Mall, Los Angeles	RSC	2	24	26	0.15	173	6.0	1,080
The Oaks, Los Angeles	RSC	2	24	26	0.15	173	4.7	1,080
Colorado U. Medical Center, Denver	MED	13	13 (est.)	26	0.25	104	4.8	
Montclair Plaza, Los Angeles	RSC	2	23	25	0.19	132	5.5	1,044
Buena Park Center, Los Angeles	RSC	2	23	25	0.12	208	5.4	1,050
Brookdale, Minneapolis/ St. Paul	RSC	2	23	25	0.12	208	5.1	1,040
Wooddale, Minneapolis/ St. Paul	RSC	2	22	24	0.11	218	5.5	1,000
Rosedale, Minneapolis/ St. Paul	RSC	2	22	24	0.11	218	5.5	1,000
Central City Mall, Los Angeles	OBD	2	22	24			4.0	1,000
West Covina, Los Angeles	RSC	2	22	24	0.10	240	5.0	1,000
Burnsville, Minneapolis/ St. Paul	RSC	2	22	24	0.12	200	7.0	1,000

(1)Employment estimates for regional shopping centers (RSC) made using a multiplier of two employees per 1,000 ft^2 gross leasable area (GLA).

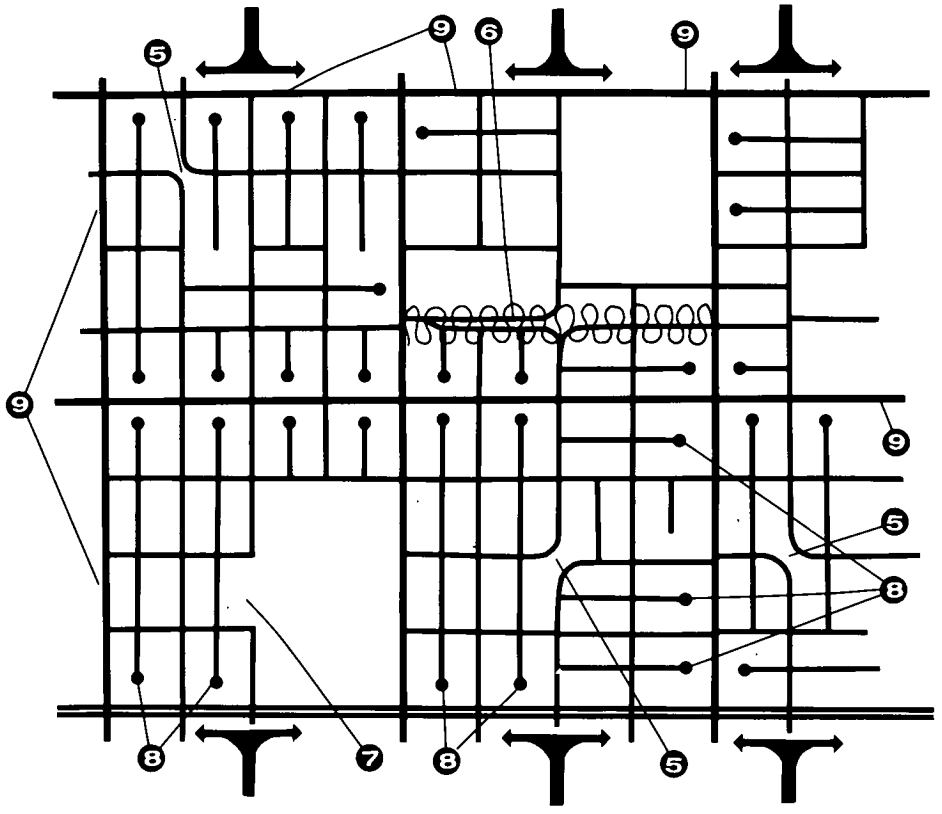
(2)Daily visitors/shoppers to regional shopping centers (RSC) estimated using a multiplier of 22 trips per 1,000 ft^2 GLA. Observed range for shopping centers across the country is 17-28 trips per 1,000 ft^2 GLA.

(3)Additional office GLA of 1,547; area shown is for RSC only.

(4)Data on additional retail and office space in this MDC not readily available; figures shown reflect only the RSC that serves as the center's focus. Total area of the MDC is 0.66 $miles^2$.

- Perceptions of the existence of traffic problems and the willingness of residents to accept solutions are strongly affected by changes (from light to medium) in the amount of traffic on a street. However, conventional objective measures, such as traffic counts, are not adequate indicators of the intensity of traffic problems as perceived by neighborhood residents (*14–16*).
- Traffic diversion schemes can have a significant effect on the amount of traffic passing through a neighborhood and on accidents. Service and emergency vehicle access has been preserved and neighborhood values have been maintained where diverters have been installed (*13*).
- The diversion of through traffic from neighborhood streets appears to have a positive impact on property values over the long run, with a benefit-cost ratio to residents exceeding three (*10*).
- Traffic noise and intrusion are repeatedly reported in neighborhood or housing surveys as primary concerns of residents (*14–16*).

Although the findings listed above are significant, they are not adequate in terms of demonstrating the merit of the various TSM or transportation-related land use actions that could be implemented to benefit neighborhoods (or adjacent arterials). Many actions have been proposed and implemented for which there appears to be no documented evidence of impact or cost effectiveness. Although it is not possible or most likely desirable to assess the impact of every



BUFFER

LOCAL STREET

PREFERENTIAL STREET

TRAFFIC DIVERSION

OBJECTIVES: DISCOURAGE OR STOP USE OF LOCAL STREETS FOR THROUGH TRAFFIC.

BUFFER RESIDENTIAL FROM INDUSTRIAL AREA.

5 INSTALL TRAFFIC DIVERTERS IN KEY LOCATIONS TO STOP THROUGH USE OF CERTAIN STREETS.

6 INSTALL DOUBLE STREETS TO SEPARATE INDUSTRIAL AND RESIDENTIAL TRAFFIC AND PARKING.

7 CLOSE STREET ADJACENT TO SCHOOL TO ENLARGE PLAYGROUND.

8 CUL-DE-SAC STREETS EVERY OTHER SIXTEENTH MILE TO LIMIT USE BY TRAFFIC AND REDUCE CONFLICT ALONG ARTERIAL STREETS.

9 UNDERTAKE SOME FORM OF STREET RENEWAL ON PREFERENTIAL STREETS TO IMPROVE THEIR APPEARANCE, SAFETY, AND CAPACITY...WIDEN, PROVIDE OFF-STREET PARKING, PROVIDE SERVICE DRIVES, AND/OR MAKE SUCH OTHER IMPROVEMENTS AS MAY BE POSSIBLE.

FIGURE 2 Redevelopment of local circulation systems (*49*).

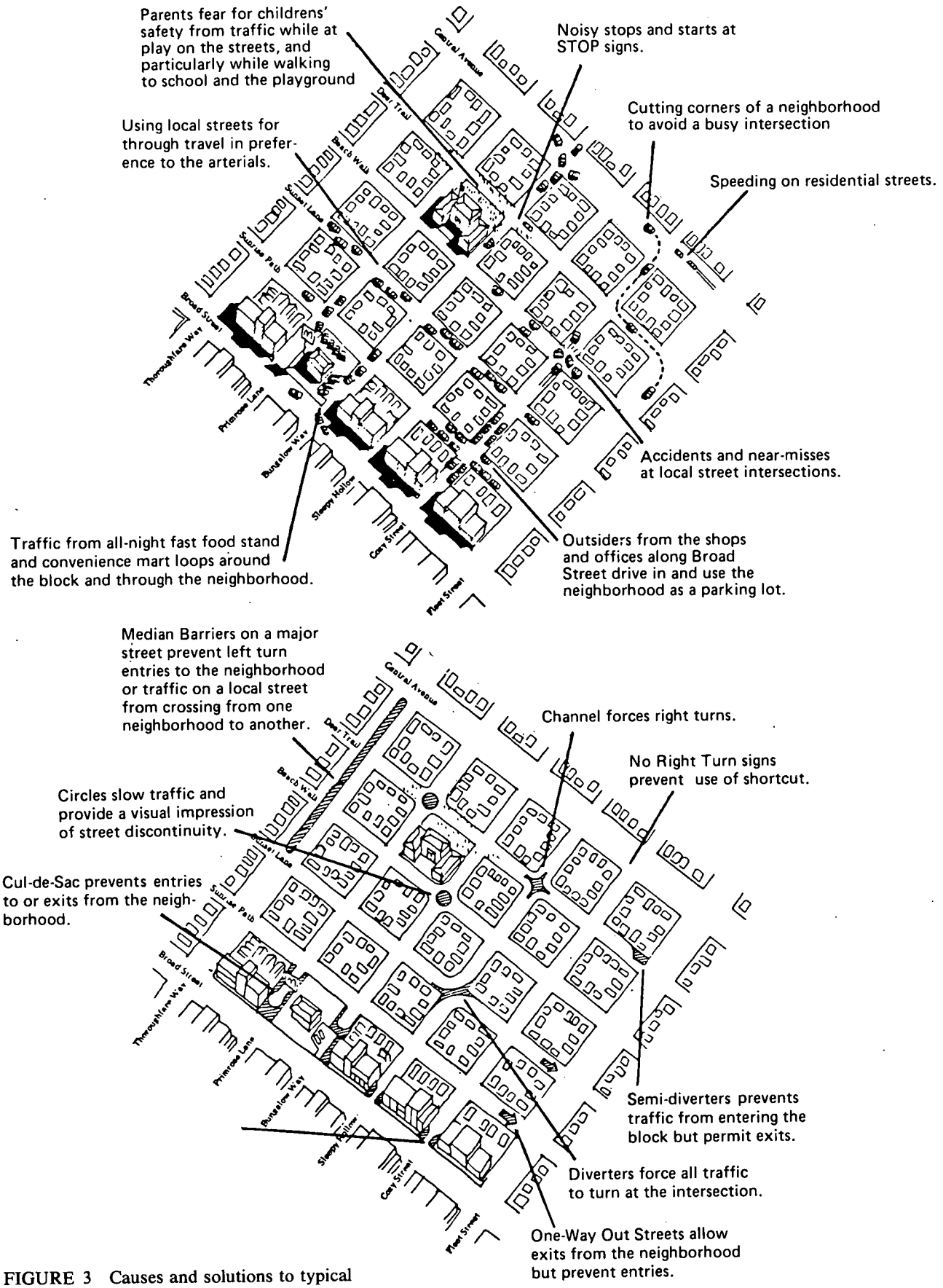


FIGURE 3 Causes and solutions to typical neighborhood traffic problems (*18*).

action, there is a need to understand more fully the nature and the degree of the effects of various TSM and land use actions. May (*16, 19*) and Smith and Appleyard (*18*) have reported on the impacts of these actions.

CENTRAL BUSINESS DISTRICTS

The CBD is usually the most complex and intensively used section of any city, and thus contains the greatest variety of land uses requiring good access and transportation facilities and services found in metropolitan areas. These factors, along with high levels of traffic congestion, help to generate and justify a wide variety of both TSM and land use actions to assure good access and circulation.

Many TSM actions have been proposed for CBD's, especially in connection with air-quality planning. However, joint transportation/land use actions are usually proposed only as part of comprehensive or large-scale efforts to redevelop or improve downtowns. Such actions may include the redevelopment of land to allow street or transit improvements, the provision of parking space at strategic locations with respect to transportation, and the creation of pedestrian movement areas separate from vehicular transportation routes.

Although there has been substantial experience in this area, the impact on transportation has not been documented systematically. Yet it is obvious that only through such coordinated planning and development of both transportation and land use can CBD's continue to function effectively. Many of the transportation actions associated with such plans may be too capital-intensive to be characterized as TSM. However, many are clearly TSM actions, and their success is likely to depend on close coordination with land use management.

There are many examples of coordinated CBD planning that include TSM actions; however, few appear to be deliberate attempts to coordinate TSM and LUM.

San Francisco Center City Transportation Improvement Program

The San Francisco Center City Transportation Improvement Program is an excellent example of coordinated CBD planning. The program is designed to identify a comprehensive set of actions to reduce congestion (*20, 21*), which include controls on land use as well as conventional TSM actions and coordination of both. It is too early to measure the results of this program. The objectives of the program are as follows (*20*):

> . . . to improve personal mobility . . . in San Francisco's growing downtown, with an emphasis on transportation measures which improve transit and pedestrian accessibility and facilitate goods movement, while reducing the impact of the private vehicle, particularly the commuter vehicle . . . .

Most of the actions proposed are focused on transportation. However, implementation of the plans is closely related to land development, and, in turn, development plans are strongly affected by TSM objectives. Actions taken under this program include the following (*20*) (italics denote particularly significant items):

Adoption by the Board of Supervisors of a policy regarding use of stop signs and traffic signals on transit streets [part of a "transit first" policy].

Dramatic increases in parking meter rates, fines for overtime parking, and off-street parking rates in public garages [particularly for long-term parkers].

Provision for vanpool spaces and reduced vanpool parking rates in publicly-owned garages.

Initiation and completion of the first Pedestrian Circulation and Goods Movement study ever undertaken for downtown San Francisco.

Modification in transit stop locations on Third and Market Streets to improve bus flow and speed and to provide additional, weather-protected pedestrian-transit patron waiting and movement space.

Removal of obstacles to pedestrian movement and resulting dramatic increase in circulation space without loss of amenities for pedestrians on Montgomery Street near Market Street.

Initial approval for new midway pedestrian mall on Belden Street.

Initiation of extended jitney service between downtown and Fisherman's Wharf.

Initiation of Interstate fund withdrawal and transfer to prevent new waterfront freeway and provide funding for new public transit-based waterfront transportation system.

Extended Airporter transit service between various hotel clusters and San Francisco International Airport.

Securing of separate grant funds to plan and undertake pedestrian safety improvements in six critical pedestrian corridors within downtown.

Development of more punitive double-parking regulations for use on transit priority streets.

Support for the design and development of an assessment district to reconstruct and maintain Maiden Lane as a pedestrian mall.

Mayoral support for flextime among private businesses and governmental employees, including sponsorship of a flextime symposium for downtown businesses and successful conclusion of a pilot city flextime program soon to be expanded to other city offices.

Completion of a site study for location of future long-term parking facilities on the periphery of downtown, and near freeway ramps, where such parking could be linked to the core via shuttle transit service.

Adoption of the "Guidelines for Environmental Review of Transportation Impacts" now being used as a standard for all San Francisco Environmental Impact Reports and any traffic impact analyses required as part of a Negative Declaration to assess the cumulative transportation impacts of downtown development.

Development of the formulas and processes for a transportation assessment fee to be assumed by each private development to pay for the increased transportation services which the demand created by that development necessitates [this has been implemented].

Funding for crosswalk improvements and signalization to improve pedestrian safety at three Chinatown intersections.

Enforcement and towing focused on parking violators on transit preferential streets.

Successful negotiations with developers and/or official review of individual development projects to:

a. Eliminate plans for parking within the downtown core.
b. Guarantee provision of short-term parking adjacent to the core.
c. Improve off-street loading provision and pedestrian movement.
d. Improve tour bus loading, truck loading provision, and pedestrian facilities and eliminate conflict with MUNI vehicles.

Support policies for, and help with, site identification to encourage housing demand in or near center city in order to reduce the need to travel.

Review of access and circulation needs related to new development has generated the following requirements for new development (*21*) (italics added for emphasis):

> In recognition of the need for expanded transportation services to meet the peak demand generated by cumulative commercial development in the downtown area, *the project sponsor shall contribute funds for maintaining and augmenting transportation service, in an amount proportionate to the demand created by the project,* through a funding mechanism to be developed by the city.
>
> The project sponsor shall encourage transit use by employees in the proposed building by means including *on-site sale of BART tickets and MUNI passes* and encouraging an employee carpool/vanpool system in cooperation with RIDES for Bay Area Commuters or other such enterprises.
>
> The proposed building shall be designed to include provision of a reasonable number of safe and secure bicycle parking spaces.
>
> Within a year after completion of the project, the project sponsor shall conduct a survey, in accordance with methodology approved by the Department of City Planning, to assess actual trip generation, trip distribution, and modal split pattern of project occupants, and actual pickup and drop-off areas for carpoolers and vanpoolers. Alternatively, the project sponsor may provide an in lieu contribution for an overall survey of the downtown area to be conducted by the city.
>
> If 10 or more spaces are made available for employee parking, the project sponsor shall implement a preferential parking program for employee carpool and vanpool vehicles to encourage ridesharing by employees.
>
> The project sponsor shall participate on a proportional basis with other hotels in the vicinity in a shuttle bus system between the hotels and the Moscone Convention Center for use by hotel guests, should such a shuttle bus system be desirable by the city.
>
> The porte cochere shall be operated with one-way circulation entering from Ellis, exiting to Mason Street only, with minimum height clearance 14 feet, minimum clear width for both exit lanes on Mason Street of 13 feet each. The porte cochere only shall be used for taxi/auto drop-offs and tour/charter bus loading and unloading. The project sponsor shall take appropriate measures to insure that taxies queue only on Mason Street for passenger pickup.
>
> A sign shall be provided at entrance to the porte cochere, indicating that (1) the porte cochere is one-way, and (2) the porte cochere is for bus loading/unloading and taxi/auto drop-offs only. Another sign shall be provided at the exit from the porte cochere, indicating that the porte cochere is one-way.
>
> There shall be a continuous sidewalk along North 5th, Mason, and Ellis Streets. There shall be only drop curbs (cut at the outside edge of curbs) for vehicle entrance/exit. The project sponsor shall widen the sidewalk, at least eight feet wide, between the porte cochere and Mason Street on Ellis for a bus stop for bus passengers. The project sponsor also shall provide for and maintain shelter on the widened sidewalk. Said designs shall be approved by the Department of City Planning.

The overall result of these requirements is to shift more of the responsibility for meeting access and circulation needs (or for avoiding problems) from the city to the developer. Presumably, this will have some impact on development location, density, and design. This will also help to assure (through a housing subsidy feature) that housing will continue to be located in the area and that moderate-cost housing will be available.

Additional land use actions could be identified as part of a CBD TSM program; however, the effort in San Francisco is notable and pioneering, and should be monitored to assess the results and emulated where appropriate.

Automobile-Restricted Zones

Other examples of the coordination of TSM and LUM in CBD's involve the creation of automobile-restricted zones (ARZ) (*22*). Such zones have been created in a number of cities through actions ranging from the closing of one or two blocks of a street to traffic to the restriction of traffic over a large number of blocks. A variation of the street closing consists of providing a second-level pedestrian system (above or below grade) to separate vehicles and pedestrians. A complementary action involves the provision of extensive landscaping and other amenities in the area of restricted automobile traffic.

The impacts of the establishment of such zones in many European cities have been documented extensively. However, documentation of U.S. efforts is not sufficiently thorough to be useful, due to the relative newnesss of many projects in this country, the lack of good data on conditions before implementation, and the lack of systematic methods for evaluation after implementation. It is clear that in some instances the creation of malls or automobile-restricted areas has had a substantial beneficial impact on land use; however, in other situations, the results are neither as positive nor as clear. Additional evaluation is necessary to determine when and under what conditions desired impacts can be achieved. Also, although there is virtually no documented evidence of the land use actions that have been taken or that might be taken to achieve the objectives of an ARZ, it is clear that land use actions or improvements must accompany changes in street use to assure the success of such a zone.

Skywalk Systems

One effort to document impacts is related to the development of skywalk systems in Minneapolis and St. Paul, Minnesota, and in Des Moines, Iowa (*23*). The following results were reported:

1. For a skywalk system in Des Moines, Iowa, the benefits were estimated in 1977 to be $561,590 per year, primarily in reduced motorist and pedestrian delay and in fuel savings.
2. The rental rates of office buildings connected to the skyway system are about $1.00 higher per square foot than for buildings not on the system.
3. Rent levels on the skyway system are generally 50 to 100 percent higher than on the ground floor and about $2.00 higher than office space on upper levels.
4. Skyways attract from one-third to three-fourths of interblock pedestrian movement.

REGIONAL ENVIRONMENTS

It is perhaps most difficult to visualize or to find examples of coordination of TSM and land use actions at the regional level. Few, if any, land use actions can be applied on a regional scale; most must be implemented one at a time in some type of activity center or neighborhood. In addition, few TSM actions that have a direct impact on land use can be undertaken in this context. As noted by Roark (*1*), there are

few examples of TSM actions that have been applied at the regional level except with respect to clean air and other federal requirements; most of the problems for which TSM actions are implemented are experienced at a local level. There are, however, some emerging exceptions of TSM actions that are being generated by a concern for the area-wide effects of growing traffic congestion accompanied by the reduction of resources with which to address traffic needs.

San Jose

In San Jose, California, dramatic growth continues in the face of severe constraints on the resources required to meet transportation needs. As a result of growing congestion and commuting and housing costs, employers in this area are experiencing increasing difficulty in getting and keeping employees. This, in turn, is leading to support for the vigorous application of a wide variety of TSM actions as well as adjustments in land use policies.

The guidelines applied to land use planning in San Jose to help alleviate transportation and energy concerns include (*24*):

- Base planning on the assumption that resources will be limited and that only projects of high priority can be implemented.
- Create a better balance between jobs and housing that will result in the most efficient use of existing facilities and the least negative impact on the environment.
- To improve mobility, (a) give careful consideration to the location of jobs, (b) develop an adequate transit system, and (c) make investments in the highway system that are aimed at making the existing system more effective.
- Encourage new job formation and commercial development in central San Jose. San Jose's central location also makes possible the efficient use of transit. Existing commuter rail service and improvements proposed for transit work best where there is a focus of activity, carrying people from several different residential areas into a core work place. Encouraging jobs in downtown San Jose will help reduce the need for automobile commuting, reduce air pollution, and conserve energy.
- Encourage manufacturing firms that depend on highway access to locate in the northern San Jose/Milpitas area. Relatively minor expansions to existing transportation systems can accommodate new job growth in this area. Truck and rail connections for factories are reasonably accessible at the present time. New employment opportunities in this area should be located closer to the residences of a larger percentage of the region's labor force.
- Encourage development of employment in the Edenvale area that can be served by existing highways and proposed transit improvements and is consistent with housing development in San Jose. This new housing is to be located in the Edenvale, Almaden, and Evergreen neighborhoods and should reduce home-to-work trip distances traveled by residents in these neighborhoods. People commuting to jobs in Edenvale should be able to make use of existing "reverse" direction highway capacity as well as the proposed transit improvements. In addition, the San Jose General Plan proposes industrial sites.
- Encourage the development of high-density housing in the northern and central county cities. Although the opportunities are limited, additional residential development that is compatible with existing development patterns should result in less commuting and related improvements in air quality and energy consumption.
- Support the industrial development policies of Gilroy and Morgan Hill to assure continued economic growth. New commercial and/or industrial development should provide opportunities for people to live and work in the same city.
- Support the construction of new housing at a rate commensurate with new job development in the county. Such construction should be consistent with the above policies. From a regional perspective, the countywide imbalance between the large number of jobs and limited new housing continues.

Data from 1978 indicate that the trend is worsening rather than improving. According to county estimates, almost 40,000 new jobs were added in 1978, whereas roughly 13,000 new housing units were constructed. The need for more housing, especially near new employment areas, is apparent (*24*).

Minneapolis-St. Paul

A concern for the high costs of low-density suburban development and related public infrastructure led the Metropolitan Council in Minneapolis-St. Paul to adopt a policy requiring land use plans for individual communities to be prepared in accordance with and support regional transportation (and utility) plans. Communities are to assure that land use plans and controls do not call for densities and amounts of development that exceed the capacities of proposed transportation facilities. In general, this requires plans calling for land use densities at or below the levels used to make regional travel forecasts or calling for the implementation of other measures to restrict traffic generation to the level of the capacities of transportation systems.

Portland

A specific example of efforts to encourage widespread coordination of land use and transportation management actions is the publication of a guidebook in Portland, Oregon (*25*). This guide contains discussions of general objectives and principles along with detailed suggestions for the content of zoning regulations and the design of transit/land use interface facilities. Although this is primarily an educational/informational effort, it summarizes suggestions, guidelines, and policies that should encourage the coordination of transportation (especially transit) and land use throughout the region. Examples of the information and guidance provided in the publication are shown in Figures 4 and 5. Because most TSM actions must be initiated on a highly decentralized basis, the development and use of such an educational/informational guide is most appropriate. It is suggested that the Portland example be used as the basis for developing additional guidelines.

The evaluations of compatibility and incompatibility suggested by this table are based on study and observation of transit-area development in comparable areas, and on recognition of the special characteristics of transit and various types of uses, including housing.

The table is a guide to the selection of appropriate transit area uses, based on these general observations. Its listings should be interpreted flexibly recognizing that design detail and individual circumstances are the actual determinations of what can or cannot be made compatible with transit.

Similarly, design detail based on study of the impact areas, individual characteristics can insure that impact area development is compatible with other surrounding uses – in other words, impact area development can be a successful buffer between transit and existing non-transit uses.

	Generally Compatible	Compatible Under Certain Conditions	Generally Not Compatible	
Residential				
Mobile Homes			•	Generally an under-utilization of high-value land.
Detached Single Family			•	Generally an under-utilization of high-value land.
Duplexes		•		Generally an under-utilization of high value land.
Town-Houses, Garden Apartments		•		Compatible as part of a planned unit development or a transitional use between low and high density uses.
High-Rise Apartments	•			Desirable to provide pedestrian access to transit station.
Commercial				
Convenience Retail, Personal Services	•			Desirable to provide pedestrian access to transit station.
Neighborhood Shopping		•		Can be designed for transit compatibility. Generates some auto traffic, possibly in conflict with transit.
Community-Level Comparison Shopping		•		Primarily auto-oriented use. Parking requirements prevent transit compatibility.
Regional Retail Centers		•		Primary auto-oriented use. However, where regional center also has residential and office functions, compatibility is possible through design.
Highway-Oriented Commercial			•	Generates auto traffic in conflict with transit-oriented uses.
Hotels, Motels, etc.		•		Not inherently incompatible. However, if use relies heavily on highway access too, conflict may arise.
Entertainment Facilities		•		Depends on type of facility. Theatres, concert halls, similar uses requiring enclosed space and population concentration are highly compatible.
Institutional				
Educational				
Elementary Schools			•	Compatibility could be achieved by design for school serving impact area residents only. However, use of transit to bring in elementary students is not desirable.
Intermediate Schools		•		Compatibility could be achieved by design; pedestrian access to station desirable.
Secondary Schools		•		Compatibility could be achieved by design; pedestrian access to station desirable.
Colleges, Universities	•			Desirable to provide pedestrian access to transit station.
Churches, Other Religious Facilities		•		Compatible when designed especially for transit; pedestrian access to station desirable.

FIGURE 4 Transit and land use compatibility near rail transit stations (*25*). (Note: originally developed by Fairfax County, Virginia.)

Cultural (Museums, Concert Halls, Libraries)	•			Desirable to provide pedestrian access to transit station.
Medical (Hospitals, Clinics, etc.)	•			Compatible when designed especially for transit site; pedestrian access to station desirable.
Office	•			Desirable to provide pedestrian access to transit station.
Industrial				
Research and Technical Manufacturing	•			Desirable to provide pedestrain access to transit station.
Warehousing, Wholesaling, Distribution			•	Generally an under-utilization of high value land; also generates use conflicts.
Assembly, Heavy Manufacturing, Other			•	Generally an under-utilization of high value land; also generates use conflicts.
Agricultural, Horticultural, Resource Extraction			•	Generally an under-utilization of high value land; also generates use conflicts.
Recreational				
Parks				
Stream Valley	•			Serves to provide pedestrian access to transit station from uses abutting park.
Neighborhood		•		Needed to serve impact area residential neighborhood, but new park requirements standards must be devised.
Community			•	Generally an under-utilization of high value land.
District			•	Generally an under-utilization of high value land.
County			•	Generally an under-utilization of high value land.
Regional			•	Generally an under-utilization of high value land.
Other		•		Compatibility could be achieved by design, depending on nature of park.
Commercial Recreational Facilities		•		Depends on nature of facility. If population-oriented and intensive, compatibility is possible through design; for extensive land rather than population-oriented uses, under-utilization of high value land.
Other				
Burial Facilities			•	Under-utilization of transportation capacity, although no of land values. Use conflicts are likely also.
Correctional Facilities				Use conflict very pronounced; also under-utilization of high value land.
Military Facilities			•	Use conflict very pronounced; also under-utilization of high value land.
Utilities Structures		•		Unless needed in an especially designed for impact areas, not usually compatible or economical.
Waste Treatment, Disposal			•	Use conflict very pronounced, also under-utilization of high value land.
Other		•		Compatibility may be possible through design and other standards.

FIGURE 4 (*continued*)

Authoritative evaluations of the transit compatibility/incompatibility of proposed developments can only be made on a case by case basis. The worksheet should be interpreted flexibly, recognizing that design detail in individual circumstances are the determinant of what can or cannot be made compatible with transit. For broader application you may wish to develop separate worksheets which acknowledge the unique attributes of specific types of land uses. In all cases, the compatibility worksheets should be used in conjunction with Tri-Met's **Service Policies and Standards.**

	Yes	No
A. Relationship to Transit		
1. Is the site within a quarter mile of a Tri-Met line in an urban area, or within a half mile of a Tri-Met line in a suburban area?	_____	_____
2. Can an existing Tri-Met line sufficiently serve the transportation needs of the development?	_____	_____
3. Will the proposed development utilize the benefit from the proximity of public transportation?	_____	_____
4. Would you use transit to go there?	_____	_____
B. Orientation to Automobiles		
1. Is the development feasible without relying primarily on automobile access?	_____	_____
2. Would the proposed development function in a manner that could be characterized other than a primarily automobile oriented use? (Would parking requirements be compatible with transit?)	_____	_____
C. The Site Plan		
1. Does the site plan orient the development to the street?	_____	_____
2. Does the site plan treat parking in a manner as to not separate the development from the street by parking?	_____	_____
3. Does the site plan provide direct building entrances to the street and to transit?	_____	_____
4. Does the site plan provide weatherization improvements for pedestrians?	_____	_____
5. Does the site plan provide for direct quality pedestrian access to transit?	_____	_____
6. Does the site plan allow for pedestrian and transit amenities such as street trees and passenger shelters?	_____	_____
D. Trip Generation		
1. How many automobile trips will the proposed use generate both in the peak and off-peak?	_____	
2. What is the potential of the proposed development to generate transit trips in both peak and off-peak?	High _____ Medium _____ Low _____	
3. What is the proposed development's potential to generate pedestrian trips?	High _____ Medium _____ Low _____	
E. Intensity of Use		
1. Is the proposed development intensive utilization of high value land?	_____	_____
2. Is the proposed development a high, medium, or low intensity use of the site?	High _____ Medium _____ Low _____	

FIGURE 5 Transit compatibility worksheet (*25*).

Aliso Viejo

The need to meet air-quality standards has led to the development of extensive recommendations for both transportation and land use actions in some communities to help reduce or facilitate vehicular movement. Because it deals with a new community, the plan for Aliso Viejo, in Orange County, California, is comprehensive in terms of both TSM and LUM. The plan calls for balanced housing to minimize commuting, relatively high densities to promote non-automobile travel and to reduce travel distances, design details to accommodate transit, and patterns of land use to minimize travel distances and to promote transit use. Although the development of a completely new community does not qualify as TSM activity, the actions included in the Aliso Viejo plan do provide a basis for plans for communities involving less change. Some of the land use measures proposed are listed in Table 3 (along with an appraisal of the impacts on air quality) (*26*).

ARTERIAL CORRIDORS

Arterial corridors offer direct and immediate opportunities for coordination of TSM and LUM. As defined by Roark (*1*), such corridors include the whole "watershed" from which traffic using an arterial is generated. They may be quite broad. However, the most immediate impacts will be seen in the relationship between the arterial street and adjacent land use. Almost any change in either street or land use is likely to have an impact on the other. Many zoning provisions are intended to deal with this relationship and to protect the functions of both the street and the adjacent land. Street-improvement standards often also have this objective. The enforcement of such controls and standards may be one of the most effective TSM/land use coordination tools available. Of course, the effectiveness of coordinating mechanisms depends on the level of change in either land use or streets, or both.

Proposed TSM actions seldom include the resources for

TABLE 3

MEASURES TO MINIMIZE AIR-QUALITY IMPACTS (ALISO VIEJO, CALIFORNIA) (*26*)

Proposal	Emission (travel) Reduction Potential
Land-Use/Urban Form	
1. Compact urban form and design to minimize travel distances	High
2. Balanced employment/projected work force to minimize VMT	High
3. Provision for 25 percent "affordable" housing	High
4. Growth consistent with PHEL forecast	Undeterminable
5. High density development capable of supporting public transit	Medium
6. Provisions for internal commercial, recreational services and industrial facilities	Medium
7. Incentives for persons to work/live in community (i.e., priority sale of affordable houses) to reduce commuter trips	Medium
8. Locate sensitive receptors (e.g., schools) in areas of least pollutant exposure	None
Facilities and Arrangements	
1. Accommodations for intra-community transit system serving the entire community (mini-bus and tram)	Undeterminable (potentially medium)
2. Transit accommodation including bus turnouts, benches, bus stop shelters, pedestrian access provisions	Low
3. Transit terminal site in Town Center connected to regional, county, and local transit systems	Undeterminable (potentially low-medium)
4. Multi-modal transit terminal site connecting rail to other transit services	Undeterminable (potentially low)
5. Internal tram system in Town Center	Medium
6. Significant traffic generators located near access to major transportation facilities	Low
7. Bicycle/pedestrian trail systems	Low

changes in land use. Some changes (expenditures) would be eligible for FHWA and UMTA funds, but, as a practical matter, few such changes are ever proposed. Funding limitations almost always result in a narrow definition of project objectives that deal only with the transportation facility.

Usually, proposed land use changes do not include provision for related or needed transportation improvements. However, in the case of large-scale developments, a number of TSM actions are not only possible, but increasingly are being required. In some instances, TSM actions are generated by the need to meet air-quality standards and may include encouraging carpooling, establishing staggered (work) hours, etc. They may also include the redesign and reconstruction of property access systems and signals, adjacent street widening, etc. Most often such actions are carried out in reaction to the design requirements of highway departments and/or local zoning authorities.

The policies and standards of San Diego are a good example of existing and emerging practice in this area (*27*, *28*), and provide detailed guidelines for the design of various classes of arterials, the location and design of driveways, parking facilities and other features, the distribution of costs between land developers and the city, and requirements for approval. Implementation of these policies assures the improvement of arterial streets in relation to evolving land development. The regulations in San Diego apparently do not deal with the potential for coordination with transit or with nonphysical TSM actions that might have some impact on street use.

The feature of land use that most directly affects the efficiency and safety of arterials is the driveway. Because the location and design of driveways can have a dramatic impact on an arterial, these features are often subject to control, usually as a part of land use zoning.

Some of the techniques that can be applied (usually to driveways) through zoning and related controls are listed in Table 4. The application of these techniques requires a commitment to the exercise of controls and the insertion of a variety of standards into zoning and subdivision regulations and other codes. Although such standards must be applied on a project-by-project basis, their cumulative impact on an arterial roadway can be substantial.

Although both TSM and land use actions are being undertaken and there is some coordination at the project level, there are few examples of deliberate attempts to coordinate TSM and land use actions on a corridor basis. There are many examples of TSM plans for arterial corridors, but none appear to contain recommendations for land use. However, corridor studies that have originated in concern for economic or community development have been conducted. Most of these studies appear to be limited in scope and do not include a major transportation element nor a readily available method of financing extensive or systematic improvements, which probably constrained plan proposals. However, the efforts demonstrate the potential for coordinated actions, including closing and relocating driveways; reorganizing or providing off-street parking; eliminating curb parking; and changing the number, location, and design of intersections.

TABLE 4

TECHNIQUES TO PRESERVE ROADWAY CAPACITY AND SAFETY (*29*)

Technique	Comment
Capacity	
Provide two driveway exit lanes rather than one.	Driveway ADT over 1,000.
Provide additional driveway.	Driveway ADT over 5,000.
Provide left-turn lane on arterial.	Varies.
Provide left-turn deceleration lane.	35 mph, 40 or more peak-hour right turns.
Provide continuous right-turn lane.	35 mph, 20 percent right turns during day.
Provide direct access only from frontage roads.	40 mph, 20,000 ADT, short frontages.
Signalize driveway intersection.	See Manual on Uniform Traffic Control Devices.
Safety	
Prohibit parking on arterial streets.	All locations.
Provide adequate driveway entrance width.	Provide minimum 15 mph turning speed.
Provide two driveways with limited turns rather than two standard driveways.	"T" driveway intersections, 40 left turns in one direction, 200-foot minimum frontage.
Provide two one-way driveways rather than one two-way driveway.	Same as above.
Channelize driveways or install median to prohibit selected movements.	Less than 100 prohibited turns per day, high driveway densities or driveway close to intersection.
Ensure adequate sight distance.	See AASHTO Policy on Geometric Design of Rural Highways.
Capacity and Safety	
Minimum driveway spacing.	See Table 2 in Bochner (29).
Minimum corner clearance.	50 feet or distance based on Table 3 in Bochner (29) (whichever is greater).
Minimum property clearance.	One-half values in Table 2 in Bochner (29).
Provide access from collector street in lieu of access from arterial street.	Corner residential parcels, corner parcels requiring more than one driveway.
Consolidation of access and connections between adjacent properties.	Frontages too short to permit minimum spacing.
Provide adequate internal circulation and parking space.	Always.

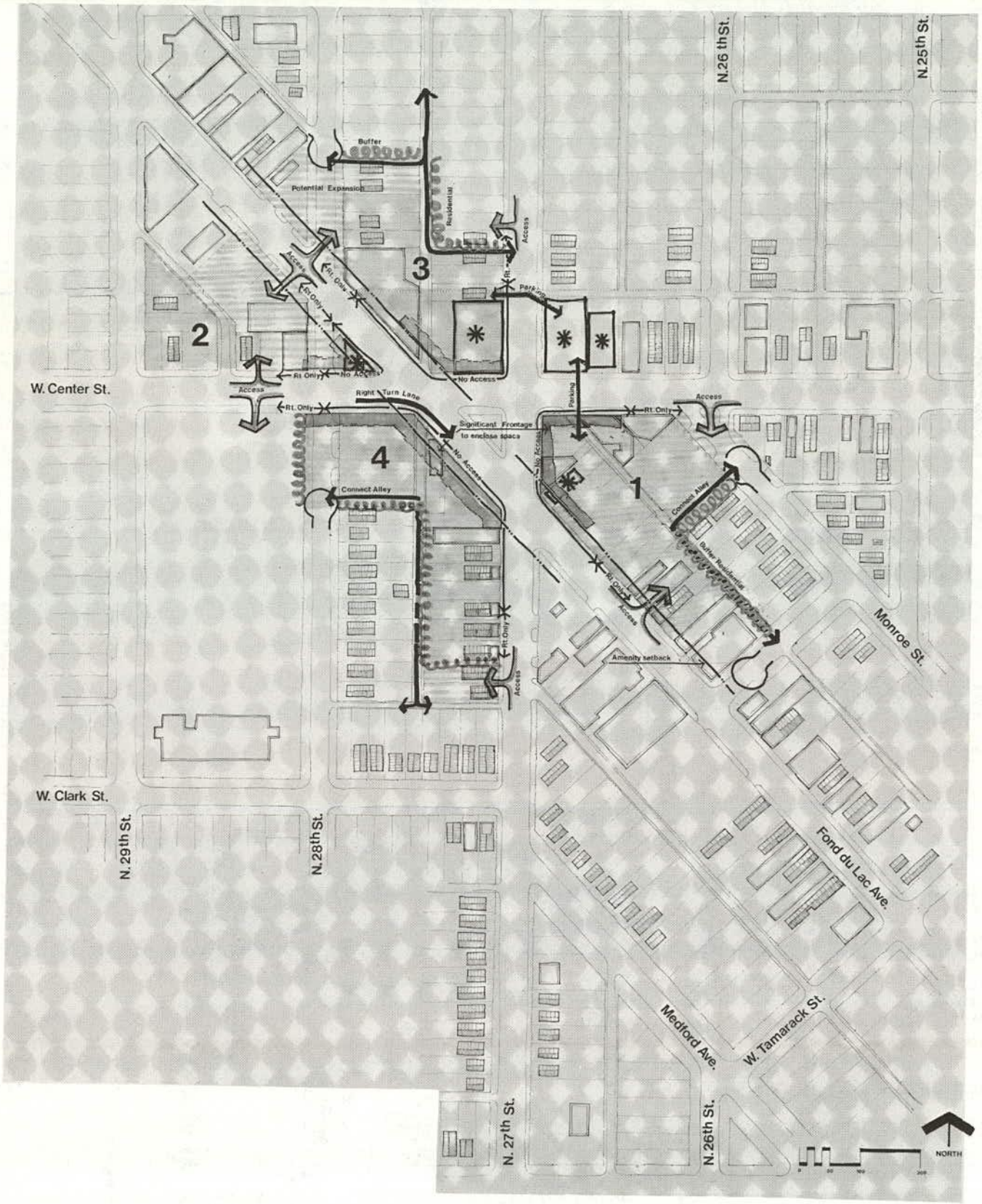


FIGURE 6 Use of guidelines for redevelopment to improve the functioning of arterial streets (*52*).

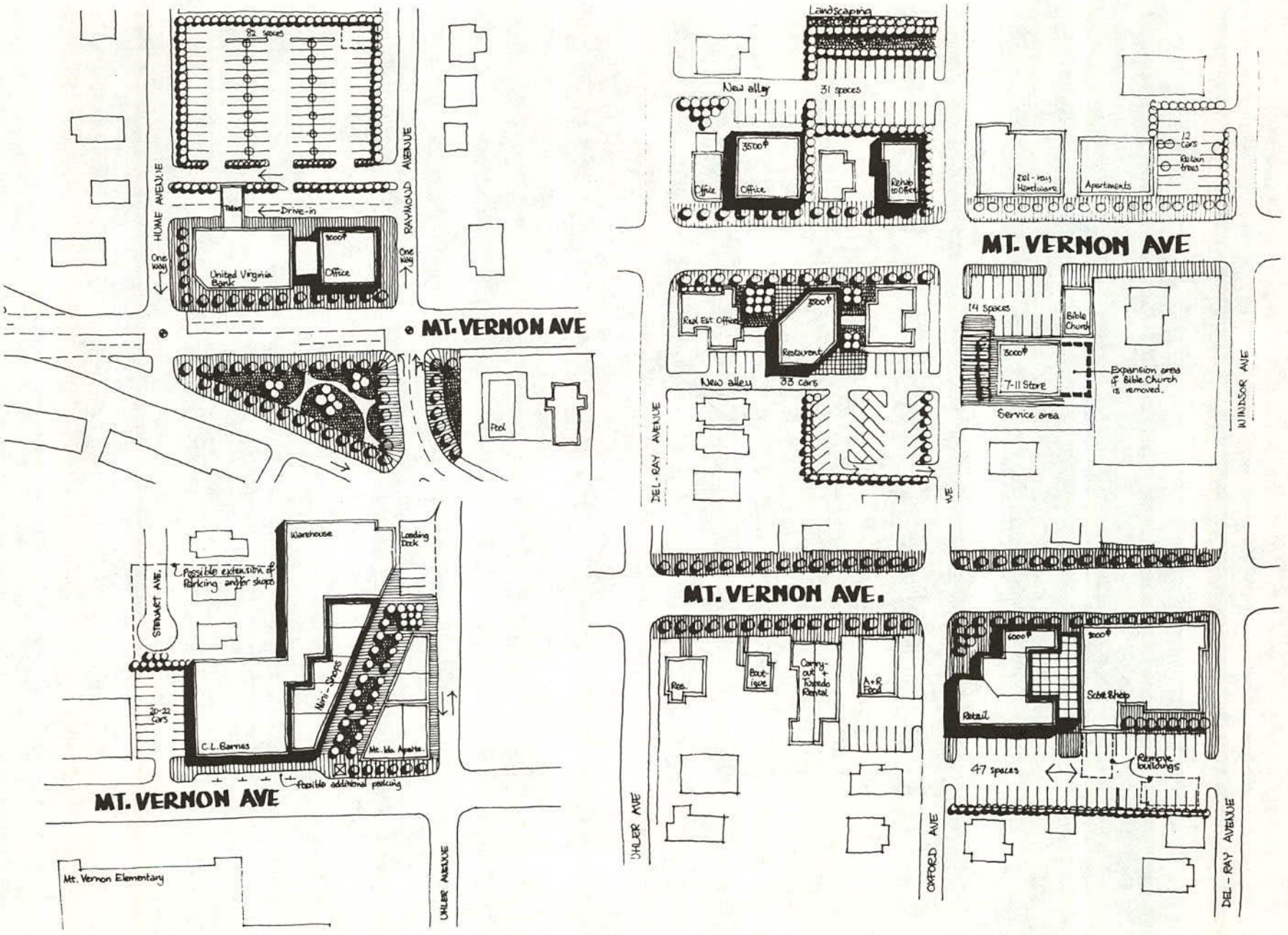


FIGURE 7 Use of a series of development projects to improve an arterial route (*50*).

Other actions include consolidating and enlarging sites for development of business or housing facilities, providing landscaping or other types of buffers, and improving pedestrian movements. Examples of such actions are shown in Figures 6 and 7.

Most of the actions cannot be justified on the basis of traffic improvement alone. However, in addition to major traffic improvements, substantial economic and revitalization benefits can be obtained. In most cases, the resulting traffic improvements could not be achieved through actions confined to street rights-of-way. Thus, if such improvements are to be made, programs involving redevelopment and provision of off-street parking space may be most appropriate. Although these programs are not conventional TSM actions, multiple benefits can be achieved, i.e., traffic, neighborhood improvement, and economic, which would justify the cost and effort involved. The potential and value of such "street renewal" should be explored further to determine whether such action can be developed into techniques for both TSM and community revitalization.

A less complex form of improvement that can benefit both transportation and land use is street beautification. This type of redesign and reconstruction takes into consideration that streets must serve property access and "frontage" as well as traffic movement. Most beautification projects are undertaken in commercial environments where values are high, congestion is great, and there are at least moderate levels of pedestrian movement. As a result, benefits can be generated in several areas to help justify costs. Examples of such projects are shown in Figures 8 and 9. However, no documented information is available to indicate the extent of impacts of these types of projects. This information would be helpful in determining whether or to what extent the costs of such projects can be justified.

FREEWAY CORRIDORS

Freeway corridors are different from the other "operating environments" with respect to TSM and LUM, encompassing large areas, often extending through two or more political jurisdictions, and involving a variety of land use and transportation concerns. Thus it is difficult to conceive of a wide range of actions that could be applied on a corridor basis, particularly on a small scale over a short period of time. As indicated by Roark (*1*), most TSM actions at this level consist of manipulations to the freeway or to freeway access. Land use actions likely would involve the encouragement or discouragement of specific types or densities of development, or control over the design of land use. The separation of land uses inherent in freeway design limits the benefits of further regulation of land use.

If, however, the function of roads providing access to the freeway is considered, land use actions could be significant due to the potential for conflicts between traffic and land use along these roads. Through land use control or redevelopment, there may be major opportunities to create densities and arrangements of land use that are more compatible with freeway access (*30*, *31*).

During the 1960's several states attempted to exercise some control over the development of lands around highway interchanges. Wisconsin is a notable example. Other states undertook educational efforts to encourage protection of interchange areas, but did not exercise controls. However, both of these approaches met with little success.

Land use controls can be particularly effective where land is still undeveloped. In such situations, a number of conditions important to the effective functioning of freeway access can be obtained, including the appropriate spacing of property access, building setbacks, the maintenance of sight distances, the clustering of related land uses to minimize the use of the freeway for short-distance travel, or the provision of driver service facilities at critical locations to minimize the need for off-freeway travel (see Table 5 and Figure 10). Although these actions might not be considered within the scope of TSM, where feasible they should have a significant impact on the efficiency of travel in a freeway corridor.

Obviously, almost any action that would improve the operation of a freeway would benefit associated land use. However, it is possible that some actions could be taken to achieve specific land use objectives, such as provision of improved buffering between freeway traffic and nearby land uses, improved access from the freeway to specific adjacent land, and access on a selective or metered basis to favor certain land use areas.

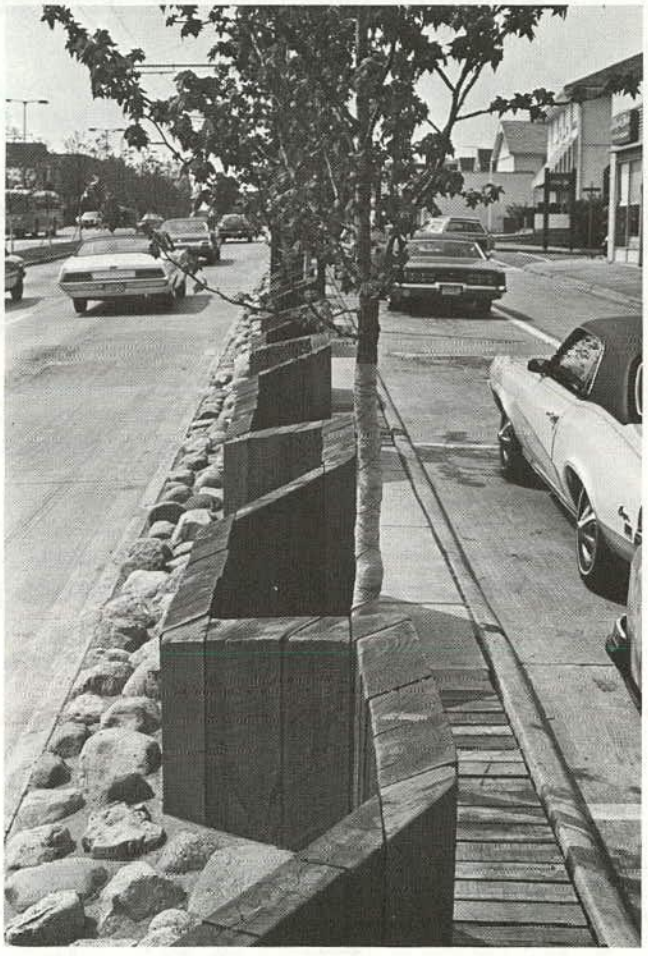


FIGURE 8 Street beautification project in Oakwood, Ohio.

FIGURE 9 Street beautification project in Grand Prairie, Texas.

Although some TSM planning at the corridor level has taken place (*32*), no evidence of the coordination of TSM and LUM at the freeway corridor level was identified in this study.

MODAL TRANSFER POINTS

Modal transfer points provide major opportunities for improvement through TSM and LUM. Because, by definition, they involve more than one transportation mode, actions related to two or more modes are possible. Also, because a mode change occurs, close relationships to land use also may be involved. For example, the mode change may provide an opportunity or a need for shipping or to obtain a specific service, or the change could require access to parking, which would also serve commercial or other functions. Thus a variety of TSM or land use actions may be appropriate.

Where new modal transfer points are being established, sound transportation design and good land use relationships should be built into the facility. Roark (*1*) has provided an excellent list of guidelines for the design of many transportation features of such terminals.

Additional potential actions related to land use include:

1. Establish land uses at the mode change terminal (or locate the terminal near land uses) that can serve people making the mode change. Certain types of retail and service activities may fit this category.
2. Establish land uses that do not conflict with (and may enhance) the mode change operation.
3. Establish land uses that can increase the efficiency of transportation facilities through increased patronage, higher vehicle occupancy, greater use during off-peak times, etc.
4. Provide land use design standards that (a) preserve and enhance the operating efficiency of transportation modes by minimizing conflicts with vehicular movements, (b) assure convenient paths for access and movement to the terminal

TABLE 5

GUIDELINES FOR LOCATING VARIOUS LAND USES IN INTERCHANGE AREAS (*30*)

Type of Land Use	Does Land Use Need a View from the Freeway?	Is Freeway Access Important in the Function of Land Use?	Does Land Use Perform a Needed Service for Freeway Traffic?	What is the Traffic Impact of the Land Use?	Remarks
1. Highway-oriented (road-user activities: motels, restaurants, service stations.	Desirable	Yes	Yes	Moderate	Most favorable locations likely to be at interchanges of freeways with major highways. Road-user activities can draw on long-distance traffic from both routes.
2. Regional traffic generators: major shopping centers, large industries, institutions, major recreational areas.	May be desirable	Yes	No	Major	Developments drawing employees or patrons from a large area. Most favorable locations are near but not immediately adjacent to, interchanges of freeways with regional routes. Secondary access to another major highway is desirable.
3. Transportation terminals and transfer points: airports, truck terminals, warehousing, etc.	Probably unnecessary	Yes	No	Major	Although volumes of generated traffic may not be large, high percentage of trucks (at some areas) may have significant impact on traffic conditions.
4. Community-type activities: neighborhood shopping centers, elementary and junior high schools, etc.	No	No	No	Moderate	Development attracts short-length, local trips that do not need, or belong on, the freeway.
5. Inactive land uses: forest preserves, cemeteries, agricultural uses, etc.	No	No	No	Minor	Land use has no adverse effect on traffic movement and may be appropriate to insulate high-volume routes or where demand for other development does not exist.
6. Other land uses: single-family residences, small businesses, etc.	No	No	No	Minor	Attracts local trips that do not need the freeway; however, generation is low. Major detriment to traffic may be frequent driveways and access points.

1. Area too small to be developed is landscaped to buffer the adjacent residential area from the noise and sight of interchange traffic.
2. Dashed line indicates closure of an old access point which would have impeded traffic and created unsafe conditions on the arterial.
3. Residential lots face on a frontage road or local street; landscaped buffer zones protect the residences from adverse effects of traffic.
4. Location of first arterial access point in relation to ramp terminals is based on distance required for safe and efficient merging and diverging of ramp traffic.
5. A minimum of 150 feet between intersections is needed to allow adequate storage of vehicles on access road.
6. Service stations, the most frequent road-user service destination, are located immediately adjacent to the access road.
7. Access and circulation pattern to all services within area is easily recognizable from cross route when approaching access point.
8. Buffer protects residential properties and screens other activities.
9. Restaurant is located convenient to motel patrons.
10. Major parking area intercepts patrons and eliminates unnecessary circulation through service area.
11. Residential and road-user service traffic is separated (i.e., the two activities front on different streets).
12. Motel units are set back from freeway and cross route to minimize traffic noise.
13. This area might be developed as a picnic and rest area for road-users.
14. Adequate building setbacks are provided along arterial.
15. Adequate off-street service and loading areas are provided to commercial and industrial activities.
16. Area might be developed for appropriate uses needing regional access and a location near the freeway.
17. Separate turning lanes and appropriate traffic control devices insure efficient intersection operation.

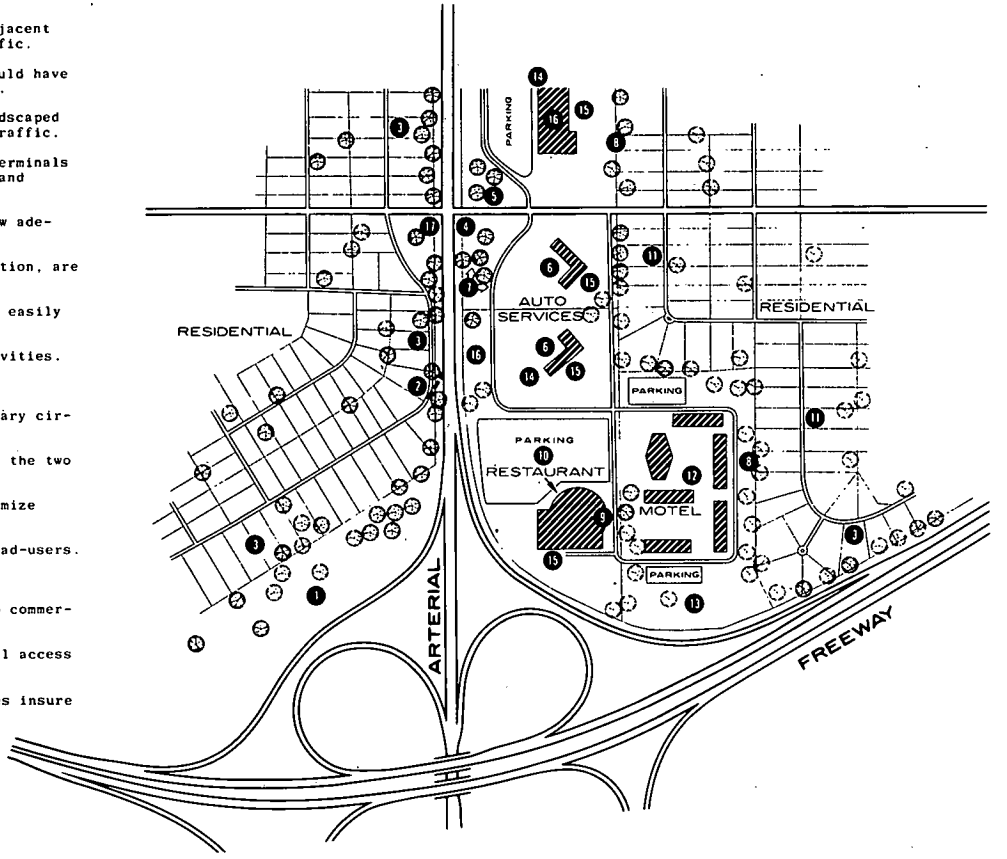


FIGURE 10 Planning principles for freeway interchange area development (*30*).

(especially for pedestrians and cyclists), and (c) provide pleasant environments offering some service or amenity.

5. Establish densities of development around the terminal within walking or a short travel distance sufficiently high to generate significant patronage for terminal facilities.

An analysis of the types of accessibility that could be provided by a hypothetical transportation system is shown in Figure 11. The types of land uses that might be most appropriate in each of the different types of "access areas" are listed in Table 6. This kind of analysis has been utilized in the rezoning of lands along the BART transit system in San Francisco. It could also be applied to other, nonrail transit systems.

Although not specifically identified as TSM, several projects embody some of these concepts. In some cases, the desired relationships between the mode change point and land use were obtained by locating the mode change facility in an area where compatible land uses existed or were planned. The establishment of such relationships is a prime objective of "joint development" promoted by UMTA and FHWA.

A number of projects have been planned to achieve the desired coordination of transportation terminals and centers

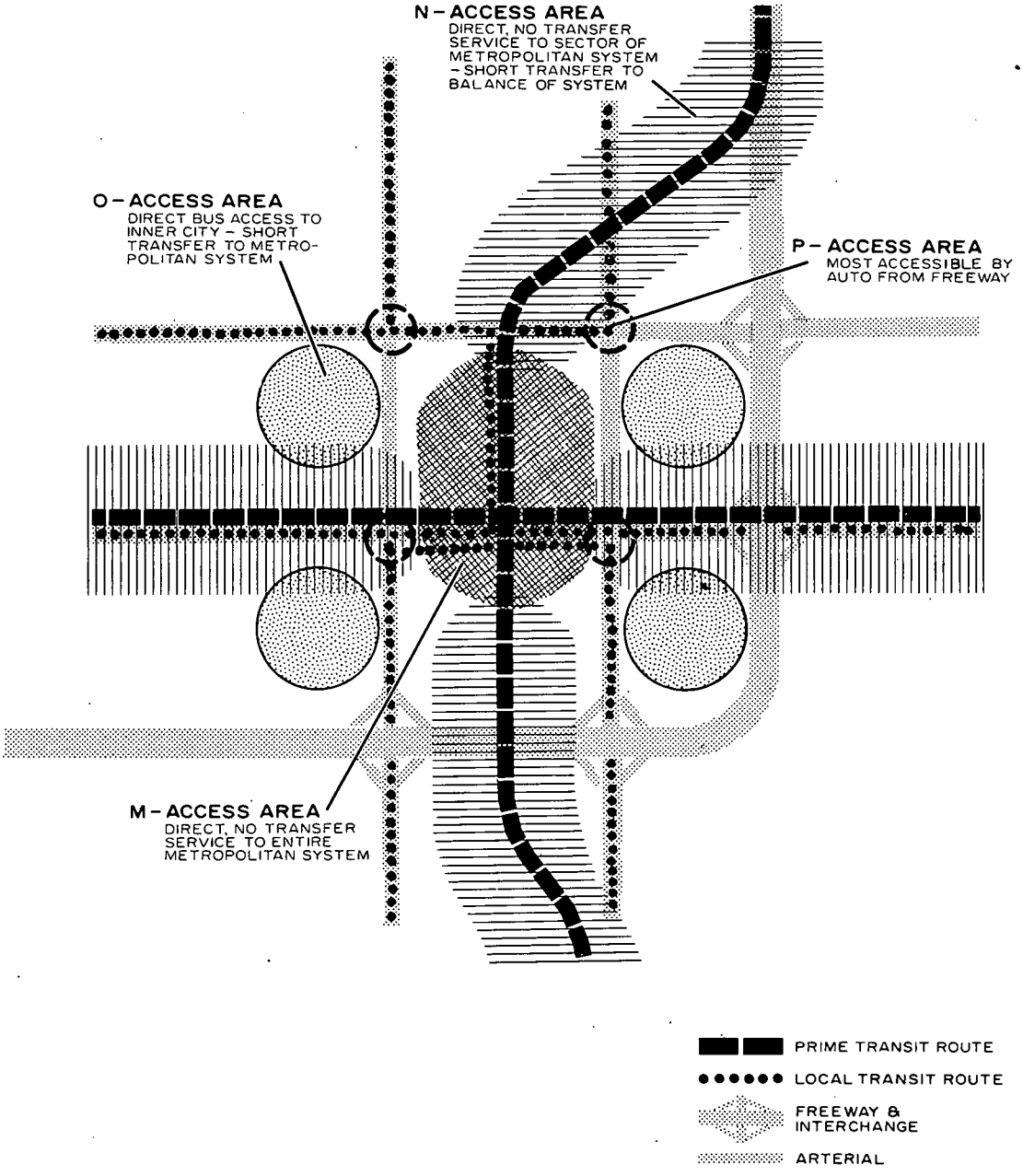


FIGURE 11 Levels of access provided by highway and transit systems for a small central business district (*51*).

TABLE 6

ESTIMATE OF LOCATIONAL REQUIREMENTS FOR VARIOUS CENTRAL AREA LAND USES (*51*)

Land-Use	Access Areas (See Figure 11) M	N	O	P
Retail Stores				
Department	X	-	-	-
Specialty	X	x	-	-
Apparel	X	-	-	-
Heavy-Durable	-	-	X	x
Offices				
Multipurpose	X	-	-	-
Single-Purpose--Including Government	x	X	-	-
Hotel-Conference-Entertainment				
Major Hotels	X	X	-	-
Conference-Meeting	x	X	-	-
Auditorium-Arena	-	X	x	-
Stadium	-	X	x	-
Theaters	X	X	-	-
Services				
Utility	-	-	X	x
Business	-	x	X	-
Printing	-	x	X	-
Parking	-	-	-	X
Intercity Terminals	-	X	-	x
Housing				
High Density	-	x	X	-

X: Probable best location. x: Alternate location

TABLE 7

APPROPRIATE PUBLIC ACTIONS IN DIFFERENT MARKET SITUATIONS (*36*)

Public Actions	Market Situation Strong	Uncertain	Weak
Cost Reduction			(2)
Property Writedowns			X
Tax Exemptions and Abatements			X
Demand Creation			(1)
Public Lease of Space			X
User Financing			X
Public Improvements (e.g., Convention Center, Fare Free Concourse Public Garages)		X	X
Land Acquisition	(1)		
Supplementary Purchase for Transit			
Supplementary Condemnation for Transit			
Holdout Condemnation	X	X	
Public Financing Mechanisms			
Federal Grants		X	X
Special Tax Districts	X		
Tax Increment Financing	X		
Risk Assumption		(1)	
Loans		X	
Guarantees	X		
Equity Participation			X
Special Zoning	(2)	(2)	
Special District		X	
Bonus or Incentive	X	X	
Floating Zones		X	
PUDs		X	
Conditional	X		
TDR	X		
Transit-Related Incentives			
Coordinated Planning of Transit Access	X	X	X
Coordinated Construction	X	X	X
Other			
Public Development			X
Jawboning		X	

Note: The numbers in parentheses represent the most appropriate public actions in the author's view.

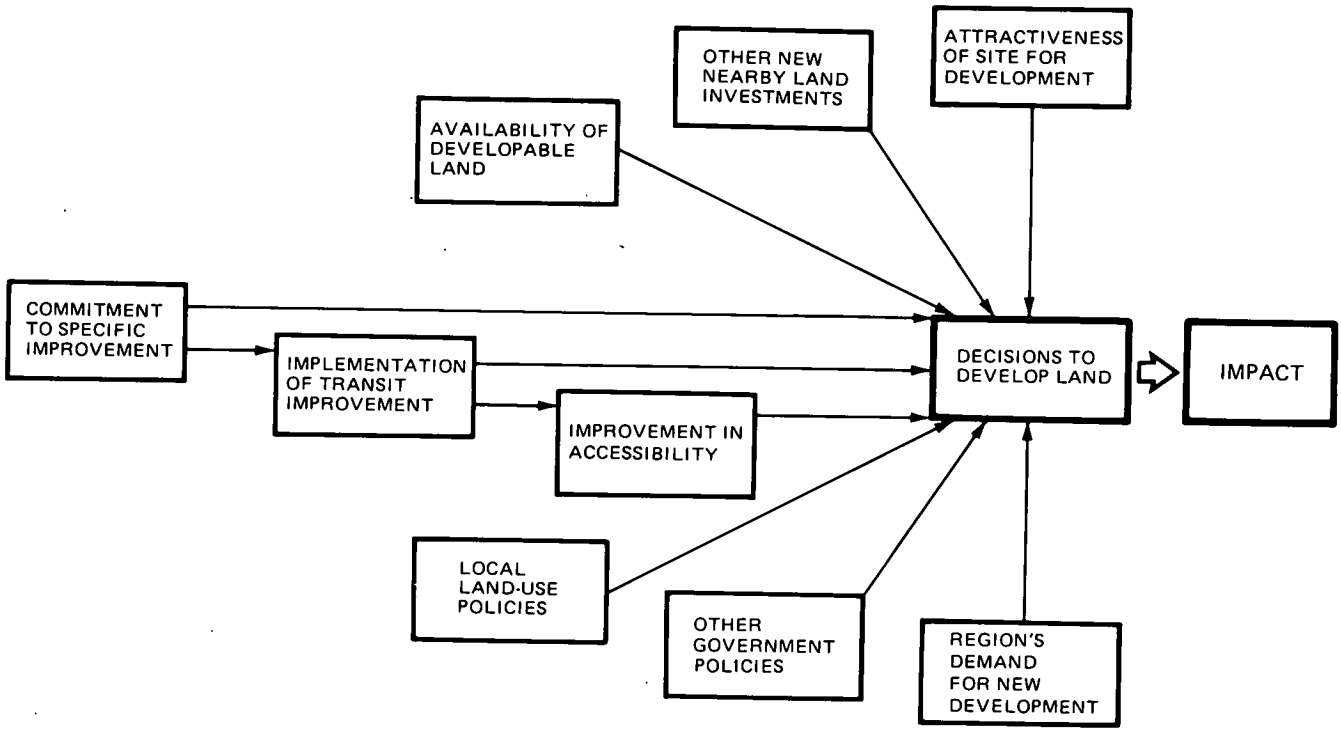


FIGURE 12 Major factors influencing land use (*34*).

and land use. The benefits of such coordination have been documented to some extent (*33–35*); however, most efforts are in the early stages of implementation and results are not yet available. Some preliminary conclusions are summarized below.

1. The limited area around a prime transit stop should be used carefully. Insofar as possible, only land uses that would benefit from access to prime transit should be permitted in the area.
2. The amount of area directly related to a transit stop is determined by the distances most persons are willing to walk. Studies indicate that usually this will not exceed 0.25 mile. However, activities with entrances within 1,200 feet of the stop area may allow parking, open space, or other support functions to be located farther away.
3. Transit stops should not be located where highway interchanges will absorb land within approximately 0.25 mile of the stop or where freeway traffic will conflict with transit collection (feeder bus) and park-and-ride movements.
4. Where possible, provision should be made for transit users to move directly from transit stops into structures associated with adjacent land uses or into collection system vehicles. In some instances, this may be achieved by providing air-rights development over transit rights-of-way.
5. Entrances to activities that attract constant, high volumes of visitors or customers should be located within 400 to 600 ft of the transit stop. Entrances to major employment or school destinations should be located with 800 to 1,200 feet of the stop. Activities involving occasional, heavy visitor use with extensive parking, such as a stadium or arena, may be located 1,000 ft or more from the stop.
6. Parking space (for park-and-ride facilities) should be located within 600 to 800 ft of, and with direct access to, the transit stop. The number of spaces should be limited to be consistent with the capacity of access streets and competition for the use of streets and land.
7. Many factors other than the provision of transit will influence the type and intensity of land use around transit stations. Several of these factors must be manipulated if land uses are to reflect and support the transit center adequately (*34*). (see Figure 12).
8. A variety of public actions may be appropriate to help shape land use around stations or terminals, depending on the strength of the market. Table 7 summarizes the results of an analysis of this subject (*36*).
9. Public action to produce compatible and supporting relationships between terminals and land uses may be one of the most efficient ways to generate increased ridership on transit systems.

CHAPTER THREE

STRATEGIC NEEDS

If, as appears to be the case, there is much to be gained from closer coordination of TSM and LUM, and from the application of LUM to achieve TSM objectives, how can greater coordination be achieved? The advantages of coordination have been recognized for many years (although not necessarily always documented through research). This recognition is the basis for many of the concepts and standards that have been included in zoning and subdivision regulations and in principles for the arrangement of streets and land use. Where new development is undertaken, such concepts and principles are often (although not always) employed. And where they are employed, the results are usually very successful in terms of safety, maintenance of capacity, buffering of land use, and economy. However, even with such examples of success, it is difficult to obtain widespread application of such practices, especially in older, developed areas. As a result, many conflicts between land use and transportation are being created, and little is being done to reduce those that already exist.

There are many obstacles to the coordination of TSM and LUM and the use of LUM. Perhaps most significant is a lack of understanding of the potential benefits of coordination in real economic terms. The impacts of congestion and conflict on both transportation and land use are very costly. Often there is a need to build whole new bypass routes, at great expense, to replace those routes that have become congested. In addition, miles of obsolete and blighted strip land use often result, which in turn devalues adjacent areas. Thus it is apparent that the benefits of coordination can be tremendous, in terms of both increasing land values and preventing loss of existing values.

In newly developing areas, coordination can often be achieved at relatively little cost, either to "transportation" or to "land use." In fact, the benefit of a transportation improvement is often viewed as more than offsetting a land use cost. Property owners may be willing to accept limitations on access, the imposition of special design standards, or even the loss of some land in order to obtain the benefit of an overall improvement in access. However, in built-up areas, where access is already provided and land ownership is fragmented, the benefits of transportation improvements may seem marginal, and the costs, especially those associated with limitations on or changes to land use, may seem to fall unevenly upon property users and owners.

This perceived inequity is a major obstacle to improvements that affect the use of or access to property. If greater coordination of TSM and LUM is to occur, much more must be known about the indirect costs and benefits of possible actions, and ways must be found to assure reasonable equity in their application.

Another obstacle to coordination is the separation of funds to be used for transportation and land development purposes. The only widespread funding program providing for the simultaneous treatment of transportation and land use has been urban development or renewal. These programs were used extensively to correct deficiencies in the relationships between land use and streets. Since the withdrawal of federal support for renewal, it has been difficult to obtain funds to undertake comprehensive improvement of streets and related land use. Funding, when available, is used for one or the other, but not for both. The added work of obtaining and coordinating funds from several sources has all but stopped efforts to plan or complete such projects.

Within limits, communities can undertake coordinated efforts using local resources, such as tax increment, special assessment, and general fund financing. However, except in unusual situations, the increased taxes generated by a project are not likely to be adequate to cover extensive transportation improvements. In most instances, the benefits of an improvement are so widespread that it would be unfair to lay the entire cost on a limited area through special assessment. And improvements solely through the general fund could be equally unfair and thus politically unacceptable.

If the coordination of improvements to transportation and land use is to be achieved on any significant basis, some acceptable and simple funding mechanism must be found. The current separation of funds—and of planning and implementing mechanisms—is bound to perpetuate independent and uncoordinated action.

If these obstacles are to be dealt with, progress must be made on two fronts. First, further research is necessary. Information should be disseminated to demonstrate the importance and value of the benefits that can be achieved. Second, funding mechanisms need to be developed that will allow an acceptable and equitable distribution of costs in relation to benefits and will produce the monies necessary to make significant progress. At the very least, the process of mingling funds from various sources (e.g., transportation and economic development) to accomplish coordinated, joint improvement should be made less difficult.

The needs discussed above apply to all of the operating environments discussed in this report. However, they are probably most significant in corridor or linear situations where benefits are most diffuse. Concepts of renewal and redevelopment must be developed and applied to linear environments, such as those related to arterial routes. Both institutional and funding mechanisms are required. Such mechanisms are also needed in downtowns, at activity centers and mode change points, and in residential neighborhoods. Only if they are developed and placed in operation can we expect to see the achievement of significant benefits of the coordination of TSM and LUM.

CHAPTER FOUR

CONCLUSIONS

GENERAL

Deliberate Attempts to Coordinate

Few documented attempts to coordinate TSM and LUM on an area-wide, corridor, or program basis have been identified. Most coordination is in the context of comprehensive or project planning and is not associated with formal TSM planning or programming. The few efforts that have been identified are in the early stages of implementation and no evaluations are available. Substantial coordination is occurring outside of the context of formal TSM programs in the normal administration of zoning and capital improvement programs and in publicly aided redevelopment.

Jurisdictional Barriers

Responsibilities for transportation and land use are almost always separated not only by department of government but also by governmental level. Thus TSM planning, especially on a corridor or area-wide basis, is almost always in the hands of a transportation agency, often at a state or metropolitan level, and is separate from LUM, which is normally a municipal function. This separation reduces the potential for coordination of TSM and LUM. Usually, mandates for TSM planning are not paralleled by mandates (and funds) for LUM, and thus there is little opportunity for coordination.

If greater coordination of TSM and LUM is to occur, jurisdictional barriers must be overcome. Because of the small scale of much TSM action, it should be possible to begin to carry out TSM and LUM at the same (local) governmental level—if the problems of jurisdictional or departmental barriers and the categorization of funds are solved.

LAND USE

Land Use Tools

The tools that can be used by public agencies to control or affect land use relative to transportation are small in number but powerful in impact. They include zoning and similar types of regulations, redevelopment, and the acquisition and control of land for public purposes, such as for parking and parks (see Chapter 1). Zoning and subdivision controls can be extremely effective and are essential to assure adequate street rights-of-way, setbacks, the provision of off-street parking, etc. However, they are difficult to apply retroactively to developed land and thus are of limited value on a short-term basis in built-up areas.

Redevelopment is another powerful tool that has been used to upgrade street systems and parking facilities in many older areas. It can also be effective when accomplished by the private sector with the simultaneous application of zoning and similar controls. Unfortunately, opportunities for land assembly and public redevelopment are sharply limited by the availability of public funds as well as by legislative restrictions on the eligibility of areas subject to such action. Private redevelopment is limited by the costs of land assembly, market conditions, etc. However, there are often significant opportunities, especially over the long run, for both public and private redevelopment in corridors where changes are being generated by transportation facilities.

Creative action in zoning and in the application of redevelopment incentives can increase the potential of these land use tools. Such actions can include the establishment of special zoning categories to be applied in areas around transportation facilities and the granting of special land assembly powers, tax reductions, or other incentives to encourage redevelopment. Some of the experience being gained in the zoning of land related to new transit systems may be helpful. The "Chapter 353" tax abatement and redevelopment legislation in Missouri and the "tax increment financing" of redevelopment in a number of states have been successful, although they have not been applied specifically to transportation environments. The manipulation of parking requirements to achieve certain transportation objectives (e.g., discourage automobile use) may be effective in influencing land use actions, especially where this represents a relaxation of established standards. The acquisition of land for public purposes, such as for a park or for parking facilities in key locations, and the resultant control and design of the transportation environment, can be an effective way of achieving transportation objectives.

Deferred Effects of Land Use Actions

Except in the case of rapidly developing areas or large projects, the effects of a land use action on the efficiency or effectiveness of transportation may be slow to emerge or difficult to discern. Where the objectives of TSM are short term, it may be difficult to associate difficult-to-implement land use actions with TSM programs, which can be an obstacle to the inclusion of land use actions as part of TSM. However, where there are opportunities to change land use and to redesign the transportation environment, dramatic, short-term impacts are possible. Where land use changes are accompanied by consolidation and control of driveways and/or improvements in the design of access and movement systems, significant, although highly localized, improvements can result. Where a series of coordinated projects can be undertaken, the results can be substantial.

Land Use Stimulation of TSM

Many TSM actions are taken in response to such land use concerns as:

- Intrusion of nonresidential traffic or parking into a residential environment.
- Shortages of parking space and the high cost of providing such space.
- Meeting air-quality standards.
- Assuring adequate access for new development.
- Improving pedestrian environments related to shopping, institutional, or similar functions.
- Reducing noise, glare, unsightly visual aspects, and other negative impacts of traffic.
- Difficulty of attracting employees or customers.
- Desire to consolidate land for development.
- Maintaining or improving safety in relation to land use activities (usually pedestrian movement).
- Reducing employee or customer travel costs.

Many of these concerns are acknowledged as reasons for action within formal TSM programs.

Documentation of Land Use Impacts

There is substantive documentation of the effects of small-scale land use actions (e.g., the effect of consolidation of driveways) on transportation (*29, 37*). Careful planning and control of land along a major street or around transit stops can have a significant impact on these facilities. Numerous small individual actions can have a substantial cumulative impact on transportation. However, if institutional barriers are to be overcome and land use actions are to become an accepted element of TSM, the value and impact of land use actions and the ways they might be best used will have to be developed and documented.

TSM

Use of TSM To Achieve Land Use Objectives

Many TSM actions are undertaken to achieve land use objectives (it could be argued that all TSM actions are designed to serve land use). In general, all TSM actions affect land use either directly through changes in access and reductions in conflict with vehicular movement or pollution, or indirectly through changes in general congestion and travel cost and mobility. In many cases, land use objectives are cited as the reasons for undertaking TSM actions. However, most often, objectives are stated in narrow "transportation service" terms, and real objectives, such as a strengthened economy, are not articulated.

There is some indication that the combination of growing congestion, continued population and employment growth, and restricted funds for major new transportation facilities is making employers and public officials more aware of the relationship between mobility and transportation costs and economic development. For example, there is increasing pressure to build more housing close to major places of employment and to encourage ride-sharing to reduce congestion (and travel costs) not only in large, older downtowns but also in extensive, dispersed employment areas (e.g., San Jose and Phoenix). Employers and investors are increasingly aware of the higher costs of doing business in areas of congestion and are making locational (land use) decisions accordingly, as well as participating in TSM programs (*24*).

Impacts of TSM on Land Use

There is growing evidence of the impacts of TSM actions on land use, especially where the impacts are direct. Measures most often used include indices of air and noise pollution, accident reduction, and personal perceptions. The relative cost of parking space and other means of access sometimes may be measured as an indication of some of the economic impacts of a particular set of actions. Much of the impact analysis in this area is a part of environmental studies. Unfortunately, the results of these studies are widely scattered, may have been derived using different methodologies, and have not been assembled and compared to permit overall conclusions.

TSM Stimulation of Land Use Action

Although there are few examples of land use actions associated with *formal* TSM programs, many actions are taken in response to TSM concerns. Examples of these concerns and potential actions include:

- Poorly located driveways or pedestrian crossings along transportation routes. *Actions:* restrictions on driveways, double-frontage lots, etc.
- Conflicts between loading and delivery activities and parking on transportation routes. *Actions:* off-street parking and loading requirements, etc.
- Encouragement of transit use. *Actions:* higher density development along transit lines, reduced parking-space requirements in transit-served areas.
- Segregation of types of traffic. *Actions:* separate industrial, commercial, and residential areas established through zoning.
- More efficient use of existing transportation and parking facilities. *Actions:* increased development densities, mixed-use development.
- Avoidance of the need to extend transportation services. *Actions:* zoning for limited use and density.
- Reduction of vehicular travel needs. *Actions:* mixed-use development, efficient arrangement of land use.

RESEARCH NEEDS

There is little current research on the relationship between TSM and LUM. The only sustained work in this area is being conducted by the Institute of Transportation Studies at the University of California at Berkeley (*19, 38–40*). Related work on relationships between the form, density, and mix of

land use and transportation has been conducted at the University of Washington (*6, 41*). Relationships between residential patterns and densities and travel and modal split are continuing concerns of researchers connected with the Regional Plan Association (*42, 43*). Work is also being conducted by Heeter (*44*). Other recent studies also indicate some scattered and fragmentary interest and work in this area (*10, 14–17, 45–47*). Most of this work is concerned with analyzing transportation actions in terms of the impacts on land use; relatively little attention is given to the effects of land development on transportation.

As we move into an era in which resources for investment in transportation facilities become increasingly scarce, land use management planning to preserve the capacity and effectiveness of transportation investments will become more important. Thus it will be essential to develop an understanding of the types and impacts of appropriate land use actions. Further research of the type reported by Schneider (*6, 41*), Heeter (*44*), and Pushkarev and Zupan (*42*) is needed, and the techniques used by May et al. (*16, 41*) should be applied to the examination of the impacts of LUM on transportation. Current work that examines the impacts of mixed-use development on the demand for parking space, sponsored by the Urban Land Institute, should be extended to identify other benefits from such land use relationships.

In addition to demonstrating benefits, further work is needed to establish and disseminate concepts, principles, and standards for coordination in the design of transportation and land use features. The work of Tri Met in Portland, Oregon, provides an example of what can be done in this area (*25*). Work conducted in the 1960's (*48, 49*) and recent reports issued by the FHWA on residential street planning (*18*) provide a basis for future study.

In summary, some efforts are currently being made to coordinate TSM and LUM. However, these efforts are seldom related to formal TSM planning and, when they are, they rarely include land use actions. There is little documented research to support the implementation of land use actions to acheive TSM objectives. The lack of research-based evidence of benefits inhibits the application of LUM techniques and may allow a misapplication of some measures. The need for such research will grow as greater pressures are exerted upon communities and developers (as in San Francisco) to reduce the impacts of land development on transportation systems or to compensate for such impacts as part of the development process. The need for research will also increase as it becomes obvious that the unilateral undertaking of TSM without supporting land use actions may not be sufficient to meet future transportation needs.

Finally, a method of funding must be devised that will allow TSM and LUM actions to proceed jointly. This could be based on the urban renewal program, which permitted the simultaneous treatment of land and transportation facilities or the policies of certain port authorities. Some downtown development corporations are also beginning to take on this dual role. Wherever possible, the techniques devised for funding should allow for the capture of benefits and the allocation of costs to those most closely affected. Widespread and meaningful coordination of transportation and land use will be achieved only if funding problems can be resolved.

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