NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
REPORT 31

A REVIEW OF TRANSPORTATION ASPECTS OF LAND-USE CONTROL

HIGHWAY RESEARCH BOARD
NATIONAL RESEARCH COUNCIL
NATIONAL ACADEMY OF SCIENCES—NATIONAL ACADEMY OF ENGINEERING

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SUBJECT CLASSIFICATION:
HIGHWAY DESIGN
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URBAN LAND USE

HIGHWAY RESEARCH BOARD
DIVISION OF ENGINEERING NATIONAL RESEARCH COUNCIL
NATIONAL ACADEMY OF SCIENCES—NATIONAL ACADEMY OF ENGINEERING 1966

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 Officials initiated in 1962 an objective national highway research program employing modern scientific techniques. This program is supported on a continuing basis by Highway Planning and Research funds from participating member states of the Association and it receives the full cooperation and support of the Bureau of Public Roads, United States Department of Commerce.

The Highway Research Board of the National Academy of Sciences-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 departments and by committees of AASHO. 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 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 responsibilities of the Academy and its Highway 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.

This report is one of a series of reports issued from a continuing research program conducted under a three-way agreement entered into in June 1962 by and among the National Academy of Sciences-National Research Council, the American Association of State Highway Officials, and the U. S. Bureau of Public Roads. Individual fiscal agreements are executed annually by the Academy-Research Council, the Bureau of Public Roads, and participating state highway departments, members of the American Association of State Highway Officials.

This report was prepared by the contracting research agency. It has been reviewed by the appropriate Advisory Panel for clarity, documentation, and fulfillment of the contract. It has been accepted by the Highway Research Board and published in the interest of an effectual dissemination of findings and their application in the formulation of policies, procedures, and practices in the subject problem area.

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FOREWORD

By Staff

Highway Research Board

The contents of this report will be of particular interest to the transportation planner and of substantial interest to the highway administrator, the legal specialist, the traffic engineer, and the highway design engineer. The results of this research will provide the reader with a better understanding of the effectiveness of existing land-use controls and of other techniques which may be considered for insuring the continuing utility of the transportation system.

It is believed that land-use controls, properly administered, should protect and enhance the public investment in transportation. Zoning, subdivision regulations, and all other land-use controls are intended to shape the pattern of urban development. As a result, they affect the utility of the transportation system. If land-use control decisions are made without understanding and considering their effect on transportation, the results may be harmful to the community and the area as a whole. Inasmuch as transportation facilities have long development times, the stability of land-use controls and land-use plans are key factors which influence the validity of the transportation plans.

The study reported herein was concerned primarily with a literature search and a canvass of selected highway departments and other agencies concerned with transportation planning. The primary objective of the research was to provide a better understanding of the effectiveness of existing land-use controls and to draft an outline for feasible further study to establish principles or guidelines for developing controls that will be effective in protecting the utility of the present and future transportation investments in urban areas.

The urban structure is reviewed in this report to illustrate how the framework changes over time. It is noted that the transportation system, which is a basic part of a region, can survive several cycles of land use. An analysis is made of existing land-use controls with their objectives, limitations, and stability. The highway system is studied with regard to access control and its design in relation with land uses and their respective traffic generation characteristics.

The study concludes that many of the existing land-use controls are dynamic and changing, and that further evaluation of the significance of these changes on the transportation facilities is needed. Because of the comprehensive nature of recent planning programs, future community plans and land-use controls may be more realistic and stable than in the past.

A balance is required between traffic movement and land service to provide maximum transportation capability without impairing necessary access. Design of the highway facilities should be coordinated with land development and the land-use

decisions should be accompanied by an assessment of the transportation improvements needed to provide the required service. Land-use controls could be used to achieve a mix of land uses with complementary traffic generation characteristics and also to distribute major generators to minimize traffic concentrations. However, over-all community objectives, including non-transportation factors, must be evaluated in the development of workable principles and guidelines.

Major problems with most existing highways can often be traced directly to the lack of access control. This is particularly true in the vicinity of freeway interchanges. Through the expanded use of land access controls and special geometric design, protection can be built in the highway which may be more dependable than existing land-use controls in preserving the utility of the transportation system.

This report presents a research outline for further study of the transportation aspects of land-use controls. The next step seems to be the establishing of principles and guidelines for developing land-use controls and other techniques that will be effective in preserving the utility of transportation systems.

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ACKNOWLEDGMENTS

A project of this scope is beyond the capabilities of any single professional discipline and requires the cooperation of many organizations and individuals in order to have maximum relevance. Primary responsibility for this research was assigned to the Traffic and Transportation Division of Victor Gruen Associates under Harold Marks, Director, and Salem Spitz, Head of Traffic Research. Other active participants in the study included Ben H. Southland and Edgardo Contini, Partners, who supervised the project; Frank Hotchkiss, Dan Branigan, and Ki Suh Park, Directors of Planning, who were staff consultants on planning matters; Allen M. Rubenstein, Head of Traffic Planning; and Joseph Belser, Head of Economics.

Particular acknowledgment is extended to the many public officials, engineers, planners, and attorneys who were consulted during the canvass of highway departments, and to the planning agencies, university researchers, Federal, State, and local agencies, private consultants, and other individuals and organizations, who contributed their time and background of experience so that the professions concerned can achieve a better understanding of the problem. Their interest and invaluable assistance are appreciated. Gratitude is also expressed to the libraries that supplied publications for review and to the many authors from whose works relevant information and findings were extracted, providing the basis for an understanding of the problems involved.

A REVIEW OF TRANSPORTATION ASPECTS OF LAND-USE CONTROL

SUMMARY

An urban region has an identifiable physical structure that changes slowly over time. Its basic elements are the physiography, major public activity centers, and the transportation system. These elements shape the area with long-term influences which are not necessarily permanent, but often survive with minor change through several cycles of land use. In contrast, land use is relatively dynamic and ultimately reflects the market place. The transportation system as a structural element must, therefore, ultimately accommodate unpredictable future land uses.

Normal land-use control techniques fall into four major groups—eminent domain, police power, contractual agreements, and nuisance law. Land-use controls have both a positive and a negative application. The positive application attempts to effectuate a desired land-use plan. It is an implementation device to achieve given community objectives. The negative application prevents hazards to the public health, welfare, and safety.

Zoning is the police power which attempts to control the location, size, and intensity of development as well as the type of land use. It reflects short-term land-use desires of the community. It is not commonly intended to establish permanence, but rather to stabilize land use for reasonable periods. The basic disadvantage of a police power is instability, because it is subject to variance as economic and political pressures develop. Currently, zoning has only limited value in providing stable land development practices. Because the time scale of a highway plan may encompass 40 years, the zoning at the time of planning may exercise little influence over the long run.

A general plan permits a more positive approach to land-use control. It outlines the future needs of the community and can reflect dynamic and changing land uses in predicting future transportation needs. The general plan is effective only if it is based on realistic community goals and economics, and is subject to modification and adjustment as community goals change. It is not a precise document and is not designed specifically for stability. Zoning, which should not be confused with the general plan, provides one of the means whereby the general plan is implemented.

In addition to the common land-use control devices, there are two other techniques—geometric design of the highway and access control—which can greatly affect the relationship of land use to the highway. With these techniques highway systems can be designed with intrinsic protection, and self-integrity is usually more valuable than reliance upon external controls which may have less long-term stability.

Establishment of stable land-use controls is theoretically attainable in a controlled economy, as in European countries where governmental control is more stringent. In a free economy, however, such control cannot usually be realized because of economic and political pressures which frequently upset the stability of an over-all plan. The only stability that has been observed is in those communities where no

appreciable growth is taking place—where land-use controls simply mirror the status quo. In larger communities most land-use controls prove to be dynamic and constantly changing. The market place will eventually assert itself, and the significance of zoning diminishes when it grows distant from economic reality. In most areas studied, this is reflected in the prevalence of rezoning, which has reached 80 to 90 percent of the requests in some communities. However, further study of the significance of these changes is needed before an evaluation can be made as to their over-all effect on transportation facilities.

Where land-use controls are utilized as a means of implementing community objectives, they frequently prove ineffective if the goals are not realistic. Frequently, economic determinants are of greater importance than land-use controls in determining the actual intensity of development. Although land-use controls foster stability by damping rapid changes in land utilization, they frequently do not reflect economic reality in the normal competitive situation.

Recent widespread interest and activity in transportation studies and planning programs for all larger urban areas indicates that future community plans, and land-use controls which are intended to effectuate them, will be much more realistic and stable than in the past. Further development of principles and guidelines to foster economically sound and practical planning programs to implement realizable community objectives can improve stability materially.

In actual practice, land-use developments may be justified by the community on the basis of over-all values created; the highway, as a service facility, may then be required to accommodate the transportation demand. However, land-use decisions should not be made without assessing the improvements that may be required to provide the needed service. Quantitative and qualitative relationships appear to be needed by which the effects of specific land-use decisions on transportation can be determined.

Although transportation systems were formerly considered largely as service facilities, they have more recently become one of the active elements which control and direct growth. The freeway is proving to be one of the most potent implementation tools available to change the face of the community. The use of highway location and design controls as a device to control land-use development appears to offer valuable opportunities to effectuate desirable practices.

New circulation system trends indicate that future facilities will have greater capacity and efficiency, while using a lesser proportion of the land area for public streets. In contrast, more land will be needed for terminal facilities, private internal circulation, and other elements of the transportation system which have previously not received adequate attention.

The highway often appears to be a more permanent part of the community than the land use or the controls that are exercised. The life of transportation facilities implies that greater flexibility should be built into the network to accommodate unknown future conditions and changing requirements. A program of highway development staging could thus correspond with changes in land use that occur during the life of the system. Some of the implementation tools which can provide design flexibility and intrinsic protection for the highway include right-of-way reservation, an expanded concept of access control, and highway design controls. The preservation of transport utility seems to lie only partially in the control of development, and more in physical design controls.

Current circulation systems consist of a composite of three separate systems which were developed at different stages in the growth of the communities. This historic composite has not been developed on the basis of detailed functional analy-

sis. The absence of functional distinction among circulation facilities in the past has resulted in premature obsolescence of many existing facilities.

The two major functions of land service and traffic movement are accommodated to varying degrees by each of the common highway functional classifications in use today, including the freeway, arterial, collector, and local service street. The radical change now taking place in travel patterns, resulting from the freeway system, emphasizes the need for re-evaluation of the functional utilization of various facilities. Little guidance is currently available as to what should constitute an optimum mix of these facilities for a balanced highway system. The objective of balance between controlled-access and free-access facilities would be to provide maximum transportation capability and safety without impairing necessary land service. The concept of optimization could be extended to seek the combination of circulation and terminal facilities that would provide maximum access and circulation capacity with intrinsic protection at minimum cost, and still provide the required access to abutting properties. The weakest links in the system appear to be between different types of facilities. One of the keys to developing improved transportation systems without sacrificing accessibility is the development of a design methodology and controls which will assure successful operation of these critical linkages.

Most of the problems of existing highways can be traced directly to the lack of access control. The deterioration and functional obsolescence of relatively new arterial facilities is largely caused by uncontrolled abutting developments. The objective of access control is to protect the utility of the highway and both inadequate and excessive access can be detrimental to that utility. Frequently the problem is not so much the number of vehicles entering as the number of points of entry and their design.

Access prohibitions to freeways are a general fact; however, access restrictions on other highways and streets have not been generally accepted as yet. Some states have extended the acquisition of full access rights to almost all new facilities. In most cases, however, control of access is exercised under the police power. Some authorities consider the application of access controls as a governmental police power comparable to zoning, which is likewise intended for the protection of health, safety, and welfare. The exercise of design and geometric control of access acts in the same manner as land-use zoning protects the public interest.

Design standards and controls are needed which would provide maximum highway efficiency and safety, and still offer adequate land access opportunities. Some agencies have developed standards of geometric design for the purpose of exercising access control on local arterial systems as well as on state highways. Frequently, direct vehicular access is prohibited between residences and arterial highways, and there are often stringent controls on driveway location for other land uses. Many agencies consider that good sense in highway development control can be beneficial to the land developer as well as to the community and the highway user.

Presently, the degree of control exercised by governmental agencies varies considerably between jurisdictions and is largely based on precedent rather than a sound analytical basis. One of the problems is how to achieve stable control of access whereby built-in safety and capacity will not be curtailed as pressure for additional access develops. A balance must be achieved between over-control and under-control, in order to be reasonable and acceptable and to remain as a stable and effective device. It is necessary to establish the relative effectiveness and applicability of each type of control with relationship to each type of land use.

Another vital need is to minimize the effects of existing deteriorating conditions with regard to current facilities. The development of procedural methods and

acceptable practices for access control techniques in conjunction with existing facilities could significantly improve route capacity and efficiency without seriously curtailing access to abutting properties.

Transportation studies have concluded that traffic generation for various types of land uses and for adjoining large areas is surprisingly similar. Some authorities have concluded that it is possible to provide optimum mixtures of land uses to provide more balanced utilization of the transportation system by taking advantage of dovetailing directional orientations and peak-hour generation characteristics. Complementary types of land uses could be located in adjoining areas around freeway interchanges and along major arterials. A better understanding of the differing traffic flow characteristics for different land uses could provide a valuable aid for guiding locational practices in order to achieve balanced traffic flows.

The theory of optimization of traffic flow might conclude that the most efficient city form, from a transportation viewpoint, is the spread city where uniform densities and disturbances of land-use types would result in a uniform pattern of traffic flow and an equalization of loads. Communities are currently developing a relatively uniform spread in suburban areas so that in the future there should be a more efficient utilization of the over-all transportation system. This may not, however, represent the most effective community from a planning standpoint. For local planning purposes there are obvious advantages in considering a balance of land uses in localized areas in order to achieve complementary traffic flow patterns, if this can be made compatible with over-all community objectives.

Techniques developed for estimating future traffic generation are based on relatively consistent total trip generation for adjoining large land areas, based on the conclusions of available transportation studies. Most researchers have concluded that, on a gross basis, population, commercial centers, and industrial employment will be consistently distributed. It is, therefore, possible to predict over-all circulation requirements for most communities and to design a transportation system which will accommodate the demands. With the possibility of increased densities in the future in some areas, it is appropriate to determine the factor of safety that is built into the system as a guide to permissible densities or, alternately, what additions or improvements may be needed to accommodate additional demands in the future in these particular areas.

Individual major traffic generators may create excessive traffic demands on highways in their immediate vicinity, but the effects on the over-all system decrease rapidly beyond the immediate point of contact with the highway. The principal design concern is, therefore, the ability of a specific highway section to absorb traffic concentrations at points of access with the development. Another valid consideration is the possibility of traffic overlap between adjoining developments, whereby traffic concentrations would become cumulative. A basic design problem is the accommodation of traffic generators of the future, the locations of which cannot be readily predicted, but whose effects are generally localized. This implies a solution whereby the highway system is sufficiently flexible to accommodate such unknown future demands, with sufficient intrinsic protection built into the highway so that such concentrations can be accommodated.

Over-concentration of particular land uses can overload the system beyond the ability of the network to absorb the traffic generated. Criteria are needed to establish limits of concentration for each type of land use to determine what size development units can be absorbed into different types of abutting highway facilities. Land-use controls would then have added significance in governing permissible development densities in direct relationship to the capabilities of abutting highways.

Such controls could also provide guidance in regard to a suitable mix of land uses which would be complementary in traffic generation characteristics. More sophisticated zoning practices could correlate and optimize land-use locational distributions to minimize traffic concentrations and achieve greater balance.

There is a wide difference between practices of the various States in regard to the treatment of freeway interchange areas. The interchange area is not necessarily a physical dimension, but a functional area which includes that portion of the community that is directly affected by the existence of the interchange. The various States have extended access controls beyond the ramp terminals for distances ranging from 100 to 1,000 ft, but such extension along intersecting highways is subject to controversy. Most officials believe that the extension of some type of access restriction should be considered. The number of access points should be minimized and special design consideration given to points of entry, so that concentrations of traffic entry are properly spaced in relation to interchange ramps.

Although the prevailing belief is that heavy traffic generators should be located farther away from the interchange area, there is some question as to the desirability of such practice. The principal concern is with the location of access points and the intensity of the generator, rather than with the physical location of the facility itself. The absence of effective implementation devices at this time to control access location and development intensity, is the principal basis for the desire to locate the facility farther away from the interchange.

The land-use controls within the entire functional interchange area, including the land-use mixture, the intensity, and relative placement, affect the efficiency of freeway interchange operation. The development of access and design controls would help eliminate current problems in the vicinity of freeway interchanges. The capacity of the interchange and of the cross street within the functional interchange area is also of major influence.

Studies of premature obsolescence of freeway interchange areas have concluded that particular design types provide greater flexibility in accommodating future development. Although the problem is usually attributed to the development that takes place around the interchange, the problem can sometimes be avoided through design methodology. Particular interchange designs (such as the expanded diamond, partial cloverleaf, and one-way frontage roads with slip ramps) appear to provide greater flexibility to accommodate future development and resolve some of the access problems normally encountered at interchanges. Many effective solutions require coordinated design of both the highway facility and the land development, whereby built-in protection is provided for the highway and effective access is provided for the development. This can eliminate the imposition of stringent restrictions on the land use itself which frequently prove impracticable.

New approaches have been developed in dealing with the interchange problem, one being the special interchange zone established in some States. The objective is the protection of the freeway interchange from excessive traffic generation, and the control of access location and volume of entering traffic. Some States are seeking similar controls along all state highways to permit the exercise of access and design controls. There is also concern with the internal design of high-intensity generators which affect traffic acceptance rates and can have a considerable effect on the utility of the system.

Some authorities would like to view the transportation function in broader perspective, including the terminal facilities and the highway as an integrated system. Another new concept would extend the highway functional area to include the corridor of influence. The new scenic highway program establishes functional zones

beyond the right-of-way which are subject to various types of control. Some visualize an extension of this functional concept of the highway which could ultimately correct many present deficiencies.

Administration of land-use controls, access controls, and design controls which will effectively preserve the utility of the highway is ultimately involved with implementation techniques. All possible tools and implementation devices which can effectuate stable practices should be reviewed.

Because many nontransportation factors have a substantial influence on decision making, it is essential that over-all community objectives be adequately evaluated in the development of principles and guidelines or their ultimate value will be limited.

CHAPTER ONE

INTRODUCTION

The problem statement for this project states:

"Proper land-use controls, properly administered, protect and enhance the public investment in transportation. Zoning, subdivision regulations, and all other land-use controls are intended to shape the pattern of urban development; they thereby can affect the transportation system. If land-use control decisions are made without understanding and considering their effect on transportation, the results may be harmful to the community.

"Since transportation facilities have long development times, the stability of land-use controls and land-use plans are key factors influencing the validity of transportation plans."

STUDY OBJECTIVES

The study reported on here was to be concerned primarily with Objective Number 1, "To provide a better understanding of the effectiveness of existing land-use controls on the continuing utility of transportation systems," and to draft outlines for feasible further study in the area of Objective Number 2, "To establish principles or guidelines for developing land-use controls that will be stable and effective in preserving the investment in transportation systems."

The current study was "to consist of a literature search and canvass of selected highway departments and other agencies concerned with transportation planning."

RESEARCH APPROACH

search and canvass, for the purpose of compiling all the currently available information and knowledge concerning this problem. Based on the information gathered and an analysis of the conclusions reached, another study to be conducted subsequently would attempt to establish principles or guidelines.

The literature search included more than 100 books, periodicals, and research papers, which were reviewed for the purpose of extracting information that would be relevant to the study. An abstract prepared for each major item covered in the literature search contained a digest of the basic conclusions and other relevant findings. These digests provided the basis for an analysis of the problem.

Considerable material has been written on various phases of this subject, but relatively few of the items provide definitive principles or guidelines that can readily be applied at this time. Much background information is now available, but considerable effort will be required to convert this information into a useful methodology.

The other principal phase of the study involved a canvass of selected highway departments, planning agencies, private organizations, university researchers, Federal, State and local agencies, and knowledgeable individuals who could contribute to an understanding of the problem. The canvass normally involved a visit with members of the agency or organization, wherein the objectives of the study were outlined and a discussion was held with regard to their experiences with this particular problem. Of particular interest were the case histories and local experiences that illustrated various components of the problem. Legislative tools available in particular States as well as agency

trol than others in preserving the utility of the highway system. New devices and techniques for implementing desirable objectives, as proposed by some agencies, were especially valuable.

The early phase of the canvass concentrated on the effectiveness of land-use controls and their interrelationship with transportation. After a number of discussions with various agencies and professional disciplines, it became apparent that the fundamental objective was the continuing utility of transportation systems, and that there were many other factors besides land-use controls that were closely related with this objective. To establish fundamental relationships which could ultimately lead to practicable solutions, it was found necessary to expand the scope of the study to include other related techniques, in addition to land-use controls, that could prove stable and effective in preserving the utility of transportation systems. The study has, therefore, included other factors in analyzing the interrelationships between land use and transportation, whereby the problem could be investigated in a broader context than was originally specified. These other major implications could not be deleted without hindering the broader objectives of the study.

The broadening of the work scope was decided upon after consultation with the administrators of the program. The effectiveness of this broadened approach was later confirmed by discussions wherein the objectives of the project were fully explored, concluding that the broader view was both necessary and desirable.

In keeping with the broadened scope of the study, a revision of the study objectives could be stated as follows:

1. To provide a better understanding of the effectiveness of existing land-use controls *and other techniques* on the continuing utility of transportation systems.

2. To establish principles or guidelines for developing land-use controls *and other techniques* that will be stable and effective in preserving the investment in transportation systems.

The research approach in the study of this broadened objective includes a number of work items beyond the scope of the original research plan. The study deals first with urban structure to establish a framework within which the transportation system and land use can be properly viewed. This is followed by analysis of existing land-use controls, their objectives and limitations, and their stability. The historic development of the highway system, current trends in highway patterns, and various methods of classifying highway functions are then analyzed. Land access controls and design controls are suggested as effective implementation techniques to provide intrinsic protection for the highway facility. Traffic generation characteristics provide an opportunity for load balancing. The freeway interchange problem is analyzed specifically and new concepts are reviewed which provide new opportunities for the future.

The basic intent of this first study was not to provide quantitative or qualitative solutions to the problems uncovered, but rather to attain a better understanding of all the factors involved. An analysis of the interactions between land use and transportation would then provide a general direction for further detailed investigations, from which guidelines and principles could be developed to provide working solutions.

The title of the study implies that it deals with all phases of transportation. This portion, however, has concentrated on highway transportation because this represents the most significant and widespread problem. By understanding the interrelationships between highway transportation and land use, it will set the basic framework for analyzing the effects on other transportation modes. Nonhighway transport modes are also intimately related with land use and significantly affect the utility of highway systems.

Future consideration of these other modes should evaluate their potential effect on land use and on the highway system in those areas where they are applicable, and their interrelationships with land-use controls. In this way the transportation system can be considered as a related network without isolating the highway and nonhighway elements.

SIGNIFICANCE OF THE PROBLEM

One of the greatest concerns of the transportation specialist is that circulation systems currently being constructed may not be adequate to handle future transportation demands in rapidly growing urban areas. The possible breakdown of the freeway-arterial system due to urban traffic concentrations is a specter that haunts much of the current thought on transportation needs of the future. This fear is probably one of the underlying reasons for the current consideration of the potential value of land-use controls to provide assurance that the transportation network will remain operative. Undue concentrations of traffic generation might result in the breakdown of circulation networks now being developed, and the most obvious approach to this problem is to avoid such concentrations. Thus, one of the principal considerations mentioned in the problem statement is the feasibility of minimizing such concentrations.

However, another prevailing viewpoint is that planning considerations which reflect community objectives should provide the principal determinant with regard to development concentrations. This view stresses that transportation is a service function and that the transportation system should serve whatever concentrations the community may wish to develop. The major objective of all planning is to develop an urban design which provides maximum opportunities for the organization of city living. The development of transportation efficiency is one element of this ultimate objective. Although these two views are based on different premises, they both have validity. The current study has both philosophical and practical overtones and it is especially important to maintain a balance between the theoretical and the attainable so that a useful product can result. It is of equal significance to reflect the various professional disciplines that are involved with this problem to assure validity and acceptance of the results.

There should actually be no basic conflict in the achievement of good transportation and good community planning.

beyond the right-of-way which are subject to various types of control. Some visualize an extension of this functional concept of the highway which could ultimately correct many present deficiencies.

Administration of land-use controls, access controls, and design controls which will effectively preserve the utility of the highway is ultimately involved with implementation techniques. All possible tools and implementation devices which can effectuate stable practices should be reviewed.

Because many nontransportation factors have a substantial influence on decision making, it is essential that over-all community objectives be adequately evaluated in the development of principles and guidelines or their ultimate value will be limited.

CHAPTER ONE

INTRODUCTION

The problem statement for this project states:

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"Since transportation facilities have long development times, the stability of land-use controls and land-use plans are key factors influencing the validity of transportation plans."

STUDY OBJECTIVES

The study reported on here was to be concerned primarily with Objective Number 1, "To provide a better understanding of the effectiveness of existing land-use controls on the continuing utility of transportation systems," and to draft outlines for feasible further study in the area of Objective Number 2, "To establish principles or guidelines for developing land-use controls that will be stable and effective in preserving the investment in transportation systems."

The current study was "to consist of a literature search and canvass of selected highway departments and other agencies concerned with transportation planning."

RESEARCH APPROACH

The research plan for the project contemplated a number of work categories, consisting primarily of a literature search and canvass, for the purpose of compiling all the currently available information and knowledge concerning this problem. Based on the information gathered and an analysis of the conclusions reached, another study to be conducted subsequently would attempt to establish principles or guidelines.

The literature search included more than 100 books, periodicals, and research papers, which were reviewed for the purpose of extracting information that would be relevant to the study. An abstract prepared for each major item covered in the literature search contained a digest of the basic conclusions and other relevant findings. These digests provided the basis for an analysis of the problem.

Considerable material has been written on various phases of this subject, but relatively few of the items provide definitive principles or guidelines that can readily be applied at this time. Much background information is now available, but considerable effort will be required to convert this information into a useful methodology.

The other principal phase of the study involved a canvass of selected highway departments, planning agencies, private organizations, university researchers, Federal, State and local agencies, and knowledgeable individuals who could contribute to an understanding of the problem. The canvass normally involved a visit with members of the agency or organization, wherein the objectives of the study were outlined and a discussion was held with regard to their experiences with this particular problem. Of particular interest were the case histories and local experiences that illustrated various components of the problem. Legislative tools available in particular States, as well as agency policies, were of special concern as being indicative of the effectiveness or deficiencies of current programs. A considerable discrepancy in practices between the various States was found, with many States having far greater con-

* In this report, references without a key letter will be found in Appendix A; those with the key letter "B," in Appendix B.

trol than others in preserving the utility of the highway system. New devices and techniques for implementing desirable objectives, as proposed by some agencies, were especially valuable.

The early phase of the canvass concentrated on the effectiveness of land-use controls and their interrelationship with transportation. After a number of discussions with various agencies and professional disciplines, it became apparent that the fundamental objective was the continuing utility of transportation systems, and that there were many other factors besides land-use controls that were closely related with this objective. To establish fundamental relationships which could ultimately lead to practicable solutions, it was found necessary to expand the scope of the study to include other related techniques, in addition to land-use controls, that could prove stable and effective in preserving the utility of transportation systems. The study has, therefore, included other factors in analyzing the interrelationships between land use and transportation, whereby the problem could be investigated in a broader context than was originally specified. These other major implications could not be deleted without hindering the broader objectives of the study.

The broadening of the work scope was decided upon after consultation with the administrators of the program. The effectiveness of this broadened approach was later confirmed by discussions wherein the objectives of the project were fully explored, concluding that the broader view was both necessary and desirable.

In keeping with the broadened scope of the study, a revision of the study objectives could be stated as follows:

1. To provide a better understanding of the effectiveness of existing land-use controls *and other techniques* on the continuing utility of transportation systems.

2. To establish principles or guidelines for developing land-use controls *and other techniques* that will be stable and effective in preserving the investment in transportation systems.

The research approach in the study of this broadened objective includes a number of work items beyond the scope of the original research plan. The study deals first with urban structure to establish a framework within which the transportation system and land use can be properly viewed. This is followed by analysis of existing land-use controls, their objectives and limitations, and their stability. The historic development of the highway system, current trends in highway patterns, and various methods of classifying highway functions are then analyzed. Land access controls and design controls are suggested as effective implementation techniques to provide intrinsic protection for the highway facility. Traffic generation characteristics provide an opportunity for load balancing. The freeway interchange problem is analyzed specifically and new concepts are reviewed which provide new opportunities for the future.

The basic intent of this first study was not to provide quantitative or qualitative solutions to the problems uncovered, but rather to attain a better understanding of all the factors involved. An analysis of the interactions between land use and transportation would then provide a general direction for further detailed investigations, from which guidelines and principles could be developed to provide working solutions.

The title of the study implies that it deals with all phases of transportation. This portion, however, has concentrated on highway transportation because this represents the most significant and widespread problem. By understanding the interrelationships between highway transportation and land use, it will set the basic framework for analyzing the effects on other transportation modes. Nonhighway transport modes are also intimately related with land use and significantly affect the utility of highway systems.

Future consideration of these other modes should evaluate their potential effect on land use and on the highway system in those areas where they are applicable, and their interrelationships with land-use controls. In this way the transportation system can be considered as a related network without isolating the highway and nonhighway elements.

SIGNIFICANCE OF THE PROBLEM

One of the greatest concerns of the transportation specialist is that circulation systems currently being constructed may not be adequate to handle future transportation demands in rapidly growing urban areas. The possible breakdown of the freeway-arterial system due to urban traffic concentrations is a specter that haunts much of the current thought on transportation needs of the future. This fear is probably one of the underlying reasons for the current consideration of the potential value of land-use controls to provide assurance that the transportation network will remain operative. Undue concentrations of traffic generation might result in the breakdown of circulation networks now being developed, and the most obvious approach to this problem is to avoid such concentrations. Thus, one of the principal considerations mentioned in the problem statement is the feasibility of minimizing such concentrations.

However, another prevailing viewpoint is that planning considerations which reflect community objectives should provide the principal determinant with regard to development concentrations. This view stresses that transportation is a service function and that the transportation system should serve whatever concentrations the community may wish to develop. The major objective of all planning is to develop an urban design which provides maximum opportunities for the organization of city living. The development of transportation efficiency is one element of this ultimate objective. Although these two views are based on different premises, they both have validity. The current study has both philosophical and practical overtones and it is especially important to maintain a balance between the theoretical and the attainable so that a useful product can result. It is of equal significance to reflect the various professional disciplines that are involved with this problem to assure validity and acceptance of the results.

There should actually be no basic conflict in the achievement of good transportation and good community planning.

However, before meaningful policies, principles, or methods can be developed, it is necessary to establish what the basic objectives are, in regard to both transportation and community planning goals.

STUDY NEED

It has long been recognized that there is a strong interrelationship between land use and transportation. However, until recently few data have been available concerning the quantitative relationships involved. In many cases even the qualitative relationships appear to be misunderstood and conclusions have been developed which may not be justified after careful examination. Recent transportation studies have established some of the relationships which are necessary, particularly with regard to traffic generation characteristics and traffic patterns within a metropolitan area. However, little has yet been done in affecting decision making by governmental agencies with regard to these relationships.

In view of the rapid urbanization of land currently under way and the large-scale program of highway construction, the need for understanding the interrelationships between land use and transportation is quite critical. The current construction of new communities and reconstruction of old ones makes it essential that the principles that govern this rapid growth be carefully analyzed to assure that adequate provision is being made for transportation needs. The normal method of circulation design is to extend traditional principles and design standards into newly developing areas. However, much of the new urban growth is radically different from anything that preceded it and the travel patterns are also vastly different. It is necessary that principles and guidelines be developed based on the factual evidence that can be gathered to assure the continuing utility of the transportation systems.

New opportunities are also presented by the current trend to revitalization of central urban areas. New redevelopment projects offer the rare opportunity to completely redesign obsolete circulation systems with major re-use of the land. This opportunity must be taken advantage of to develop proper relationships between land use and transportation, or one of the best opportunities will have been lost.

CHAPTER TWO

URBAN STRUCTURE

An urban region has an identifiable physical structure, an essential framework that changes slowly over time. The basic elements of that structure are given by Row and Levinson (*180*) as the physiography, major public activity centers, and the transportation system.

PHYSIOGRAPHY

The physical geography, topography, land and water forms, etc., are readily recognized as basic controls of the urban structure. Many of the important urban regions of the world owe their initial existence to natural features. Cities were founded where rivers joined oceans or provided water for life. Other cities grew around terrain providing good military defensive positions. Even railhead cities reflect the facts of natural geography in the location of the rail lines. And today's new cities, even with man's amazing ability to reform nature, still show adaptation to topography in their physical form. In fact, as man learns more about nature he tends to realize that the more his cities conform to the physiography he finds, the more likely they are to provide the best service for their residents, including the most beauty.

MAJOR PUBLIC ACTIVITY CENTERS

The next shapers of the urban structure are the important public places; the parks, the forests, the squares, the centers of government and culture and recreation, the educational centers, the community gathering places—called the major public activity centers. These are fundamental structural elements—privately owned or government owned —which endure with the growth of urbanization. Perhaps not as stable or permanent as physiographic features, they are, nevertheless, structural elements.

These are, outside of work places and dwelling places, the focal points of the region or community. They are fundamental features once established, and carry great weight in relation to some dynamic features. Research industries will tie to the universities, cities grope toward the recreation areas, offices spring up near the civic centers. Before personal transport was available to virtually all, urban areas clustered tightly around these focal points. Today the clustering is less, but the transportation systems still lead to the foci.

THE TRANSPORTATION SYSTEM

The third fundamental aspect of the urban structure framework is the transportation system. Locating cities on rivers, harbors, railheads, canals, wagon trails, and so forth, has always been an expression of civilization's demands for trade and communication—and resultant need for transportation. Prior to the railroad, cities were high-density clusters tied to water routes and harbors, with much smaller nucleations at crossroads. Railroads not only brought new cities into being, but also changed the shape of the old ones.

By the end of the 19th century the concentration of industry and commerce in urban regions, and the development of high-rise buildings, permitted techniques of land use to widen the gap between transportation needs and facilities. The central cities became, as Netherton (*152*) has stated, ". . . characterized by the crowding of population and economic activity into small areas where the arrangements of land use often showed no logical relationship to the factors entering into the conduct of business—among them the urban area internal transportation system . . . by 1905, traffic congestion at rush hours was described as the foremost problem of the major cities in the United States."

Between 1870 and 1910 there were tremendous changes in urban areas to provide for transportation needs, mainly through mass transit surface railways and elevated lines. In the days of horsecars and foot transportation, limiting commuting distances to perhaps 2 or 3 miles, urban areas rarely exceeded about 20 square miles. With the new methods of mass transportation, the radius of urban movement was increased to more than 5 miles and the size of major cities to about 80 square miles. Because of the fixed channels for this form of transportation, a relatively rigid pattern of urban development resulted. The regular street systems of the city were used mainly for purposes of land service and land access.

The automobile, however, changed all this quite drastically by providing a tremendous expansion of personal mobility. Along with the increasing number of vehicles and their increasing use, came increasing distances and better accessibility. The radius of movement in a modern city is 25 miles or more and some of the larger urban areas cover up to 2,000 square miles. Even more important, the automobile has changed the demands of travelers for transportation facilities as they maximized their use of the new freedom of movement. Homes no longer had to be close to the railroad or streetcar for those who could afford automobiles. When the motor bus brought this expanded choice to those who had no autos as well, the previously open areas between the arms of the rails filled in, and made possible the current city form.

LAND USE

All of the previous facets of the urban structure are relatively permanent and stable, fixed in location. In reality, even they change, but slowly in comparison to the dynamic and growing elements of the city called land use.

A study of the history of urban areas shows that much of the land use is dynamic and even seemingly permanent land uses have, as time progresses, given way to others without seriously changing the structure of the region. Ultimately perhaps, land use reflects the market place. But the market itself is changing. To some extent these changes reflect or are reflected by changes in transportation modes and facilities, but for the most part the public rights-of-way remain where, and often what, they were when the now defunct land uses were first established.

Outside of cities the highways were originally meant to be entries to the countryside for the city dwellers and bridges between cities. They are now alignments along which the city has penetrated into the agricultural and forest lands and deserts. The highways are being used as if they were the streets and boulevards of one huge, dispersed city (*168*). In doing so they have taken away much of the internal pressure of growth and change in the central cities. As the structure has grown, the body has filled in and shows every evidence of continuing to do so.

Just as the elevated and subway transit systems in the largest cities of the past enabled these cities to grow beyond the limited service areas possible through walking, the transportation systems of today—the freeway and highway—permit new areas to come to the fore and not only provide bedrooms and customer sources for the established downtowns, but also physically expand the size of the community to encompass new business areas, new industrial and residential areas, and new recreational areas in the dispersed city. The expansion of these urban land uses is inseparably linked with the pattern of highways. The boulevards of yesterday, holding together and uniting the dispersed portions of cities, have become the regional expressways of today, holding together and uniting the dispersed portions of metropolitan regions, often encompassing major portions of States.

A city is most usefully viewed as containing both structural and dynamic elements where, in reality, all the elements are dynamic but the structural ones are the slowest to change. They will have a longer and more stable influence on many of the characteristics of a region than the more rapidly changing dynamic features of an area. The transportation system, a basic part of the structure of a region, can survive several cycles of land use although whatever predictions can be made today would apply only to the first cycle.

For the city to grow and develop in its dynamic characteristics to its utmost capabilities, the transportation structure must be carefully controlled and designed. This almost permanent feature should be subject to the most detailed and intensive consideration and study in its placement, planning, and design. In this way transportation can be made to provide its maximum value to the dynamic factors of the region.

SPATIAL ARRANGEMENT OF CITIES

Mayer (*135*), in speaking of the interaction of cities and transportation, said: "The multiplicity and variety of functions and activities of modern cities would be impossible without adequate transportation facilities and services; transportation furnishes access to the hinterlands and to

trade areas, the sizes of which, in turn, are functions of relative accessibility." The human desire for privacy, for individual pieces of land, for personal expression in homes, has in many parts of the country been counterbalanced by the need for employment, for social interchange, for access to those things only the urban conglomerations can offer. But the recent extension of roads and the almost universal availability of automobiles and trucks in this country have provided a solution to conflicting needs and desires by expanding the "city" to cover huge areas of low-density use with higher-intensity nodes. The automobile has made possible multiple concentrations and nucleations spaced farther apart, more effectively serving the large areas of land which are today's metropolitan regions.

The high-density city dwelling places are no longer the sole source of labor for industry, nor of customers for the products offered. The need to locate on high-capacity transportation corridors no longer limits industry to railroad sidings or harbors or river ports. The transport advantages of the concentrated city, which at one time were critical in industrial and business location, are rapidly being minimized with good road systems in low-density areas. Workers have been moving into the suburbs and surburban industrial plants have followed. The Massachusetts Route 128 development which rings Boston is an example of this type of spread from the high-intensity city to the dispersed city.

In the modern dispersed regional city covering thousands of square miles many of the older traditions of concentration of industry and commerce in areas easily accessible to employees and customers by the old methods of transportation are no longer valid. Carroll (*42*) said: "It is the spatial arrangement of human activities which the transportation system must serve. The spatial pattern for most cities has evolved slowly and has been influenced by a variety of factors such as transmission of power, construction technology, terrain, and the transportation system itself. A factor which is often overlooked or dismissed as not being amenable to measurement, is that of personal values. This factor is much too important to ignore."

People do not wish to travel too long to work. Yet, they have not necessarily chosen residences or work places which minimize the time that they actually travel. It is clear that the work-trip travel time is only one of many values which people weigh in their decision as to where to live or where to work. Things such as the neighborhood, schools, cost, transportation facilities, or any other peculiar factor which may have value to the individual decision maker will be included in the over-all decision. In many modern low-density urban areas the work trip has turned out to be relatively low on the scale of human values. It would appear, then, that a pattern of land use or land-use controls must carefully consider the conflict of desires to live near the work place but far from industrial areas, near shopping but far from traffic concentration, etc. One way in which some of the conflict can be resolved is through inclusion of transportation facilities which counteract great physical distances with speed, making time distances small.

In the older, high-density cities, rapid transit facilities provide much of the "shrinking" effect of speed on distance. The newer, low-density cities have relied more on motor vehicle transportation and express highways to achieve this end. Both techniques work with other forces, especially the economic market forces, as growth of the urban area continues, modifying initial ideas of land use as land development overtly demonstrates the desires of the residents and the business and industrial community.

COMMERCIAL DEVELOPMENT GROUPING

Garrison (*81*) describes the spatial structure and conformation of business enterprises in urban areas in four classifications—nucleations, urban arterials, automobile rows, and highway-oriented. Another set of terms to express his groupings are shopping centers, business district fringes, and highway-oriented. In the older urban areas the pattern is much more sharply defined than in many of the newer, auto-oriented areas. In both, shopping centers of various sizes (from community to regional) stand out fairly clearly with regard to the general nature of their location, adjacent to major arterials or freeways.

The trend in many smaller business district cores is a form of nucleation, extending for a relatively short distance perpendicular to the urban arterials and for a long distance along the arterials. Some of this is due to zoning restrictions, but much of it, apparently, is due to economic tendencies to associate in this manner. A more recent trend in this type of development appears to be the very small shopping center. In these installations, as opposed to the community or regional shopping centers, the basic occupants are small, privately-owned shops which, in time past, would have located somewhere along the main street of the town. These miniature nucleations provide for the parking needs of a number of small shops, without relying on the highway for storage. Because of their relatively small size, they do not ordinarily penetrate into the surrounding area, and their physical form can be either lateral or longitudinal—in the latter case the physical characteristic is similar to a series of shops along a frontage road.

Many business district fringe developments, called automobile rows by Garrison (*81*), exist throughout the urban region. They do not mix into shopping centers, they do not mix into central business districts, they do not exist away from the main highway. Flaherty (*70*) would probably include this group in his "highway service district." These are not specifically service areas, nor are they highway-oriented usages in particular, but are fundamentally automobile dealers for new and used cars with certain other uses mixed in. More closely related to Flaherty's usage are the actual highway-oriented activities.

Certain business types are successful only when highway-oriented. They exist not only between urban nucleations, but are scattered within urban areas of all types, at intersections of arterials. Some find their way into

shopping centers, others rely solely on major intersections, while still others move outside the dense areas onto the inter-nucleation highways. Included in this group are not only gasoline stations, restaurants, motels, etc., but such businesses as building supplies, radio and TV sales and repair, lumber yards, and miscellaneous repair facilities. The physical size distribution in this group of commercial activities covers an extremely wide range, indicating a broad range of rent-paying ability per unit of land area.

Most highway administrators and land-use planners tend to deplore the practice of strip commercial development along major highways. However, Garrison (*81*), Creighton (*B10*)*, and others believe that such development serves a necessary function by providing locations for highway-oriented business which cannot be accommodated elsewhere, at least partly because they depend on traffic exposure for their existence.

It is possible, however, to limit the amount of such land use and its location. If the design is developed as a nucleation in the form of a linear shopping center with access to off-street parking restricted to select locations, the development could become no more objectionable than other forms of commercial development.

Although specific businesses exhibit fairly specific contiguity and occupy relatively clear portions of the city form, their spatial distribution when considered on a regional basis is undergoing considerable change. The change is clearly associated with the improvement of personal transportation facilities. The extension of high-speed freeways and other arterials permits location of commercial enterprises in areas of relatively low rent costs without loss of accessibility. Although the location of the four classifications may be changing, their organization is relatively consistent.

* References with B numbers will be found in Appendix B.

CHAPTER THREE

LAND–USE CONTROLS

TYPES OF CONTROLS

The normally accepted land-use control techniques fall into four major groups (*40*). Eminent domain involves actual acquisition of land, ordinarily through purchase. Police power regulates land use through zoning, subdivision regulation, licenses, etc. Contractual agreements, which may or may not involve direct money transfers, are often entered into by the highway department to minimize adverse development of land. The fourth, the doctrine of nuisance law, relies on legal interpretation to prevent or eliminate land uses which damage the community.

Land-use controls have both a positive and a negative application. The positive application is an attempt to effectuate a desired land-use plan, or general plan, previously established. Such applications of land-use controls represent an implementation device to achieve given community objectives. The negative application is as a police power to prevent damage to public health, welfare, and safety.

EMINENT DOMAIN

The eminent domain technique, which involves actual acquisition of land by the governmental agency, is clearly the most effective way to control use of land. It is also by far the most expensive. Thiel (*201*) wrote, "Since an agreement by which land owners transfer redevelopment or other rights has the power of a contract, violations of these rights are not likely to occur." However, eminent domain involves the payment of public monies for the property rights acquired.

Considering the thousands of miles of arterial and express highways that could require protection, it can be readily seen that the cost of applying eminent domain procedures at all locations where problems might arise would be prohibitive. But there have been and will continue to be cases where purchase, excess condemnation, leaseback, acquisition of development or conservation easements, and especially acquisition of access rights, will be applicable in the development of an adequate and adequately protected transportation system. Extensive use of this procedure, however, would be economically and politically impossible.

POLICE POWER

The land-use control devices of the police power have been tested in the courts and found to be enforceable without compensation to the affected landowner. They are much less restrictive than the eminent domain powers, allow for consideration of local special needs, and their cost is only that of administration if an enforcing organization exists. The basic disadvantage is their potential instability, particularly excessive flexibility dependent on local whims and lay officials.

Zoning, by far the most widely known land-use control, reflects short-range land-use desires of the community. It was originally established to solve problems of incompatible land use and the protection of the public health, welfare, and safety. Zoning controls the location, size, and intensity of development, as well as the type of land use. It is not intended to establish permanence, but to stabilize land uses for reasonable periods.

Zoning is not the only police power available for controlling land use. Campbell (*40*) lists additional police powers such as licenses and permits, mapped streets, development control, and subdivision regulation. Whereas zoning is fundamentally an attempt to control the type and quantity of development, these other aspects, particularly in their relation to traffic and transportation, attempt to control the quality of the development. Thus, the mapped street can prevent construction of permanent or semi-permanent buildings or other improvements on property which will ultimately be required for public highway purposes, and subdivision regulation can minimize interference with arterial streets by controlling points of access to the highway system as to quantity and location.

Police power can be an effective device if used, but in many communities its application is either limited or subject to considerable variance as pressures develop, both politically and economically.

OTHER CONTROLS

Contractual agreements, which may or may not involve direct money transfers, are sometimes entered into by highway departments to minimize adverse development of land. The doctrine of nuisance law relies on legal interpretations to prevent or eliminate land uses which damage the highways. Use of these devices is seldom found, and it is clear that the two basic aspects of governmental control are the police power and the eminent domain power.

PREVALENCE OF ZONING

Zoning is actually an uncommon device in many areas of the country. The Bureau of Public Roads reported in 1963 (*209*) that only 17 percent of all the counties in the United States had adopted zoning ordinances. Even fewer of these counties had any long-range land-use plans, and a sizeable proportion of those counties that actually had zoning ordinances or land-use plans did not have any paid planning staffs to carry out the objectives of the plans or the ordinances. To further emphasize this lack, the Bureau report separated out those counties which either contain or abut a portion of an Interstate Highway route, where less than one-half were so equipped.

Although there are many areas of the country where land-use controls do not exist, most of the growing metropolitan areas where problems of growth are most significant are regulated by formal land-use controls. One notable exception is Houston, Texas, where no public controls exist, although some controls are exercised through private covenants. A detailed analysis of the history of land-use development in Houston as contrasted with other major metropolitan areas, would be of considerable interest and value for this study.

ZONING OBJECTIVES

A confirmation of the legality of zoning occurred in 1926 when the United States Supreme Court settled that the concept of a police power has a positive aspect which enables the community to act before private land use injures its public interest. This opinion stated: "The primary objective of modern zoning under the police power is to lessen or prevent those private uses of land which, if allowed, would depreciate the value of all surrounding land through practical restriction of its usefulness." This early opinion has been vastly expanded during the past 40 years through practice, to cover incompatibility; nuisances; public health, safety, and welfare; and other influences. Of particular interest is the possibility expressed by some authorities that zoning could conceivably apply just as well to the case where private uses of land which, if allowed, would depreciate the value of surrounding land through the damaging of the transportation system, inasmuch as transportation is a fundamental need for land to retain value.

The objectives and limitations of zoning are expressed most authoritatively by practicing planners (*B18*) whose typical comments include: "Controls on land must apply to a realistic situation, or in the long run the controls will fail," and, "Land use forms a viable and dynamic, constantly changing situation." Zoning, as Thiel (*201*) has said, requires "constant attention which is difficult to sustain over a long period of time . . . zoning is vulnerable to review, change, and pressure from special interests." Sussna (*195*) commented that we should not ". . . make the mistake of attempting to cure all of our municipal ills through zoning."

Kent (*227*) points out that zoning is not long-run and should not be regarded as predictive. Zoning is an attempt to stabilize economic influences for successive short runs. But the time scale of a highway plan may encompass 40 years, or more. Over such a period the zoning at the time of planning may not exercise much influence.

THE GENERAL PLAN

Zoning is often confused with a general plan. The general plan, however, is not a precise document, but is a guide to the community, outlining the needs of the future and the magnitude of those needs. It is designed for growth and is aimed at community goals. Zoning, on the other hand, is the means whereby certain phases of the general plan are implemented.

The general plan, if properly done, will be founded on realistic community goals and realistic economic factors, in combination. It will include consideration of all those things which go to make up a community—the structural elements such as parks, major public open spaces, and transportation systems, and the dynamic elements such as land use, social and sociological factors, political and educational factors. As with most plans, unless it is

founded realistically it will not succeed in its task. In the case of the general plan, the foundation is community goals and economic factors, both of which are dynamic rather than stable.

The general plan, in the context in which professional planners use that term, is never a final document. It should be reassessed and adjusted on a continuing basis as community goals change or the economic pattern changes within the community.

It usually has no legal standing in most communities, but represents the objective toward which land-use controls strive. It must be accepted and utilized or it will exercise little influence on the development pattern of the community.

If the plan is realistic and is understood, it becomes a picture of what the future would look like if there were no change in the foundations upon which it is built. As the foundations exercise their dynamic characteristics it will be continually subject to revision, but a properly drawn general plan allows for modifications and is flexible enough to accept them without creating drastic structural changes.

The general plan, in which future land use and future transportation are fundamental factors, must be developed around the combination of the two rather than allowing one to take precedence over the other. These two factors must be developed together, with constant communication and continuous interaction, until the optimum combination for the physical and social characteristics of the community is reached.

CONFLICTING VIEWPOINTS IN ZONING

The power to zone resides with the local authority and the interest such authority represents is the local interest. The interests of a city or county and the interests of a highway planner can be rather different. The benefit that a city perceives when it zones near a highway is different when it considers itself acting singly, from when some agency regulates zoning near highways by all municipalities. Frequently, it is to a single municipality's immediate financial benefit to develop intense uses in its area adjacent to a highway. For, although the benefits are received by this municipality alone, the costs are shared by all those using the highway; that is, by the people of other municipalities and with other destinations. Therefore, the costs perceived by the municipality are less than the cost to the community as a whole.

The highway planner can evaluate the costs to the entire community. But the highway planner does not have the power to zone or to enforce zoning, so that the over-all interest is frequently not represented in the decision making process. The more enlightened community will attempt to take these other viewpoints into consideration, but there are few guidelines available to assist them in their evaluation. This need for procedural guidance is a basic problem at the present time.

Some States attempt to provide guidance to local jurisdictions in an advisory capacity. Others have sought to obtain the zoning power around freeway interchanges and State highways to exercise firmer controls in protecting the utility of the highway facility. Wisconsin has probably proceeded as far as any State in attempting to achieve such legislation, but the question of State control of land use is a highly controversial one and most States prefer to avoid such controls at the State level in favor of strengthening local land-use controls.

CHAPTER FOUR

LAND-USE STABILITY

STABLE LAND-USE CONTROLS

Establishment of stable land-use controls is theoretically attainable in a controlled economy. Effective controls are available in many European countries where governments exercise considerably more power than in the United States. City planners in the Scandinavian countries, Great Britain, and elsewhere, exercise firm control over the types of land uses that are developed. New towns have been constructed through governmental authorities in the suburbs where master plans were firmly adhered to. This type of governmental restriction over development can permit relatively reliable estimates of transportation demands.

In a free economy, however, such degree of control cannot be realistically exercised. Economic and political pressures, as well as changing community objectives, may alter an over-all plan. In fact, the newer approaches to city and regional planning are based on a degree of flexibility which can accommodate dynamic change.

Some communities in the United States have attempted to exercise strong control over local development. Detailed land-use plans have been prepared which zone virtually every parcel for a specific land use, even though only a small proportion of the area has yet been developed. This practice has not proved successful in some rapidly growing areas where controls alone could not implement the

community objectives. Some new plans have only recently been developed, and it is too early to predict their degree of success in stabilizing land development. Further detailed study of the history of land development in these areas should prove quite valuable.

The only real stability that has been observed to date is in those areas where no appreciable growth is taking place, particularly in smaller communities. In most cases their land-use controls reflect stability because they simply mirror the status quo, which is unchanging. In the larger metropolitan areas change is apparently inevitable, and these are the areas where most of the current problems are being experienced.

MARKETPLACE CONTROLS

Land-use controls must weigh all the benefits which might accrue to the community through more intensive land uses and densities, as well as the detrimental consequences, if they are to be realistic. The marketplace will usually assert itself, and a plan or program which recognizes that this will occur and plans for it has a much greater opportunity to succeed. The value of zoning diminishes when it grows distant from the economic realities of a community.

The literature on this subject emphasizes that it is improper to equate land use and controls. Thiel (*201*), for example, reported that in most of the areas he has investigated, economic forces assert themselves in the prevalence of rezoning. As examples he reported that some 90 percent of nearly 1,000 requests for rezoning zoning appeals, exceptions, special use permits, etc., were granted in New Orleans; and in Philadelphia more than 80 percent of the requests for rezoning were accepted. Because most requests for rezoning involve a change from a more restrictive to a less restrictive zone (such as from residential to commercial or from low-density residential to high-density residential), the control value of zoning is lessened by this succession of zone changes, variances, conditional use permits, etc.

However, the large proportion of zoning change requests which are granted may not be as significant as they at first appear. Many of the granted changes may be of little consequence, representing minor variances rather than major land-use modifications. Although it is likely that the zoning changes that are granted affect only a minor proportion of the total land zones, some of the changes can be of major local significance. Conclusions based on available zoning history must be further analyzed to evaluate the over-all extent of zoning changes with regard to their effects on transportation facilities.

UNREALISTIC LAND-USE GOALS

Where land-use controls are utilized as a means of implementing community objectives, they frequently prove ineffective if the goals are not readily attainable. One example of unrealistic zoning is excessive zoning for industry, common in many communities. Industry normally provides a desirable tax base from which the community derives substantial support. It is natural, therefore, for most communities to offer major incentives to attract industry into the community. One element of this competition is the reservation of substantial parcels of land for industrial purposes, even though there may not be any immediate market for such development. With each community competing for the limited amount of industry, it is customary for a region to optimistically reserve a quantity of land for industrial use many times greater than the absorption potential within the foreseeable or even distant future.

In some rapidly growing metropolitan areas it has been found that industrial land has a lower valuation than residential land, due to the lack of market potential for industry. The effect has been a mounting pressure for rezoning of such land to uses which can be more readily marketed. These pressures are frequently resisted in the optimistic hope that the community will ultimately be successful in attracting industry and thus improve its tax structure.

In the interim, however, the land may lie fallow for decades. This example of land-use controls reflecting community aspirations rather than realistic economic potential illustrates the lack of realism in some of the zoning practices. A transportation plan based on such unrealizable potential is unsound.

Land-use controls should also reflect a viable and dynamic economy in commercial zoning, rather than preestablished criteria which break down under political and economic pressures. In many communities the current general plan specifies commercial development in specific areas. This may have resulted in development of some isolated business structures, without the areas ever reaching their full potential. In the interim, development of new transportation facilities may offer new commercial opportunities on larger and less expensive tracts of land more accessible to regional facilities and located in a superior environment. Although the community may have sufficient land zoned for commercial uses to theoretically accommodate any anticipated demands, the locations may be obsolete with regard to current standards for large-scale development and not reflect the latest economic trends. Other elements that can inhibit development at such locations include high land cost, multiplicity of ownership, and difficulties of land assembly. The inertia and stability of the current plan may represent community objectives, but not necessarily economic reality; hence, the overwhelming pressures for the zoning of additional commercial acreage.

As a result, there has been a tendency for other factors to be the principal determinants in regard to locational decisions. The new shopping center will most frequently develop where land values have not yet risen beyond the acceptable range feasible for such development. With the wide choice usually available in a large geographic area, it is frequently the entrepreneur who determines the location of the facility rather than the land-use planner. With the prevailing competition that exists between adjoining communities, each community will vie for the opportunity to attract the development into its area and to obtain the sales tax advantages and employment opportuni-

ties that accompany this type of development. In effect, the larger the development the more desirable it appears to the community. The problem of stable land-use controls is thus compounded by conflicting community desires and interests as a development becomes larger in scope.

DEVELOPMENT PREDICTABILITY

The many individual parcels of land which make up a region are not mutually exclusive of each other. Instead, each land holding is dependent on every other land holding when a new land use is considered. For example, before commencing on a major commercial development, the potential investor will carefully consider the uses of the land holdings in the vicinity to attempt to establish the potential economic validity of the investment. If he finds that the market is already saturated with that type of development he will not proceed, or perhaps may reduce the size of the proposed investment. A similar case could be presented for a proposed apartment development or an industrial tract.

This type of analysis is a relatively powerful tool, and the results of such economic analyses are often better determinants of potential development than existing land-use plans or zoning ordinances, as can be seen by comparing the actual intensity of development with the permitted intensity in most communities. The real estate economist can estimate the expected total quantity of commercial, residential, and industrial land in a given portion of the community, based on market analysis. He cannot, however, specify location of these various uses.

Many land-use changes take place as a result of economic obsolescence as well as physical obsolescence. The succession of land-use cycles that takes place in rapidly growing communities represents a phase of economic obsolescence resulting from location. The conversion of a single-family neighborhood into medium-density apartments represents one recognizable cycle in the evolution of an urban area. In a more advanced stage the area may further evolve into high-rise residential or commercial. Land-use controls generally foster stability by damping rapid changes in land utilization, but they do not change economic reality in the normal competitive situation. When an oversupply of any form of land use occurs, some of it will demonstrate economic failure and land use will change to better fit the demands and needs of the community.

If a large enough area is considered, the land uses and, to a great extent their intensity, can be predicted within limits, based on population predictions which have demonstrated a fairly high reliability. From the aspect of traffic generation, the total needs of the transportation system serving a community or large portions of urban areas can probably be predicted within reasonably narrow ranges. On the other hand, the potential development and, therefore, generation of traffic for any given location is much less predictive.

FUTURE LAND-USE STABILITY

Land-use controls are becoming more realistic and more nearly reflect what is likely to happen. Unrealistic goals of the past often succumbed to market place pressures. With this experience as a guide, newer plans attempt to establish plans that consider and respond to economic determinants. The reported frequency of rezoning often reflects the obsolescence of many of the older land-use plans, which had not been updated for many years.

The current availability of Federal and State funds for planning purposes and the tremendous interest at the Federal level in planning programs, indicate that the planning programs now being developed will not knowingly be permitted to become obsolete. The continuing transportation planning program, which is required to be based on over-all community land-use plans, has stimulated the development of general plans and land-use controls in all larger communities. Provision is made for periodic updating of these plans, and the land-use controls that are intended to effectuate them. This has inaugurated a new era in planning programs, in which future land-use plans will be far more reliable and realistic than in the past. Hopefully, this will permit control which is not as subject to short-term variations in the market place and political climate, because the plans will have a sounder basis in fact.

There will, undoubtedly, still be zoning changes and other modifications in many locations. Such changes will occur in those rapidly growing areas where detailed predictions of land use cannot be made with any great assurance. Most areas, however, will probably adhere to the land-use plan so that the proportion of land affected by land-use control changes may be relatively minor.

Regional planning, conducted on a comprehensive basis with meaningful goals and based on economic reality, can develop a realistic plan. Realistic land-use controls based on a realistic general plan can provide some degree of stability. However, these planning tools must be re-evaluated periodically to reflect changing objectives and situations.

Future study must examine these trends in greater detail, to determine whether land-use controls in the future will, in fact, be more reliable and stable than in the past. Methods must also be sought to correct some of the deficiencies that have been found, and others that will be uncovered in future studies.

CHAPTER FIVE

THE HIGHWAY SYSTEM

LEGAL CONCEPT OF HIGHWAYS

In its legal definition the public highway is a public way for the use of the public in general for passage without distinction. This concept has been expressed by Netherton (*152*) as a "generic name for all kinds of public ways—ways common to all the people of the State having occasion to pass over them . . . to constitute a highway it must be one over which all the people of the State have a common and equal right to travel, and in which they have a common, or at least a general, interest to keep unobstructed. . . . Today, public interest in a highway still consists basically of the right to travel upon the land of another freely and without interference. . . ."

It is important to recognize that the legal concept of a highway deals with rights—privileges and powers to act in a certain manner—rather than matters of substance. Actually, there appear to be two sets of rights involved in this legal concept. The right of the public to travel unrestricted reflects the basic reason for building any highway. The use of a strip of land for the public, however, creates a unique feature in a community wherein the impact of the highway created is felt not only by the land owner of the property traversed, but also throughout the entire economic and social life of the surrounding region. The other set of highway rights involves those persons whose land abuts the highway, and of these probably the most important in terms of this study are the legal relationships dealing with control of access to and from the highway.

In England the history of highways began with the power of the Crown—the concept of the "king's highway." The intensive enforcement of the public right-of-passage over these king's highways was undoubtedly bound up in the early political and economic development of the nation.

In American law, which is based to a very great extent on English law, the taking of land for highways was largely uncompensated in Colonial times. When roads or streets were laid out through privately owned land, the owners generally valued the benefits of these highways much more highly than the duties which the highway laws imposed on them. In some colonies the original land grants specifically reserved portions of each grant, in terms of percentage, for future use as highways, whereas in other colonies the Continental concept of eminent domain was brought from Europe.

HIGHWAY DEVELOPMENT

Considerable insight can be derived from a review of how the current circulation system developed historically. The first attempts to create over-all street master plans for American cities occurred more than a century ago, especially in the newly developing midwestern cities. These cities were limited in area, and lot sizes were small. There was little distinction in street width, spacing, or function, and the streets usually formed a grid pattern. This was a tremendous step forward from older communities where most streets had neither continuity nor uniform width, with alignments largely derived from historical accident. A relatively small-scale community served by this grid network did not generate any substantial traffic volumes, so that land uses could be adequately served with little conflict between transportation and land access service.

To minimize walking distances, most urban patterns were designed to provide maximum frontage on the access streets, tempered to some extent by the economic necessity to maintain blocks of adequate size for development. So long as complementary activities remained close together, they were reasonably successful in meeting these objectives. Thus the physical ground level shape of the older sections of cities was formed and these areas developed 100 years ago and more have survived, with little basic change, outliving several cycles of land use.

In more recent years cities began to develop a hierarchy of arterial streets which was usually superimposed on the older small grid pattern. This new system was based on the grid of mile section lines, and a new type of circulation system was developed that corresponded more closely with the increasing movement demands.

This new plan of arterial highways provided a general guide for locating major highway facilities in newly urbanized areas, which established continuity and consistency of the circulation network. A few routes, which provided the greatest continuity for through traffic, were then incorporated into the newly developing State highway networks and became the principal circulation facilities of the area.

It soon became apparent that the concentration of traffic on these highways was capitalized upon by developers of commercial facilities. The proliferation of such development along the entire length of the arterial soon diminished its usefulness for non-local traffic service. Faced with premature obsolescence of the highways for the service of through traffic, officials sought solutions to ward off the problem and guarantee that repetition would not occur.

This initiated a third phase in development of the highway system, superimposing a controlled-access freeway network over the existing system. Current circulation networks, therefore, consist of a composite of three separate systems, developed at three different times to serve different stages in the growth of the cities. The resulting composite is largely a result of historical accident.

The freeway system is now being expanded to accommodate the need for rapid movement over longer distances to serve the mushrooming growth of the urban areas. However, this does not necessarily represent the ultimate system, and this process may be repeated in the future with

still another system (perhaps initiated by the automated highway concept) to permit even greater speeds and capability for even greater travel distances.

CIRCULATION SYSTEM TRENDS

A century ago it was commonplace to devote up to one-third of the land in a development to public rights-of-way and streets. In recent developments this reservation is often only one-half that amount, while still maintaining adequate access and circulation, There has been a departure from the pedestrian scale and a start on reflecting automobile-scale mobility, which permits longer blocks and fewer intersections. This trend has greatly eased the problem of traffic control and has improved street efficiency by reducing the number of major conflict points.

Examples of this trend can also be observed in other land uses. Many urban renewal projects are creating "superblocks," which drastically reduce the area devoted to streets. Regional shopping centers utilize large sites surrounded by freeways and arterial highways, and completely void themselves of internal public streets. Large industrial developments often consist of superblocks with few interior public streets.

There is also a discernible trend toward removing transportation facilities from the immediate vicinity of the pedestrian activity area, whether the land use is residential, industrial, or commercial. Many new living, working, and shopping facilities are being developed in relatively large units without internal streets. Automobile access is provided to parking facilities surrounding the development, in preference to a penetration of the development. Thus the trend to a larger-grained pattern in the transportation system has its parallel in land use. Small lots and small holdings are no longer easily marketable. The trends in both transportation and land use have followed the same pattern, and this is not coincidence. They have both begun to reflect the automobile scale and this trend is continuing.

This has great significance in transportation requirements. The new circulation system must have greater capacity, greater efficiency, and provide for higher speeds with increased safety. Although a lesser proportion of the land area may be devoted to public streets, much more land will be required for terminal facilities, private internal circulation, and other auxiliary needs which must be considered as elements of the transportation system. These elements, frequently ignored or at least overlooked in the over-all system, must now receive greater attention.

It may at first appear paradoxical that there is currently a reduction of area devoted to public streets in the face of increasing traffic requirements. This is a result of increased personal mobility and increased efficiency of the road facilities being provided. It can be shown that a freeway lane can provide the capacity of three surface street lanes. Lanes on new arterial highways, with some access control and effective geometric design, have considerably greater capacity than ordinary surface street lanes on older facilities. Predictions of the land required for an ultimate freeway network in a typical metropolitan area indicate that no more than 2 to 3 percent of the total area will be needed. Yet the freeway network is expected to handle up to 50 percent of the total travel. This is indicative of the tremendous efficiency that is being developed for the new transportation facilities as contrasted with previous systems.

OPTIMUM HIGHWAY SPACING

Positive criteria for achievement of an optimum transportation network have not yet been fully developed, although much useful research has been done. Most existing research studies have been based on the user-benefit rationale, which at present is the only systematic approach to this problem. An analytic study for establishing the spacing of expressways and arterial streets was developed in conjunction with the Chicago Area Transportation Study. By traffic simulation and assignment methods, theoretical expressway and arterial highway spacings were developed to minimize the combined costs of construction and travel. This minimum cost methodology is consistent with normal highway engineering criteria.

In addition to highway user and construction cost considerations, however, there are many other elements which have a bearing on expressway and arterial street spacing. These planning elements, dealing with community values, have not yet been sufficiently analyzed for an objective method to be developed to incorporate them into the evaluation process.

One useful approach might be the development of an optimum size theory for various land-use development units. If a range of sizes could be established for self-contained units, arterial highways could be spaced to circumscribe these units without interfering with their internal operation. The arterials could be designed to accommodate the traffic demand with a flexible capacity achieved by varying the number of lanes. Access from individual development units to the perimeter arterials could be limited to optimum intersectional spacings to provide maximum capacity efficiency on the arterial network.

One interesting factor in relating transportation facilities to land use is the constancy of this relationship. Carroll (*B09*) emphasized the uniformity of the cost-benefit relationship that results with almost any density of development. The cost per mile for development of a new highway facility varies directly with the density of development within the area affected. However, the utilization of the facility also varies directly with density of development, and the benefits to users, accruing from the development of a new facility, will vary directly with the utilization of the facility. Such analysis would indicate that the ratio of user benefits to development cost is practically constant, inasmuch as the more expensive facility will be utilized more intensively.

HIGHWAY ADEQUACY

The fear that the highway transportation network may experience overload and obsolescence in the future appears to recur constantly. This is largely based on the experiences of the past, where traffic congestion appeared to continually increase despite the investment of billions of dollars in

new highway and freeway systems. Predictions of system failure are prevalent, and there appears to be little factual evidence available either to prove or disprove the validity of these contentions.

Methodology is available to determine the adequacy of the highway and freeway networks, based on various densities of land-use development. These interrelationships can be used to determine what factor of safety is provided in the current patterns of highway development in relation to varying land-use densities. It can, therefore, be established whether increased densities could be accommodated, if considered desirable, and, alternatively, what modifications might be necessary in the transportation network to accommodate higher densities. In the case of high-density corridors, non-highway transportation systems may be justified.

Another alternative is to balance out higher densities with additional open space to reduce over-all density to a level that can be efficiently accommodated by the highway system.

The parameters of alternative courses of action have not yet been fully developed, although transportation studies have developed criteria for specific communities. It is necessary that the findings of various transportation studies in regard to the interrelationship between land-use densities and the transportation system be correlated in order to develop generally applicable conclusions and guidelines.

HIGHWAYS AS DEVELOPMENT TOOLS

Highways were formerly considered primarily as service facilities to provide access for abutting land developments. More recently, however, the highway facility has been recognized as one of the active elements which controls and directs growth, and as one of the forces that shapes the community.

One of the greatest causes of pressure for rezoning is the accessibility created by new freeways in larger metropolitan areas. A general plan developed prior to the freeway system cannot reflect the changing land economics which follow the introduction of a freeway. The usual effect of the new transportation facility on adjoining land is to promote rapid development because of improved accessibility, visibility, and exposure. The freeway itself can be a most potent implementation tool in furthering community objectives. This has not yet been fully recognized in many communities, where stability and inertia impede necessary changes. In most cases no consistent policy has been developed to reflect the radically new situation that has been created.

Community impact studies have indicated that new highway facilities create new land values, illustrating phenomenal increases in land values for most uses adjoining new freeways and especially around the vicinity of interchanges. Some authorities believe that this reported increase of land values actually represents a transfer of values more than an actual creation of additional values. In some cases these new values around new highway facilities have been created to the detriment of existing values around older transportation facilities which have been superseded. New opportunities around freeway interchanges are taken advantage of by the development of new commercial and industrial sites which are better located with respect to transportation facilities, and have the advantage of a new environment freed from the blighting influences of existing older developments. The achievement of a proper balance between the creation of new opportunities and the preservation of existing community values provides one of the most difficult problems with relationship to new facility location.

In some areas the obtaining of access rights along a highway has the auxiliary effect of eliminating development which would occur along the new route if access were permitted, and would become competition to existing developments. This is considered justified as a useful by-product, on the basis that new competing development would divert business from existing commercial developments and would prove detrimental to existing communities. Thus, one of the beneficial effects of obtaining access rights is the controlling of development, permitting the revitalization of existing commercial developments rather than encouraging new development along new routes. Such access controls also have the corollary advantage of eliminating interchange and intersectional traffic problems which would accompany new development along the route. The practice of using access control primarily as a means of eliminating competition to existing developments may be questionable with regard to the intent of the legislation, but as an auxiliary effect it apparently has proved valuable in some areas.

A more comprehensive planning philosophy with regard to highway location is actively pursued by some States, which carefully analyze all of the planning aspects of alternative highway locations. In Michigan, for example, an attempt is often made to locate freeways close to the central area of a community, rather than as a more distant bypass route which avoids the central city. The objective is to provide improved accessibility to the central area and create new development potential immediately adjacent to the downtown core, which will tend to stabilize and strengthen the central area.

In contrast, the alternative of locating the freeway more distant from the central area creates opportunities for competition and draws much of the commercial vitality to new locations around freeway interchanges. This type of bypass frequently results in a deterioration of the central area, particularly with regard to commercial and office facilities.

In one Michigan city a new freeway that was located immediately adjoining the downtown area resulted in a new department store being developed in the central area to complement and strengthen existing commercial developments, rather than in some suburban location where it would have created severe competition with the central core.

The use of highway location and access controls as an effective implementation device to encourage desirable land-use development practices appears to offer a valuable tool and further exploration of this device should prove rewarding.

THE HIGHWAY IN THE URBAN LANDSCAPE

In addition to the new role of the highway as a tool in shaping metropolitan area growth, it has achieved additional prominence in affecting the visual structure of the city. Freeways have become one of the most dominant elements of the urban landscape, rivaling natural topography. An individual's perception of a metropolitan area is largely developed through his daily visual contact with the community as he drives along the freeway. The highway has, therefore, assumed a much greater significance than as a transportation device alone. The land use immediately abutting the highway has also become part of the urban landscape, achieving a prominence which is unparalleled.

Land-use controls must now take into consideration the aesthetic and visual opportunities presented by the highway in the urban landscape. This is an area where little has yet been done, although programs such as the Scenic Highway Program have brought this new element into sharper focus.

A few instances have arisen recently where the need for relating land uses to the freeway system has received special recognition. Fresno, Calif., has initiated a project to analyze the implications of its new freeway locations on the land uses immediately abutting the routes. The acquisition of various properties in conjunction with the freeway right-of-way requires a study of relocation potentials. The study would ascertain the most appropriate locations for various types of land uses in relationship to the freeway. It would establish new commercial and industrial sites and attempt to integrate these land uses and their access with the interchange designs. Recommended controls of land use, property subdivision, and design adjoining the freeway would be developed. The freeway design would also be correlated with the land development immediately adjoining, taking into consideration the visual opportunities afforded and possible joint utilization of rights-of-way for multiple land uses.

Similar studies have been undertaken in Pasadena and other California communities. Multiple use of rights-of-way, including the use of air rights over and under freeways for parking and other purposes, has introduced a new dimension in the integration of the transportation facility into the community, whereby both the transportation and land-use functions can complement each other most satisfactorily.

THE HIGHWAY CORRIDOR CONCEPT

According to Levin (*B01*) there is need for a wider concept of the highway based on functional considerations rather than physical limitations.

The corridor concept of the highway facility is dealt with specifically in the new scenic roads legislation. The primary purpose of the law is to permanently protect the highway corridor with regard to scenic values, even though this might involve considerable additional cost. It deals with various zones within the corridor that are affected by the highway, as follows:

1. The immediate zone is the actual right-of-way occupied by the highway.
2. The inner zone beyond the right-of-way has a legal and functional status where controls are exercised.
3. The outer zone is largely defined for purposes of protecting the view and is subject to somewhat lesser controls.

Some authorities anticipate that this functional concept of the highway can also be extended in other directions to correct some of the deficiencies of current highways. An expansion of controls for the purpose of protecting the functional and safety aspects of the highway is an interesting concept that should be thoroughly examined for possible application with regard to stabilizing highway utility.

CHAPTER SIX

HIGHWAY FUNCTIONAL CLASSIFICATION

HIGHWAY FUNCTIONS

The functional classification of highways is of relatively recent origin. The idea that a highway system could consist of a hierarchy of roads was advanced in the early part of the present century in an attempt to apply the principle of division of labor which had proved so successful in industrialization. The intent was to organize travel and transportation facilities so as to multiply the capacity of highways. It was stated that three distinct types of movement could be identified on the roads, which would reflect three purposes of highway function: access to land, service of various objectives of travel within the community, and intercommunity travel and transportation.

At that time most of the highway systems had the primary function of furnishing land access and, without the streets and highways, land development would have been almost impossible. At the same time, simply living within the community led to development of certain transportation activities requiring the traversal of these

land access areas and the mobility function became important on some of the roads involved. This access function was even more stressed in urban areas, where land holdings were relatively small in size and each parcel required its own access. In retrospect, the tremendous highway building program of the 1930's and 1940's, where well-built highways provided extensive land service, has resulted in much premature obsolescence due to a failure of recognition of functional distinction. Even today, the importance of this mobility portion of the highway function as a factor in community service, as opposed to land service, is not fully recognized by the general public.

FUNCTIONAL CATEGORIES

Since the early portion of the present century, several proposed breakdowns by functional classification have been made. Each had its own peculiarities, but all are basically similar in some respects. The major differences are in the number of levels of classification and mixture of function, but all of the schemes recognize the two extreme functions of land service and through highway mobility or movement.

In any modern consideration of a functional classification of roads, there are two categories of public ways which are always present. One serves movement almost exclusively, while the other is almost wholly oriented to land access. The modern freeway is distinguished by two features which are always present—controlled access and grade separation. Freeways do not normally provide access to abutting land in any direct way. Their purpose is area accessibility and the intent is to make it possible for highway transport to get to and from an area safely, conveniently, and economically.

Freeways have proved their ability to carry out this intent. It is the short trip from freeway to destination that is becoming the problem. Just as air travel for many trips takes less time between airports than to and from airports, inadequate cross-highways seem to add an inordinate travel time to the trip. It is on these cross-highways in urban areas that the functional classification appears to break down.

These cross-highways can, of course, be permitted to serve any level of land access that is desired. In most of the extreme examples of congestion in the vicinity of freeway interchanges, it will be observed that no control of land access has been exercised on the cross-highways, thereby converting them to land access streets. This, of course, is the other extreme in functional classification. These are the local land service streets available for access to all abutting property. The streets are lined with driveways, alleys, curb cuts of all sorts, and curb parking is normally a major obstacle to traffic flow. Such streets cannot move large quantities of traffic for any distance. Because of the lack of land service from freeways and inadequacy of transportation service from access streets, it is extremely doubtful that a total highway system made up of only these two components can provide an optimum under normal conditions.

Thus, two or more additional functional levels are ordinarily included in highway systems. The higher order of these is the arterial (sometimes called primary, trunk highway, major highway, etc.), which can provide excellent service between areas of a community. In order to have this capability, however, it cannot provide a high level of land service and, in fact, should not provide any direct land service at all where possible. Its function is generally two-fold—to provide a high-capacity connection between the long-haul freeways and the land service street pattern, and to provide for relatively fast transportation within a community when the trip lengths do not warrant use of freeways themselves.

Occasionally arterials feed directly into land service streets. In many cases, particularly in small communities, this arrangement is satisfactory. In larger communities, where the arterials carry heavy traffic volumes and where direct distribution into land service streets creates too much friction and conflict with these larger volumes, there is a second level, generally known as a collector (secondary highway, connector, etc.)

This category forms the transition from the minimum access of the arterial to the almost complete access of the land service street. The collector provides occasional access points into abutting property, but its main function is to provide frequent contact with numerous local streets at public street intersections. The limited number of intersections with arterials permitted by the use of collectors helps to maintain arterial flow at a reasonable level while at the same time collectors provide a convenient distribution system into the direct land service roadways.

Under most circumstances, a highway functional classification system can be reduced to the four levels indicated—freeway, arterial, collector, and local service. Intermediate classifications or subcategories for any of these can be introduced, simply by choosing a somewhat different mix of movement versus access, but the introduction of additional classifications rarely clarifies and usually confuses the system. Some systems of functional classification have broken each of the lower classifications into a number of subclassifications. Such extensive specialization may be useful in special cases, but it would appear that a more limited classification scheme would provide adequate flexibility for most occasions, as well as greater simplicity in its application.

Numerous categories of highway facilities are now in use with little uniformity among agencies. Further study is needed of the exact role and function to be served by each type of facility, and especially the geometric design characteristics which differentiate them. Each category should be evaluated for the particular characteristics that would be most suitable for each type of abutting land use.

HIGHWAY FUNCTIONAL CHANGES

The radical changes that have taken place in the functions and use patterns of some of the highway classifications with the advent of the freeway emphasize the need for re-evaluation of highway planning practices. Previously, trips of any substantial distance were served by the arterial street system, which provided the only continuous, regional

linkage. With a relatively uniform distribution of development intensity in large suburban areas, traffic flow patterns were often relatively uniform and continuous throughout much of the network of grid arterials, with exceptions on the approaches to central areas. Upon completion of the freeway network, most trips of substantial distance are diverted to the new system. The arterial network then serves principally as feeders for the freeways and for shorter trips which would not benefit by using the freeways.

A number of significant pattern changes take place when this occurs. Major traffic flows that formerly paralleled a freeway route re-orient themselves in a direction perpendicular to the freeway. Arterial traffic flows that were relatively uniform before, greatly increase in intensity approaching freeway interchanges, and experience lower traffic intensity in the area between freeways. This variable demand placed on different arterials and on different portions of the same arterial would indicate that a pattern of uniform arterial spacing and uniform cross-section is not necessarily consistent with the demands being imposed. The possibility of varying highway width in accordance with traffic demand may provide a new opportunity for greater transportation balance in accordance with the needs of development.

Commercial development which proliferated around the arterial highway has reduced the utility of the highway for through traffic. However, the facility itself can continue to serve a useful although changed function. It now provides land access as well as serving the shorter trip which remains on the highway. Wherever its former function has been absorbed by a new freeway facility, the highway now performs other types of service to accommodate changing conditions. Although its function may have been impermanent, the physical structure can continue to serve the community in a useful manner.

This change has usually taken place in an unplanned fashion. The access function has been thrust on the facility with few controls, and the result is a facility which cannot serve its current functions efficiently. The objective in the future should be to anticipate that change will occur, and to build in those controls which will minimize the effects of disruptive influences.

HIGHWAY PATTERN CHANGES

Many changes have taken place in street and highway patterns in new areas to correspond with functional changes. However, the pattern of arterial highways has generally remained the same. In many metropolitan areas the grid system of arterial roads is maintained at the same general spacing as before, and the proportion of land area devoted to arterial streets has remained the same. The additional land devoted to freeways has increased the total land potentially reserved primarily for the through traffic function by between 2 and 3 percent.

Considering the radical changes that have taken place in the arterial function with the advent of the freeway, it is appropriate to analyze the new role of the arterial highway after completion of the freeway network. Prior to the freeway concept, when the arterial street formed the highest class of highway, lengthy continuity was required to allow it to serve its purpose. This principle was carried down to the lowest level and resulted in the typical grid patterns of most of our metropolitan areas. With the advent of the private automobile as a primary transport mode, the acceptability of increased travel distances permitted development of residential areas served by discontinuous street patterns for local access roads. Today it is uncommon to find modern residential subdivisions (or industrial parks or regional shopping centers, for that matter) with continuous internal street systems.

With this precedent, and with the freeways as a backbone system, serious consideration might be given to raising the level of street on which discontinuous operation would be acceptable. There may be a need for a duplicate system of continuous arterials at lower service levels for those persons who do not wish to use freeways, and for emergency or peak conditions when the freeway is inadequate to meet demand. It would seem, however, that the need for long-distance continuity at the collector level, and even for minor arterials, may be subject to review.

In the development of new facilities it is no longer essential for origin and destination to be connected by a straight line to provide effective traffic service. Most motorists today measure their driving distance and convenience in terms of travel time rather than physical distance. There is less concern with travel mileage than with travel ease and clarity, and especially with time. Freedom of movement is considered more desirable than directness of movement, as long as clarity is maintained. This concept offers much greater flexibility than when an optimum highway was equated with a straight highway. Further exploration of this basic concept may produce valuable results in developing effective transportation facilities for the future.

Major changes in street area and in street pattern have occurred on the local streets. In many current developments the land devoted to local and access streets is only about one-half that required in the old gridiron-type pattern. The reduction in total street area which has been noted historically has been accomplished by an increase of block sizes and the introduction of curvilinear-type designs in the newer residential areas. There has actually been a net increase in area devoted to the movement function of arterials and freeways, but this has been more than compensated for by the reduction in local street area.

The trend in renewal of older areas is to reduce street area by the creation of superblocks and the elimination of unnecessary local streets. In most cases, however, some of the old streets must be retained for service and access, even though they may not be needed for movement.

Another factor which often discourages the abandonment of older streets is the need for maintaining utilities and easements within these rights-of-way when excessive costs do not permit their relocation or abandonment. Only in the case of total renewal has it generally been feasible to materially reduce street areas in older neighborhoods.

Although a greater proportion of the land was devoted to streets in older urban areas, development intensities were

usually higher, so that the ratio of street area per resident was about the same as in newer developments with less street area. There were, of course, fewer vehicles on the streets, but those vehicles could not be moved as efficiently and congestion was apparently just as prevalent as today.

Obviously, today's conditions are vastly different from those of previous eras, and the circulation requirements are quite dissimilar. The need for a re-evaluation of circulation requirements is clear. The interrelationships between the transportation facilities provided and the land uses served must be analyzed in the light of the new conditions and opportunities that are currently provided; even those practices of two decades ago are questionable when examined from the viewpoint of the post-freeway era.

OPTIMUM HIGHWAY BALANCE

Accepting the premise that a modern highway system must be comprised of several different functional types of facility, the question arises as to what would constitute an optimum mix of these facilities for a balanced highway system. One of the elements of balance is between controlled-access and free-access highways to provide maximum transportation capability and safety without impairing land service. The objective of balance would be to achieve an optimum mix between freeways, arterials, collectors, and local streets, which would provide maximum capacity and safety, minimum land utilization and cost, and adequate land service.

These new concepts may have only limited applicability for some time in areas that are already fully developed. There is already a tremendous investment in the street and highway network which must be maintained with minimum change. The greatest challenge and opportunity lie in those areas where no commitments presently exist. Because the urbanized areas will virtually double in size during the next 20 years, a very sizeable portion of the land that will be in use in the next generation is not presently committed. A re-evaluation of transportation requirements in these newly developing areas could result in a more balanced transportation pattern, providing better service both to the highway user and to the community.

The concept of optimization could be carried even farther in seeking the combination of circulation and terminal facilities that would provide maximum capacity and minimum cost. The most economical transportation system would provide the greatest transportation capacity and the shortest travel distance. Relating this principle to a freeway system, the least over-all investment may be a system whereby the freeway and terminal facility are contiguous, so that the driver can terminate his trip without entering any intermediate surface highway facility. Discussions with various highway officials have disclosed that there is an increasing trend in transportation system design to consider the terminal facility as well as the travel facility, in order to provide optimum service for the highway user. The complete circulation function includes both traffic terminals. Examples of such systems have already appeared, where direct connections have been provided from a freeway facility to a parking facility, although such examples are still relatively rare.

CHAPTER SEVEN

ACCESS CONTROLS

EFFECTS OF UNCONTROLLED ACCESS

Many of the problems of existing surface highways can be traced directly to the lack of access control. Prior to extensive application of the freeway concept, most arterial highways were developed with little control of direct land access. The high traffic volumes (representing potential customers) along such routes created a demand for commercial development, which resulted in a proliferation of commercial uses along the facility. The most profitable marketing of adjoining properties was achieved by subdividing the highway frontage into the largest number of frontage units, which were then sold to individual owners. When the need for parking and servicing became obvious, individual property owners sought individual driveways, resulting in highways with an endless series of access points. Each of these represents an intersection with the highway, and their proximity is a prime cause of the chaotic situation so widely condemned by highway administrators.

The highway administrator is only too conscious of the deterioration and functional obsolescence of an entire generation of new arterial facilities which were built only a few decades ago. The huge investment that was intended to develop much needed highway capacity was largely dissipated through the premature obsolescence of these facilities as abutting developments grew along the entire length. Most of these older main roads are structurally adequate, but operationally deficient as arterial routes. The cost of improving these facilities to regenerate their traffic utility is often so great that it is generally less expensive to build a new facility than to salvage the old one, and a completely new facility is built, paralleling the old one but in a different location.

In many instances highway administrators condemn the

land-use practices which permitted the problem to develop. Obviously, if commercial development had not been permitted to expand along the highway, this obsolescence would not have taken place. This explains the specific interest in an analysis of land-use control practices to determine how and where such practices have been faulty in the past, as a guide toward avoiding a recurrence of the current situation. Or perhaps the problem lies not so much with the development as with the lack of other controls that could have prevented the problem.

It is essential that the basic problem be correctly analyzed so as to avoid a repetition of the same problems that caused the demise of the old highway. Most agencies appear to be well aware of the inherent dangers. However, there are some cases where adequate protection for the new facility has not been built into the new route.

CAPACITY VERSUS ACCESS

The objective of access control is to protect the utility of the highway. It is apparent that the land service function decreases the capacity of a facility. But little is known as to the quantitative effects, or of the effect of different designs of land service. The capacity of a highway is normally expressed in terms of number of vehicles per hour for unrestricted flow conditions. This number is modified through the application of various factors to account for the actual existing conditions. These modifiers normally include such things as commercial vehicle traffic, lane widths, grades, curvature, etc., but do not normally take into account conflicting vehicular traffic in terms of number and pattern of cross streets, driveways, etc.

Under conditions of light to moderate traffic flow along the arterial, and without an excessive number of points of entry, there will be adequate gaps in the arterial traffic to permit the side traffic to enter without major disruption. Under conditions of heavy traffic, however, relatively few entries from each of many driveways can create serious problems for the arterial, and for the side traffic itself, in terms of excessive delay. Often, attempts to solve these problems consist of the installation of traffic control devices at street intersections, and occasionally at major driveways. In many business districts the excessive number of signals installed has contributed much to the over-all congestion and low service levels experienced in those areas.

Although the effect of driveway access points has usually been considered and recognized as detrimental to a major highway, the effect of numerous street intersections has not received the same consideration. There is, of course, little physical difference between an entering stream of traffic from a street and from a driveway. Quite often it is clearly evident that the problem is not so much the number of vehicles entering as the number of points of entry and their design.

A study by Major and Buckley (*228*) of access point spacing along an arterial stream of traffic considered the problem from the point of view of the abutting property in calculating arrangements to provide for minimum delay to entering traffic and, alternatively, maximum capacity for the entering traffic. Their results, however, are also applicable to the highway itself. They found that a multiplicity of driveways or access points at close intervals produced not only undue conflict with the arterial, but mutual conflict with each other, resulting in lower capacity and increased delays for traffic from abutting property entering the highway. On the other hand, spacing those driveways adequately distant from one another to permit the highway traffic to regain its random flow characteristics between driveways proved to be the most satisfactory arrangement to minimize delay to the entering traffic, as well as to maximize the arterial flow.

If a method were developed to predict the amount by which highway capacity is reduced by various types of land service, a valuable tool could be made available to governmental agencies, because it would be possible to demonstrate the effectiveness of various degrees of access control in the increase of highway capacity.

ACCESS CONTROL EFFECTIVENESS

In almost every reference where the question of protection of interchange areas or protection of main highways of any sort was considered, the use of access control as a fundamental tool was emphasized. Of course, the greater the demand on an arterial, the more important this control becomes. In the immediate vicinity of interchanges, where the most intense traffic volumes will normally be encountered, the need for access control is of greatest importance.

Acceptance, both by the public and by the courts, of access prohibitions to certain highways and to freeways, is a general fact throughout the country. However, acceptance of access control and limitation for other highways and streets has not been generally reported. There are many reasons for this situation. In some communities the land ownership breakdown is such that prohibition of a driveway on an arterial street to a given parcel of land would often be equivalent to total denial of access to that land, a situation which would require utilization of eminent domain powers and compensation to the landowner, rather than police powers. Other communities have found that the potential tax revenue from proposed developments was just too tempting to lose because of a battle over access to a major highway, a very common demand of large developments. Many cities have rarely had sufficient staff to convince the developer either of the impropriety and detrimental effects of that access upon the development itself, or to analyze the situation adequately enough to develop access which would not be so damaging. From the point of view of the developer, limited access often creates limitations that would not otherwise exist. If the limitations that access control puts on the potential land use are unreasonable, access control will prove unstable and ineffective in protecting the utility of the highway.

ACCESS CONTROL FOR NEW FACILITIES

Freeway facilities provide the principal example of preservation of transportation capacity through elimination of all access rights. Some States have extended this principle

to include many other new State highways. Connecticut has found that purchase of full access rights in conjunction with new rights-of-way is only slightly more expensive than to acquire the right-of-way without such access controls. Therefore, they have established a policy of usually purchasing access rights whenever new rights-of-way are acquired. This is particularly applicable in rural areas, where the low additional cost makes this policy economically feasible. In more urbanized areas obtaining access rights along new highways is frequently prohibitively expensive. New Jersey indicates that a general policy of obtaining access rights with new highway alignment rights-of-way would not be practicable in an urban area, due to cost considerations, except in the case of freeways.

Discussions with land-use attorneys (*B11, B14, B15, B16*) indicate that reasonable control of access can generally be exercised by the State under the police power. However, unreasonable controls are compensable and the principal area to be resolved is what constitutes reasonable access control. Carroll (*B9*) considers the application of access controls to highways as a police power that is exercised in a manner similar to zoning. It is intended for the protection of health, safety, and welfare through the exercise of design and geometric control of access privileges in the same manner that land-use zoning protects the public interest.

Some States exercise such control in the review of all subdivision plats abutting State highways and through driveway ordinances. Wisconsin attempts to limit access to the highway to minimum 1,000-ft distances between intersections. Michigan attempts to achieve access control by proper design on a cooperative basis; wherever possible, an attempt is made to have all driveway access from a cross street rather than directly from the State highway.

Although many agencies have been successful in exercising access control through subdivision ordinances, there is sometimes a loophole available to developers which has created serious problems. Subdivision ordinances often control division of land only when five or more parcels result. The local governmental agency can then exercise control. In many States, however, land splits resulting in four or fewer parcels are not subject to subdivision controls. Some developers have used this loophole to subdivide land into four parcels, and then later to re-subdivide each parcel into four more, thereby evading the intent of the ordinance. This device can then be used to justify the need for additional driveways.

Michigan is attempting to combat this practice with a new law that makes any land parcel subdivided into five or more subparcels within a 10-year period subject to the subdivision ordinance. This will extend the controls to cover most cases of attempted evasion of subdivision requirements, so that improved access control will be possible in the future. Many cities and counties have ordinances which must be adhered to for any lot split to combat this practice.

The application of access controls under the police power, rather than acquisition of access rights through purchase, appears to offer a significant tool with many long-range opportunities.

ACCESS CONTROL FOR EXISTING FACILITIES

Wisconsin has the power to impose effective access controls for existing State highways. A trunk highway above a specified traffic volume is declared a controlled-access facility and a public hearing is held which results in a freeze of existing access conditions, taking into consideration requests of adjoining property owners for additional access. After that no additional intersections are authorized unless they can be individually justified and fit the State's policies with regard to access along the particular route. Access controls are exercised under the police power, based on public health and safety considerations.

Wisconsin has also extended the controlled-access highway law to cover county trunk highways. The County Board holds hearings where access locations are fixed and maps are prepared showing official locations of highway entrances. These access restrictions cannot be removed without another public hearing, although property owners can resort to the courts to obtain additional access within 30 days of the hearing and prior to adoption of the official map. The only legal requirement appears to be that properties are entitled to direct access from a highway, but the courts have held that the property owner suffers no compensable loss when a frontage road is constructed, even though this may incur additional travel.

One of the most serious problems in most States is the achievement of stable controls with regard to access restrictions. In the case of freeways, the acquisition of all access rights provides permanent protection which is not subject to deterioration over the years. However, in the case of restricted-access highways there is the danger that restrictions may be diminished over long periods of time. Eventually, the built-in capacity and safety may be seriously curtailed as the pressure for additional access points is increased.

The method of fixing access locations by law is a useful method to establish controls which are not readily subject to local pressures, and to assure that political expediency has minimum effect on the highway facility. These and other tools for implementing restricted access control should be studied for wider application.

CHAPTER EIGHT

HIGHWAY DESIGN CONTROLS

DESIGN FLEXIBILITY

If the highway is not to become prematurely obsolete, it must serve changing requirements. A greater degree of flexibility in design may be able to accommodate a changed demand that might be imposed in the unknown future. Many existing road facilities are obsolete with regard to the type of service that they are now required to provide. Once constructed, a road is fixed in location and alignment, and the facility can very well persist through several cycles of land use.

As a transition occurs from rural to suburban to urban conditions, each phase in the development of the area has different requirements. Initially only two lanes with minimum access control may be needed, later four lanes with partial access control, and still later six lanes with restricted access. Ultimately, even greater capacity approaching an expressway may have to be developed.

Some jurisdictions have recognized the need for such stage construction, and have reserved sufficient rights-of-way to satisfy the increasing demands of the future, even though the initial facility may be of a minimal nature. In California the construction of rural freeways is initiated with the development of a two-lane facility, which is redeveloped and upgraded as increasing needs become apparent. This requires that the initial design provide for such upgrading and that sufficient right-of-way be acquired to make it possible.

Design flexibility permits a periodic reassessment of the changing function and new requirements of the area, which permit the transportation facility to keep pace with new developments. Not all facilities can be designed with this degree of flexibility. However, it may be possible to develop a system of design which will permit greater flexibility of operation and opportunities for upgrading service without a tremendous additional investment in right-of-way.

Carroll (*B9*) suggests that the intensity of land use can be correlated with the number and capacity of highway facilities provided to serve such land use. This general correlation is calculable, and both the land use and the highway facility should logically be developed in parallel with each other, so that the transportation facilities balance the proposed land-use intensity. With this approach the key element is flexibility of design to prepare for an intensification of land use that may occur subsequently. It would appear possible to develop a detailed methodology whereby the staging of highway development would be kept in close correspondence with the intensification of land uses served by the highway. If this type of programming could be developed, it would provide one of the soundest approaches to relating transportation and land use positively.

Past history illustrates that right-of-way reservation is probably of extreme importance, even in those areas where long-term planning provides transportation needs estimates. "The continuing concern in the field about over-design is probably misplaced; in the long life of cities, examples of over-design are rare. The concern of proper design is long-term service." This applies primarily to freeways and arterials, and not to local streets.

"Space for the channels of movement that are an integral part of any community composite, must be ample beyond anything that we have yet thought necessary." It would appear to be necessary that, just as city planners strive to preserve flexibility to adjust land uses as future needs develop, highway planners must preserve their ability to accommodate future transportation needs which cannot now be evaluated, but which are inevitable.

The circulation system must also be considered as a chain of related elements which must all fit together, so that no individual element is overburdened more than another related element. The design of the system must be flexible enough to avoid premature obsolescence by a breakdown of one of the critical links. It is especially necessary to develop greater design ingenuity which will guarantee that the critical linkages between the freeway and the surface highway facility, between the freeway and the terminal facility, and between the highway facility and the terminal facility, can operate successfully. This appears to offer one of the paths toward greater efficiency of highway expenditure as well as improvement in operation.

DESIGN CONTROLS

The ultimate objective of geometric design controls is to achieve built-in protection for the highway facility which will be relatively permanent. The rapid rate of obsolescence of many existing arterial routes is partially due to a lack of basic principles and guidelines available to the administrator who must make daily decisions with regard to these matters. The general use of access control, parking restrictions, intersectional and driveway spacing controls, frontage roads, raised medians, and other techniques, can have a tremendous effect in preserving the integrity of the highway facility. However, their value is limited unless the agency which must implement these devices is familiar with what constitutes desirable practice.

The degree of control exercised by governmental agencies varies considerably between jurisdictions. Some governmental agencies have made great strides in establishing design patterns and policies which permit the highway to develop built-in self-protection to preserve its inherent capacity, and to ensure permanence in the transportation investment. In reviewing some of the basic thinking and logic upon which these policies are based, it has become apparent that the basis was largely established by precedent and rule of thumb, rather than by an intimate knowledge of the relationships that exist. In order for these types

of controls to be favorably accepted by the community, especially when they exercise a greater degree of severity than is common, it is essential that the reasonableness of such controls be established.

The practicability of application of specific traffic control techniques is directly related to the type of land use immediately abutting the highway. Creighton (*B10*) has provided a basis for highway design standards abutting strip commercial development and commercial corners, which can be expanded to provide general guidelines for other agencies. Horwood (*B11*) has also studied design standards for controlled strip development with regard to length, spacing, and provision of frontage roads.

The value of design controls can be most effectively illustrated by relating their effects to highway capacity. An expansion of currently available studies would provide guidance for the highway administrator with regard to the effective application of these techniques, and also present conclusive evidence of their effectiveness in improving highway efficiency. The development of design standards which would provide an optimum combination of efficiency, safety, and land access would permit the effective application of the police power to achieve maximum public safety and to protect the public's interest in the highway facility.

In most cases heretofore, traffic restrictions and controls have been viewed as remedial measures used by traffic engineers in an attempt to minimize existing problems. The basic purpose here would be to establish the relative effectiveness and applicability of each type of control with the objective of preserving highway utility by initial installation of such devices in a planned manner, rather than attempting installation as a remedial measure afterward, when it may be impossible without major disruption of the community.

DESIGN CONTROLS IN NEW AREAS

Implementation of design controls can be effected under legislative as well as police powers. Legislation now under consideration in Wisconsin would establish State control on a 1,000-ft strip on either side of State trunk highways. This would permit the exercise of controls for all State routes to protect the aesthetic features and the utility of the route. The Southeast Wisconsin Regional Planning Commission has proposed a model zoning ordinance which would effectuate similar types of design control by local agencies. The State also establishes certain controls prior to re-selling surplus properties, which include the establishment of scenic easements, signing controls, setbacks, access controls, and other restrictions which reserve special advantages for the highway.

Some local agencies have developed standards of geometric design for the purpose of exercising control on arterial systems. Ventura County, California (*B8*), has established a policy for prohibition of direct land access to the primary and secondary road network for residential development, limiting intersection spacing to between 1,100 ft and 1,500 ft. Raised medians are normally proposed with left-turn pocket lanes provided at all intersections. In commercial areas the County attempts to prohibit left-turn access less than 600 ft from a principal intersection. A left-turn pocket lane is then provided to accommodate vehicles wishing to turn left into the development. Under some conditions additional driveways may be permitted with access limited to right turns in and out.

Creighton (*B10*) advocates that no direct access be permitted from residences into arterial highways, as a general policy. He also advocates stronger control of driveway location and minimum spacing requirements, the general restriction of cross streets into arterials at ¼-mile intervals, and the elimination of on-street parking on arterial highways. Access restrictions are commonly employed in residential areas, where driveways along arterial highways are often prohibited. Land access is accomplished by the use of service roads, back-up design, or side-on culs-de-sac for developments abutting arterial highways.

An interesting theme which recurred frequently in discussions with agencies throughout the country is that good sense in highway design control can be beneficial to the land-use developer as well as to the community and the highway user. There should, in actuality, be a common bond between property values and community welfare, whereby there is a positive effect on the development by the exercising of certain controls which would be in harmony with the developer's objectives as well as providing benefits for the highway user and the community. Traffic problems with new development can be minimized, provided the development is physically controlled and designed to minimize these difficulties, and the highway is physically controlled and designed to minimize any adverse effects of the development.

DESIGN CONTROLS FOR EXISTING CONDITIONS

During the discussions with various agencies, many examples were cited of serious problems where commercial and other types of development followed the installation of the highway. The most serious involved cases where little or no access control was exercised. This often resulted in continuous driveways, which could not be distinguished from the highway pavement, or a frequency of driveways which interfered with each other as well as with the highway. The most severe problems were encountered where no effective median barrier was provided and left-turn access was available continuously for the abutting developments. In those instances where stringent driveway location controls were exercised and where median barriers were installed, the problems were less prevalent, even though similar development intensities were permitted. It therefore appears that the major concern in many instances is not with the development that is permitted, but with the access that is uncontrolled.

Most improvements for present facilities are designed to minimize the effects of existing deteriorating conditions. Strip commercial development has seriously impaired the effectiveness of many routes as transportation facilities, while at the same time it has increased the need for capacity to serve the abutting developments. Faced with this condition, most States have developed a two-sided program. One is the development of new facilities which, in

effect, abandon the existing facility for through traffic purposes. The other is upgrading of the existing facility to a standard of design which can provide through traffic service while also serving abutting developments.

Where existing facilities are upgraded, it is frequently necessary to acquire additional right-of-way and widen the highway. A median effectively controls left-turn movements, which are a principal problem in serving abutting developments, and intersections are generally limited to significant cross streets, many of which are signalized. Most access to abutting property is achieved by right turns in and out, or from frontage roads, minimizing the detrimental influences on highway capacity. This type of improvement has generally resulted in significant increases of route capacity and has not seriously affected access opportunities to abutting properties, particularly where opportunities are provided for a change of travel direction at reasonable intervals.

New Jersey has developed restrictive access design policies which have been especially effective in upgrading older highways. Barrier median curbs, unbroken for many miles, have been installed along older routes. Medians control the flow of traffic under the police power, but also eliminate conflicting left turns and other undesirable movements. Access to abutting property is provided by right turn only where no breaks in the median are permitted. A change of travel direction is made possible by grade separations and ramps, which permit the driver to leave the highway and reverse his direction by negotiating a U-turn.

New Jersey has also developed new types of intersections along major arterial routes so that left turns are not required from the left lane. These practices were usually necessitated by restricted rights-of-way, where left-turn pockets would have been impractical. Additional intersections or grade crossings are strongly resisted; on some routes intersections have been limited to ½-mile or 1-mile intervals. In some cases a "jug handle" design has been developed through the acquisition of special rights-of-way along the outer side of the highway. In other locations new cloverleaf-type roadways have been developed at grade, whereby drivers negotiate three right turns beyond the intersection into a signalized cross street. These types of intersection design utilize existing roadways or new rights-of-way specifically developed for that purpose. Both the cloverleaf at grade and the jug handle have high turn capacities, and offer one effective solution to the left-turn problem along existing routes where rights-of-way are limited. Massachusetts has also used the jug handle design effectively, but has more frequently utilized a wide median design where U-turns are permitted within the median.

Massachusetts also is upgrading some existing arterial highways into expressway facilities, with grade separations at major cross streets. One-way service roads are added on both sides of the express roadway, with access from the new express lanes to the service roadways achieved by slip ramps on and off the expressway. Access to adjacent development is concentrated at specific points and restricted to right turns on and off the service roads. Vehicles can reverse their travel direction by using special U-turn bridges provided at intervals. These types of improvement are relatively expensive, and the standards are not as high as on new facilities. However, this may be the only course available in some locations to correct existing situations which have become intolerable.

Wisconsin is attempting to remove excessive driveways from trunk routes by combining access at specific locations. Crossroad connections are provided at no greater frequency than ¼-mile, if possible. Where present driveways occur at greater frequency, they have a program by which frontage roads may be installed which provide openings to the main roadway at intervals of about ¼ mile.

In some States the improvement program has not been completely successful in rural areas due to its safety record. In Connecticut, unusually high accident rates have continued along some highways that have been improved in this manner. The reason appears to be that the improved facility presents a false appearance of safety, resulting in speeds unsafe for the actual conditions. The occasional traffic signal surprises the motorist and accounts for a high incidence of rear-end accidents. Collisions with roadside obstructions and accidents involving vehicles entering and leaving commercial driveways are also prevalent. In many cases States have preferred to relocate the highway rather than attempt an improvement of an existing facility where access could not be reasonably curtailed.

INTERNAL DESIGN

Although the primary concern of the administering agency is the control of access locations and the design of the highway geometry to provide access to abutting properties, the traffic operation within the property served has considerable bearing on the effectiveness of the access control. Especially in the case of large traffic generators, provision of adequate reservoir area within the property, so that vehicles can be accepted into the facility as rapidly as the highway can deliver the traffic, is of prime concern in the efficiency of operation of the total system. Similarly, the design of adequate exit facilities will also affect the efficient operation of the highway.

Frequently, the effectiveness of internal traffic design will govern whether a particular development intensity can be accommodated effectively or whether traffic congestion will ensue. The control of land use is, therefore, intimately related with such elements as access control and internal design.

The City of Los Angeles and other local agencies attempt to provide some degree of control of internal design when reviewing driveway location permits. Other agencies attempt to exercise some degree of control by requiring a review of the plot plan for the development. It is essential that those agencies which have the power of review and approval be fully aware of what constitutes effective internal design and what design elements create problems. It is also necessary to find more effective implementation tools which will make it possible for local agencies to review internal design features in conjunction with land-use controls. This type of control is seldom exercised, but it has many implications that directly relate to land-use control decisions.

CHAPTER NINE

TRAFFIC GENERATION

TRAFFIC GENERATION CRITERIA

The most obvious relationship through which land use and transportation are associated is the traffic generation potential of the land use which must be accommodated by the abutting highway. In the absence of criteria whereby the decision-making body can evaluate the interrelationships between the land use under consideration and the transportation demand generated, the agency is severely handicapped. Consideration is then based on the over-all value of a particular development to a community, and it is optimistically presumed that the highway, as a service facility, will be able to accommodate the transportation demand.

Although governmental bodies have the power to control the intensity of development, they are usually unable to relate optimum intensity to circulation requirements. In most cases the agency has neither the time, the facilities, nor the personnel to analyze the complex land-use-versus-transportation relationship. They must make daily decisions by rule of thumb, and by applying established practices and procedures which may have little relationship to the problem. Many of them candidly admit that they must adhere to obsolete policies for the lack of more basic guidelines.

In some States available technical capabilities at the State level are used by local authorities to evaluate proposed land-use changes and their effects on abutting highway facilities. Michigan law requires notification to all property owners within 300 ft of all zoning changes under consideration by a local authority. This informs the highway department of all proposed zoning changes adjacent to State highways and freeways. The State conducts studies of the effects of the proposed change and advises the local agency of possible problems that might accompany such change. Various controls are recommended which are frequently adopted by the local jurisdiction as part of the rezoning of the property.

In this manner local agencies receive competent technical advice relating the proposed change, and its effects, to the highway system. The State also examines the site design to assure that required future rights-of-way for the highway are protected, and that access control is achieved where needed. This practice, although only advisory, permits the exercise of uniform controls throughout the State for the State Highway System.

This type of advisory service may be subject to wider application to assist local jurisdictions with technical problems. However, technical criteria on traffic generation, including quantitative and qualitative relationships, are not yet readily available, so that the effects on transportation of specific land-use decisions can be determined.

TRAFFIC GENERATION CHARACTERISTICS

The characteristics of traffic generation have been developed in conjunction with various transportation studies, but they have not been assembled for general application by local agencies. From the traffic generation factors developed, it is apparent that commercial districts are the highest generators of traffic demands on a land area basis. However, high-density apartment residential districts often match many of the commercial districts in their generation. Industrial development rarely approaches either on a land area basis. Industrial parks, in particular, often generate traffic volumes, for the acreage involved, of the same order of magnitude as some single-family residential areas. This is particularly true of the total daily use, but the usual concentration of industrial trips in peak hours more than counterbalances this, and industrial traffic design demands are much closer to those of medium-density apartment residential areas. Commercial areas, on the other hand, do not normally create a significant traffic problem in morning periods, but their midday traffic loads and, more importantly, the addition of commercial traffic to the highways during the industrial exiting traffic peaks, commonly result in the worst condition.

Much current planning appears to have a tendency to assume high traffic generation in commercial and industrial areas, and low traffic generation in residential areas. The validity of this assumption is questionable, particularly where apartment units are involved. Typical zoning ordinances, with their concentration of apartment units, create an unusual problem in some areas. Although realizing that there are many other aspects involved in the choice of a city form, Neuzill's (*153*) comment that "It would seem consideration should be given to a more uniform dispersal of apartment elements throughout suburban residential areas . . ." should be kept in mind in preparation of city plans.

One of the biggest single problems in traffic generation characteristics of land uses is the extreme range of potential factors which might occur for each of the major categories ordinarily included in a zoning ordinance. The implication of this is that it would be helpful if zoning ordinances were developed in greater detail, with a finer breakdown in land uses, although the probability of this is slight.

Highways must be designed to meet, as nearly as possible, peak traffic demands rather than average traffic demands. Neuzill (*153*) found that work trips, the major component of peak-hour traffic, were fairly independent of household size and only moderately affected by vehicle ownership. Under this condition it is likely that in any given development or area, the dwelling unit density controls the traffic generation, and multiple residential housing

will generate more peak-hour trips per unit of land area than single-family residential. In typical low-density multiple residential, this generation could range from two to three times as many peak trips per net acre as single-family, while in areas of high-density multiple the value could be as much as ten times.

In industrial communities the problem of peak loadings and peak concentrations may occupy less than 3 hours out of the day. On the other hand, commercial and business communities often exhibit conditions of high levels of demand for 8 or 10 hours out of the day, but with lower peaks.

There is reason to believe that certain mixtures of land uses could provide physical distribution of traffic demands to develop lower peak loads in industrial-type communities and not greatly affect peak loadings in commercial communities. Work and shopping hour staggering could also show significant benefits in trimming peak-hour demands. For many land uses the significant differences in peak-hour characteristics and in travel direction may offer significant opportunities for load balancing.

TRAFFIC LOAD BALANCING

Horwood (*B11*) emphasizes the low utilization of some elements of the transportation network even during peak periods, as contrasted with others which are overloaded. He is interested in establishing a methodology whereby balanced use of the individual elements of the highway system can be achieved. One approach would locate complementary types of land uses in different parts of the freeway interchange area. Residential and industrial land uses frequently have opposite and complementary traffic flow characteristics, while commercial development also has some elements of dovetailing traffic characteristics. Better understanding of the differing traffic flow characteristics and intensities for different types of land use would provide valuable aid in guiding locational practices toward balanced traffic flows on available transportation facilities.

One conclusion that might develop from an optimization of transportation facilities is that the most efficient city form, from a highway transportation point of view, is the fully spread city. A city having completely uniform densities and distributions of land-use types throughout the metropolitan area would probably result in a uniform pattern of traffic movement and an equalization of traffic loads on all facilities provided. The loads occurring directionally in morning and afternoon peak hours would be spread and distributed in all directions on all facilities. The only exception might be a central core area, which would have more pronounced directional trends. Although this may represent the most efficient transportation, it may not represent the most effective community. The ultimate objective is an optimum community, which operates effectively as an organic whole, and there are many considerations and values other than transportation that govern the shape of the community. To a great extent, however, communities are developing a relatively uniform spread in their suburban areas, so that in the future the multidirectional flow of traffic will become more pronounced and result in more efficient utilization of the over-all system.

In a more localized fashion, there are obvious advantages in consciously considering a balancing of land uses around interchanges and in adjoining areas of other transportation facilities in order to achieve the complementary traffic flow patterns which are beneficial from the standpoint of transportation efficiency. These can often be made compatible with over-all community objectives, so that the two primary objectives can supplement each other. Research conducted by Thiel (*B1*) also has concluded that land-use mixtures in the four quadrants of a freeway interchange can balance traffic generation characteristics to avoid intense peak loads. Through a balanced mixture of commercial, industrial, and residential land uses, he believes that traffic peaks can be minimized by eliminating overlaps of traffic concentrations.

ESTIMATING FUTURE TRAFFIC

Several techniques have been developed for estimating future traffic volumes. One technique of particular interest is that developed by Schneider (*229*) for the Chicago Area Transportation Study. By using a combination of local street spacing, arterial spacing, expressway spacing, and mean trip lengths, he developed a way to distribute various trips among these categories of highways. To convert the distribution to volumes, he applied a factor based on the over-all trip density per square mile. The total trip generation for a square mile of land area is assumed either constant throughout the entire area under study, or slightly different, depending on the general character of the land use within the square mile. In typical urban areas, trip generation is relatively similar; even the extremes are not far apart.

As the size of the total area under consideration is increased, the range becomes smaller because the usually high-intensity generators cannot economically be located within close proximity. In a typical freeway grid cell of 4 by 4 miles, it is unlikely that really significant differences in total traffic generation would ultimately be experienced from one cell to another in typical modern suburban metropolitan areas.

According to Carroll (*B9*), in most transportation planning programs the large zones that are commonly employed tend to have an average density which is quite comparable from one zone to another. The gross generation of traffic is hardly affected by the types of development within the zone, or the intensity of such development, as they tend to average out within a given general area. It is possible, even in the absence of a plan, to estimate total gross acreages for various land uses that will probably occur in a typical area, and the gross traffic generation from such a land-use mix will be fairly consistent, whatever the assumptions may be. It is only the localized distribution of land use which may affect the transportation network, and then only in a localized manner.

Voorhees (*B17*) strongly supports the basis of this approach by indicating that, on a gross basis, population, commercial centers, and industrial employment will be found to be consistently distributed in large areas. Levinson (*B13*) also concludes that only major concentrations of development will have an appreciable effect on the

transportation network, and then only in a localized fashion. The actual quantity of jobs, commercial development, residential population, etc., will be relatively fixed for the typical total community. The only significant variable is where these facilities locate, and in what form and concentration. The similarities that have developed from one community to another, and between segments of a community, have become more pronounced than their differences. This finding has profound implications on the planning of transportation facilities.

Of special significance in this regard is the Hartford Area Transportation Study, where five alternative land-use configurations were analyzed in relation to their transportation requirements. It was concluded from the Hartford study that the total transportation network requirements were basically the same for each pattern studied. There were few instances where any particular highway facility was significantly more affected under one pattern as contrasted with another. The only real variability appeared to be in specific sections of facilities where local concentrations significantly affected highway operation.

This consistency may be particularly valid for lower-density communities where there are no high-density corridors to be served. In a few high-density metropolitan areas such uniformity is less pronounced and these generalizations may not apply.

Schneider's formulas have been tabulated by the Upstate New York Transportation Study to be used for large areas to develop broad general estimates of transportation needs with results, as Schneider (*229*) has said, ". . . realistic in a soft, fuzzy way—just about as realistic, in fact, as assignment results." This technique is, of course, most satisfactory when dealing with undeveloped areas that are to be built upon, or portions of metropolitan areas under transition from obsolescent buildings or uses to newer uses. It provides a flexibility of design to accommodate, on an over-all basis, traffic generated by facilities and generators which cannot be directly predicted.

TRAFFIC CONCENTRATIONS

In a localized area, the transportation facilities available may control the type and extent of land-use development that is feasible. Land-use decisions should not be made without evaluating transportation demand and assessing the improvements or additions required to provide the service needed. Criteria are needed to establish limits of concentration to determine when it is advisable to develop in smaller units distributed in wider geographic locations.

Land-use controls such as zoning can assist in correlating land-use concentrations and locational distributions to help minimize traffic concentrations and achieve a greater balance of traffic load. It would be beneficial for zoning practices to be related to these more complex considerations to achieve the most effective interrelationship with the transportation facilities that serve the land.

For the highway designer the more immediate problem concerns the ability to absorb high traffic concentrations. Keefer (*B12*) and Voorhees (*B17*) indicate that traffic from high-volume generators dissipates rapidly beyond the point of contact with the abutting highway facility, because at each succeeding intersection additional traffic distribution channels become available. Therefore, the major design problem involves the absorption of the traffic concentration at the point of access. Another valid concern is the probability of overlap between one development and an adjoining development, whereby the traffic concentrations can become cumulative in effect.

The probable minimum life of a structural element in a community, such as a highway, is 40 years or more, while the effective life of many traffic generators proves to be considerably less. Transportation arteries must be protected in such a manner as to maximize the system flexibility to accommodate relocations of traffic concentrations and generators and the other dynamic changes which are almost certain to occur in a community over the life of the highway facility.

CHAPTER TEN

FREEWAY INTERCHANGES

THE INTERCHANGE AREA

The traffic problems engendered by recent changes in land-use concentrations are being shifted to new areas. The most important of these from the viewpoint of commercial development and transportation are the interchange areas where freeways or expressways join major surface arterials.

Most of the research studies conducted in recent years relating to the problem of land-use controls and transportation have concentrated on these areas. In most cases these studies have considered land-use developments that have followed construction of the freeway, especially highway service commercial facilities that provide the motorist with needed services. Although this type of commercial development has been the most common and has inspired the largest number of studies, the problems are not as severe as those involving major regional shopping centers and large-scale industrial park developments, which have also congregated around interchanges.

There is some question as to just what is meant by the

interchange area. This does not refer solely to the ramp connections themselves, nor does it limit itself to some relatively short distance either side of the ramp connections. Interchange area is not a physical dimension, but a functional dimension, and a major traffic generator some distance from the physical interchange can be just as serious a problem for that interchange as if it were located near the ramps. The interchange area, then, is that portion of the community directly affected by the fact of the existence of an interchange at a particular location.

INTERCHANGE SPACING

One aspect requiring special attention is the number of interchanges to be provided on a given freeway section. If, for example, in a rapidly growing area an inadequate number of interchanges is provided, the development tributary to each could prove excessive in traffic generation for the capacity of the given interchanges and their associated highways. Provided the freeway is adequate for the total demand, an adequate number of interchanges, distributing both development and the traffic load tributary to each, could more easily accommodate the expected development.

Campbell (*40*) points out that a realistic and valuable approach at interchange areas would be to balance construction costs, land-use control costs, and detrimental effects of extensive development on one side, against the benefits of construction, land-use controls, and development on the other. By far the greatest difficulty lies in evaluation of the economic benefit of roadside development—how much and to whom? Also problematic is the emphasis, and resulting evaluation of a given situation, by various governmental levels. The local municipality in its desire for high tax revenue is often in direct opposition to the State government, which desires minimum interference and maximum traffic capability on new highways. When the approach suggested has been developed for application, the analysis of individual interchange development—including benefits and costs for the traveling public, the land development, and the land-use controls—could possibly be extended to include a section of freeway with any number of interchanges.

ACCESS RESTRICTIONS

A major problem in the immediate vicinity of freeway ramps has been that access restrictions often stop at the ramp terminal. Netherton (*152*), in his definitive work on control of highway access, indicates that full control of access from property to highways which intersect expressways (freeways) at ramp locations is provided for by policy and by law in many States, regularly extending access prohibition for distances from 100 ft to as much as 1,000 ft beyond the terminal points of the interchange ramps. In many other States this technique is utilized when unusual physical circumstances indicate its desirability. However, he says: "The long-range wisdom of such measures may be questionable when the objectives of interchange planning are considered. . . . Extension of expressway design and access control to the secondary streets and roads intersecting or feeding the interchange, *when applied beyond the point necessary to assure that traffic will move in and out of the interchange in a safe and orderly manner,* has serious disadvantages not only from the viewpoint of the land developer, but also from the viewpoint of the expressway user and the land-use planner, who seeks to make the best use of the space available in the interchange area."

It would appear, then, that although complete denial of access (except via properly designed ramp connections) is generally accepted as necessary for the freeway or expressway system, the need for total denial of access is not as clear for the arterials feeding the freeway system. Provision of some access without undue disruption of the arterial flow is indicated to be feasible by the Major and Buckley study (*228*). A degree of control of access intermediate to the full denial along freeways and the virtually unlimited access of local streets could consist of minimization of the number of intersecting locations combined with careful design for these points of entry, and control of these locations with traffic control devices where necessary. Concentration of traffic flows into single entry ramps could prove satisfactory both for the land user and for the expressway and highway user.

In the case of the rural interchange where development would be fundamentally highway-oriented services, a frontage road could provide one satisfactory type of control. In the suburban interchange areas, where regional shopping centers or major industrial facilities often develop, concentration of the traffic generated by these facilities at a few entry points where traffic control devices can be installed with minimum detriment to the arterial, might be the indicated approach. Further, design of the interchange ramps themselves to minimize interference with flows (loops, bridges, etc.) could also be a significant factor in maintaining optimum operation of the interchange and its associated highways.

LENGTH OF ACCESS CONTROL

Many States extend access control beyond the ramps, but there is no agreement as to how far such control must extend to achieve effective results. With the inception of the Federal Interstate Highway Program, the extension of control received a considerable setback, because the Federal agencies did not require extension of access controls beyond the ramp terminal for Interstate Highways. In fact, the Federal program virtually prohibited the expenditure of Federal funds materially beyond the ramps, presumably because of the additional expense that would be involved. In the absence of Federal funds for access acquisition, some States eliminated this provision from their standards, and many freeways, including Interstate Highways, no longer had the advantage of access control beyond the ramp area. Some authorities claim that the Federal Government made an error in not encouraging extension of access control, and that this has created serious problems in areas where new facilities were developed with access points close to the ramps.

Some authorities have proposed that access rights be obtained for as much as 1 mile on each side of the freeway interchange. A national association of county governments, having become quite interested in the control of

land use in the vicinity of freeways and highways, has considered the possibility of forbidding driveways on major arterial roads within 1 mile or ½ mile of an interchange. As an interim measure they proposed the freezing of existing conditions to halt the problem of mounting interference around interchanges.

Discussions with highway departments and land-use law experts have indicated a variety of viewpoints with respect to the propriety of access controls around interchanges. Most authorities acknowledged that some degree of control is essential. An opposing view is held by some States, which would prefer to further limit their involvement, as indicated by one comment that even the freeway ramp could logically be considered as part of the local road system, subject to control by local agencies rather than by the State. This is based on a belief that traffic becomes local in nature as soon as it has left the freeway. However, the State's primary concern is to assure that there is no back-up onto the freeway, and some extension of controls along the ramps is usually considered essential to protect the freeway lanes themselves. In many cases the State is anxious to avoid any type of control which can be exercised at the local level. Although this may be theoretically desirable, the difficulty appears to be that local agencies often do not accept this responsibility, with the result that no control is exercised.

TRAFFIC GENERATOR LOCATION

One of the primary concerns of many States with regard to freeway interchanges is the possibility of heavy traffic generators, which can overload the highway, locating in the immediate vicinity of the interchange. There are many examples of locations where this has taken place. Michigan cites one new plant in a quadrant of an interchange where 12,000 employees were required to achieve access to the plant from the interchange cross street. The resultant traffic congestion has led them to the belief that heavy traffic generators of this type should be located farther away from the interchange, and that only light traffic generators should be permitted around interchanges. Service-type commercial developments that serve the highway user are generally mentioned as a type of commercial activity that is warranted around interchanges. They believe that other types of development can just as well locate farther away from the interchange and between interchanges.

However, even though a major traffic generator is located a considerable distance away from the interchange, it will still have significant effects on the arterial leading to the interchange. For example, a regional shopping center located a mile from the freeway interchange ramps could require major expenditures in improving the arterial leading to the ramp area, and still burden the interchange itself with heavy traffic volumes. On the other hand, the same shopping center located only a short distance from the interchange, with lower-density development at farther distances, might not require extensive expenditure on the arterial and the investment could then be applied to providing higher capacity for the interchange itself. The higher-capacity interchange may be needed in either case; the difference is how much will be spent on the arterial leading to the interchange.

In the words of Atkinson and Menhinick (*13*), ". . . If design and controls are adequate, the amount of traffic concentration and possible delay at an interchange will be determined by the amount of interchange traffic generated by the entire area served by it, rather than the amount generated in its immediate vicinity alone." The interchange problem then, is twofold—to maximize the capacity of the interchange itself by design, and to adequately anticipate future land use on a realistic basis in the entire area which will be served by the interchange. This assumes that the freeway itself has sufficient capacity to absorb the traffic load. The interchange capacity is also highly dependent on the ability of the cross street to receive and supply traffic. Maximization of the interchange capacity requires attention to the geometric design of the cross street within the entire functional interchange area and not just in the vicinity of the ramps.

In terms of optimum transportation, the most efficient circulation system may involve the location of large traffic generators near freeways, with small traffic generators farther away. This arrangement has the advantage of providing heavier traffic movements with the shortest travel distances on surface highways to reach the freeway. It could have considerable effect on the capacity required for surface highway facilities, and thus result in considerable economies.

However, this advantage must be tempered with the related problems concerning locations immediately adjoining freeway interchanges. In exploring this problem with a number of States it was generally concluded that they are not as much concerned with the location of the heavy generator as with the location of access points. The proximity of specific land uses to the interchange was not of special concern to them as long as the access to these generators was sufficiently far removed so that they did not overload the transportation facility. If access could be located at a reasonable distance away from the ramps, where the traffic generated could be readily absorbed into the highway, they would not have serious objections with regard to the location of the generators. The general problem appears to be that the States do not now have effective tools to restrict the locations of access driveways to abutting properties. They therefore seek instead to encourage the location of the entire facility beyond the influence area of the interchange, where it will not affect them directly.

Another common objection expressed to the proximity of large traffic generators in the immediate vicinity of freeway interchanges is that internal design of the generator may not provide an acceptance rate adequate to guarantee no traffic back-up onto the highway or freeway. This specific problem concerns internal design controls for which special safeguards must be provided.

INTERCHANGE ZONE

An alternative approach has recently been activated in some states in regard to the establishment of land-use controls around interchanges. State laws have been enacted,

such as the one in California, where an "interchange zone" has been established at certain new freeway interchanges. Authority has been placed under the counties and the general intent is that the county will exercise land-use control in these zones. However, there appears to be little guidance available as to the objectives and the opportunities created by such a program. The general impression left in discussions with various officials has been that, even with the best intentions, it is questionable whether the counties will be successful in effectuating adequate control at these interchanges.

Wisconsin attempted to obtain legislation in 1947 to control land around interchanges. This legislation was probably ahead of its time, and was not passed. However, the State intends to reintroduce such legislation shortly, with the hope that the need will now be more apparent. It would authorize the State to plan land uses within a 1-mile radius of all freeway interchanges.

Regarding the intent of such legislation, State officials indicated that the purpose was largely based on their desire to protect the highway from excessive traffic generation in the immediate vicinity of the interchange. Their particular interest is in controlling the location of access and the volume of entering traffic. They consider the cross highway as part of the interchange area in a functional sense, and believe that it should be subject to controls. In effect, the legislation would provide an implementation tool which would require that land owners submit a land-use plan to the State for review. In this manner the State would have a better opportunity to control the principal elements with which it is concerned.

These officials further believe that there are other legitimate reasons to control land use beyond access location and volume. They are especially concerned with the visual contact of the highway with abutting land in respect to scenic opportunities and aesthetic considerations. They believe that some interchanges should be developed with specific land uses, and others should probably be left free of any development. They do not believe in the need for provision of highway user services at all intersections, and feel that such services can probably be concentrated at selected interchanges which serve as direct entrances to communities. Some interchanges could probably be restricted to the development of recreational uses (golf courses, camping sites, etc.), where such facilities would be accessible to the highway user.

Before this new type of zoning can become an effective tool, it is necessary to explore more fully the objectives of interchange planning. Such clarification is essential so that proper administration of this type of zoning can benefit the interchange area, both from a planning and from a traffic viewpoint.

INTERCHANGE DESIGN FLEXIBILITY

As in the earlier case of the arterial highway which experienced premature obsolescence due to strip commercial development, there is now being experienced the obsolescence of some freeway interchanges soon after construction. Traffic congestion sometimes requires the complete reconstruction of the interchange, sometimes at fantastically high costs where new buildings have to be acquired to obtain the additional right-of-way.

The problem is generally attributed to large traffic generators that develop in the interchange area. Of equal concern, however, is the type of interchange design that proved unable to handle the traffic generated. A number of studies, investigating locational theories with regard to developments that take place around freeways, have concluded that some types of interchange design can more efficiently handle adjoining developments than other types.

Various interchange patterns in use include the condensed diamond, expanded diamond, full cloverleaf, partial cloverleaf, and split diamond with connecting frontage roads. Serious problems were found at some types of interchanges—including those of traffic control, weaving, capacity, turning movements, safety, access where heavy traffic flows are experienced. Frequently, the underlying source of the problem was the interchange area design. With some designs, potentially heavy left-turn movements can be converted to free right turns, controlled intersections can be spread sufficiently so that progressive movement can be maintained on the cross street, adequate storage and weaving distances can be provided, and other operational advantages can result. In addition, access restrictions can be maintained for some distance beyond the ramps where desirable, so that intensive land-use development near the interchange does not create intolerable operational problems.

The problem with more elaborate interchange design in the initial construction is the additional investment required when it is unknown whether any large traffic generators will wish to locate at a specific interchange in the future. This problem can be alleviated partially by stage construction designs, although the reservation of sufficient right-of-way is an essential element. One method is the use of the expanded diamond to permit future construction of a partial cloverleaf design. Another effective method is used in Texas and other States, where one-way frontage roads are developed on both sides of the freeway using a split diamond of slip-ramp pattern to serve the frontage roads. Commercial development is located along the land side of the frontage roads. The method of service, which utilizes right turns in and out, eliminating left-turn conflicts, has also effectively resolved some of the access problems normally encountered in the vicinity of interchanges. This type of design has proved generally effective in providing access to highway-service commercial facilities, where the driver can readily leave the freeway and enter it again immediately beyond the service area. This design is also effective for other types of development adjoining freeways. Here an effective solution to the problem appears to lie in coordinated design, which is subject to the control of the highway administrator, rather than in attempting to place stringent restrictions on the land use itself, which frequently proves impracticable of achievement.

Michigan uses the expanded diamond interchange as an effective design solution to the problem of upgrading freeway interchanges as increased traffic generation requires such improvement. This is used in place of the condensed

diamond that is commonly employed. The expanded diamond ramps enclose an area which can accommodate cloverleaf ramps at such time as they may become necessary. Although this type of design involves more land acquisition than the conventional diamond, the additional cost is considered to be warranted wherever the land can be easily obtained without affecting existing development. The design provides for the future construction of cloverleaf ramps in some of the quadrants, as may be needed at some future target year. The additional cost is, therefore, justified on the basis of traffic forecasts. In those instances where traffic forecasts may not justify the inclusion of cloverleaf ramps, a safety requirement establishes a minimum sight distance between ramp termini which justifies the spreading of the diamond ramps for reasons of increased safety. Although many States construct expanded diamond interchanges as the first stage in the development of an ultimate cloverleaf or partial cloverleaf interchange, this type of design is not normally encountered as a standard practice.

The use of flexible interchange designs offers one solution to the problem of premature obsolescence. An economic evaluation of the additional cost involved in acquiring sufficient land for higher-capacity interchange types, such as the expanded diamond design, as compared with the possible cost of interchange reconstruction at some of these interchanges in the future, could be used to provide an economic basis to justify the acquisition of the additional right-of-way initially. Further study of interchange and cross-road capacities with the expanded diamond, one-way frontage road with slip ramps, and other design types could provide justification for the additional expenditure as well as valuable guidance in the choice of interchange types.

CHAPTER ELEVEN

CONCLUSIONS AND SUGGESTED RESEARCH

This study has concluded that a broader application of the principles of land-use control and the development of more realistic controls may provide an effective tool to protect the utility of the highway system. Another effective technique is the provision of intrinsic protection for the highway system through access control and geometric design. The study has identified many of the factors which show the greatest promise and offer the best opportunities for achieving the desired objective. The interrelationships between land use and transportation should be investigated in a broad context in order to establish the fundamental relationships involved. The proposed extension of this basic study should analyze these principles in detail to develop techniques for their application.

The objective of the proposed additional study is "to establish principles or guidelines for developing land-use controls and other techniques that will be stable and effective in preserving the investment in transportation systems." This should be initiated by analyzing all information dealing with interrelationships between transportation and land use that are pertinent to the principal purpose of the study, the protection of the utility of the transportation systems. Included should be existing programs and policies which have proved effective, conclusions of completed research studies which provide some of the principles and guidelines needed, and studies currently under way which relate to this subject and provide new opportunities for the future.

The current study has revealed that there is a considerable amount of information currently available which should be disseminated more widely, other available information which has a bearing on the problem but which cannot be directly related without additional work to make it applicable, and a considerable area in which little has yet been done but is deserving of future study. The proposed study should develop specific principles and guidelines in those areas which are most pertinent and applicable. It should also suggest further research in related subjects which appear to have merit in furthering the basic objectives. The subject is obviously so broad that no single study can hope to cover all pertinent aspects.

The following listing has been prepared of many of the areas uncovered in the current study which are deserving of further study:

1. History of land-use development in comparison with land-use controls for selected areas.
2. Effects of zoning changes on transportation facilities.
3. Probable future stability of land-use controls based on general plans currently being developed.
4. Methods and techniques to develop increased stability in land-use controls.
5. Highway network relationships to land-use densities.
6. Highway location as an implementation device to encourage desirable land-use practices.
7. Development of functional highway concept.
8. Function and design of highway classifications in relation to abutting land uses.
9. Re-evaluation of circulation requirements and designs in response to new conditions and opportunities.
10. Balance among different highway classifications to achieve optimum transportation.

11. Effects of various types of land service on highway capacity.
12. Establishment of access control by legislative and police power techniques.
13. Methods for achieving greater highway design flexibility to accommodate future demands.
14. Applications of geometric design controls to achieve intrinsic protection of the highway.
15. Control of internal development design for highway protection.
16. Application of traffic generation characteristics to relate transportation and land use.
17. Balancing of traffic loads by land-use mixtures.
18. Prediction of transportation demands based on uniform distribution of traffic generator location.
19. Highway design techniques to absorb traffic concentrations at points of access.
20. Principles and practice of access restriction in the vicinity of freeway interchanges.
21. Traffic generator location in the vicinity of freeway interchanges.
22. Application of interchange zone concept and other land-use control techniques to preserve the utility of the freeway interchange area.
23. Application of interchange design techniques and high-capacity system design to minimize freeway interchange obsolescence.
24. Interrelationships between non-highway transport modes and land use and effects on the highway system.

Some of these require detailed attention as directly applicable to the problem. Others are significantly related to the subject but might be considered as secondary to the specific objectives. The primary subjects should be treated in considerable detail, whereas the secondary subject matter should be analyzed to establish applicability and suggestions should be made for future study in those areas having greatest potential.

Many professional disciplines should be included in the proposed study to attain meaningful and lasting results. Traffic engineering, highway planning, and urban planning provide the principal professional approaches to the problem.

It is essential that the study be an interdisciplinary undertaking to reflect numerous points of view. Without the support of all affected professionals during the development stage, there is a danger that the program evolved would not be adequately implemented.

APPENDIX A

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APPENDIX B

CANVASS OF AGENCIES AND CONSULTANTS

1. Bureau of Public Roads; F. Thiel, J. Yasnowsky, D. Levin.
2. California Division of Highways; C. Beer, B. Frankland.
3. Connecticut State Highway Department; W. Osgood.
4. Massachusetts Department of Public Works; G. Wey, S. Hoffman.
5. Michigan State Highway Department; J. Meyer and others.
6. New Jersey State Highway Department; J. R. Cunningham, W. R. Bellis, D. W. Gwynne, J. Hyde.
7. Wisconsin State Highway Commission; D. Haist and others.
8. Ventura County, California; A. Weber.
9. Tri-State Transportation Committee; J. D. Carroll. Jr.
10. Upstate New York Transportation Study; R. Creighton, T. Lathrop.
11. E. Horwood, University of Washington.
12. L. Keefer, Transportation Consultant.
13. H. Levinson, Wilbur Smith & Associates.
14. D. Mandelker, Washington University Law School.
15. R. Netherton, Highway Research Board.
16. K. Gilbert, City of San Diego.
17. A. Voorhees, Transportation Consultant.
18. F. Hotchkiss, D. Branigan, and others, Victor Gruen Associates, Planning Department.
19. E. Rowe, City of Los Angeles.

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