Future Highways and Urban Growth

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FUTURE HIGHWAYS

AND

URBAN GROWTH

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Under Commission From

THE AUTOMOBILE MANUFACTURERS ASSOCIATION

February, 1961

PRINTED IN THE UNITED STATES OF AMERICA
February, 1961

A Night View of an Urban Section of an Interstate Freeway

FOREWORD

In 1956, the Congress of the United States authorized a long-term program of expanded highway construction, financed through special federal taxes paid by motor vehicle owners. The program is administered through the U. S. Bureau of Public Roads, which has supervised all federal-aid highway projects since 1916.

The new program will span a period of 16 years (fiscal 1957-72). Its objective is to provide increased financial assistance to state and local highway departments in the construction of major urban and rural traffic routes to standards of safety and capacity needed for present and future motor traffic volumes.

A key element of this expanded road program is the National System of Interstate and Defense Highways — a nationally connected 41,000-mile network of urban and rural freeway routes.[1]

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[1]*Freeways* are divided highways with *full* control of access. They pass under or over all intersecting crossroads, and permit continuous, uninterrupted flow. Their entrances and exits are located only at specifically designated points, and there is no direct access from abutting property. They may be toll roads or toll-free.

The term *expressway* is often used interchangeably with *freeway*. Technically, however, an expressway has only *partial* control of access, and may have occasional intersections at grade.

This study of Interstate highways and their impact on urban transportation was conducted by Wilbur Smith and Associates, consulting engineers of New Haven, Connecticut, under commission from the Automobile Manufacturers Association.

Purposes of the study were threefold:

1. *To determine the extent to which the Interstate highway system will meet the freeway requirements of urban areas of the United States up to the year 1980, and also the extent of requirements for fixed-rail and express-bus urban rapid transit systems in large metropolitan areas;*
2. *To project the future use of urban and rural Interstate highways, and to appraise their effects on traffic growth and the relief afforded to other roads and streets;*
3. *To assess the direct benefits to motorists in the form of fewer accidents and lower vehicle operating costs accruing from completion of the Interstate system by 1972, as well as the general benefits to the national economy, land values, and public services.*

Many individuals, organizations and agencies assisted in providing needed background information for the study including the Bureau of Public Roads, the various state highway departments, and the American Transit Association. The entire firm, and particularly Herbert S. Levinson and F. Houston Wynn who were principally responsible for technical development, gratefully acknowledges the assistance of all who cooperated.

Wilbur Smith and Associates

February, 1961

REPORT IN BRIEF

This is a comprehensive study of the National System of Interstate and Defense Highways as it relates to future travel requirements and the changing shape of metropolitan America.

Urban-Suburban Growth

Two of every three residents of the United States now live in urbanized areas, with half of these urbanites living in suburban regions outside central cities.

Expansion of Suburbia — Virtually all population growth of the next two decades will be in suburban portions of metropolitan areas. By 1980, three of every four of the nation's anticipated 245 million people will be urbanites — and over half of the nation's populace will live in suburbia. Most new growth will be at population densities of approximately 2,500 people per square mile. This will about double the amount of land located within expanded urban limits by 1980.

Land-Use Changes — Changes in population densities and land-use patterns have accompanied the expansion of suburbia. The move to the suburbs has precipitated new shopping centers and a dispersal of commercial services and industrial plants. Downtown, there has been a relative drop in sales and employment as the central business district has become more specialized as the locus of government, management and finance. Many of these changes can be expected to continue as multi-center communities increasingly develop to meet the needs of automobile-oriented 20th Century cities.

Transportation Changes and Characteristics

Past development of large cities and their downtown areas was encouraged by reliance of urban residents on public transportation. This condition now has changed substantially. Both the city and its suburban areas are increasingly dependent upon automobiles and motor trucks for movement of people and merchandise.

Studies of urban travel characteristics in a dozen widely dispersed cities explain the increasing role of the automobile and truck in urban areas. They provide a basis for projection of future travel and evaluation of future express highway potentials.

Total Trips — The urban resident makes about two trips per day in a car or transit vehicle in large cities and two and one half or more trips in small cities; in all cities, the resident travels about 10 miles each day in all pursuits.

Trip Purposes — Approximately 20 per cent of all daily urban trips are to work; 18 per cent for business and shopping; 12 per cent for social and recreational purposes; 40 per cent, to home; 3 per cent, to school; and 7 per cent for miscellaneous reasons.

Travel Modes — In all but a handful of large cities, the automobile now accounts for more than 85 per cent of all urban travel and is usually the dominant form of transportation for persons entering the downtown area.

Transit travel is predominantly focused on the central business district whereas automobile travel is diffused throughout the urban area.

The choice of travel mode has become closely related to car ownership and population density, which, in turn, are usually related to family income. Generally, low income is consistent with high density; income increases and density decreases with distance from the central business district.

As urban densities continue to decrease, and as car ownership becomes greater, automobile travel will become ever more dominant in future years.

Persons who have the use of a car make more trips than those who must use public transportation: households without cars average less than one trip per resident per day, whereas households with more than two cars average three or more trips per resident per day.

Trip Lengths — Existence of urban freeway systems will tend to increase urban travel by about 10 to 15 per cent as a result of freeway time savings and new freeway-oriented land-use patterns.

Average vehicle trip lengths in the survey cities are expected to increase from almost 4.5 miles at present to more than 5.0 miles by 1980.

Trips on freeways are longer than other urban trips; by 1980, motorists using freeways will travel about seven to nine miles on freeways and about two miles on surface streets, whereas trips made entirely on arterials will approximate four miles.

Present and Future Travel

Increases in automobile ownership and use are expected to continue throughout the country, particularly in urban areas, commensurate with a rise in living standards and the over-all national economy. The ratio of private cars to persons will probably increase about 20 per cent by 1980 with one passenger car registered for about every 2.4 persons. By 1980, total registrations are expected to reach 120 million.

Nearly one half of the nation's motor travel now occurs on city routes that account for only 10 per cent of total highway mileage. This urban travel will more than double over the next two decades, while rural highway travel will increase about 30 per cent. By 1980, about 60 per cent of the anticipated 1,277 billion yearly vehicle miles of travel will be within expanded urban area limits.

Urban Freeway Needs

The National System of Interstate Highways, now under construction and scheduled for completion by mid-1972, represents the backbone of an urgently needed urban freeway network.

Existing Freeways — This 41,000-mile national freeway system embraces about 6,700 miles planned within present urbanized areas of the nation. The remaining 36,300 miles are intercity routes.

About 2,100 miles of urban Interstate system freeways were in use early in 1961. Other urban freeways not on the system brought the total of existing urban freeways to approximately 2,900 miles.

Anticipated Freeway Travel — A completed freeway system in any metropolitan area can be expected to accommodate a good part of all urban travel, particularly as the areas increase in size. Freeways will serve more travel, be more extensively used and, therefore, become increasingly valuable in larger urban areas.

> In communities under 100,000 population, travel on freeways can account for up to one fourth of all daily vehicle miles. In metropolitan areas of more than one million persons, half or more of all vehicle miles of travel would be accommodated by an adequate freeway system. The average volume expected on each mile of a complete freeway system varies from about 25,000 cars per day in cities under 100,000 population to about 70,000 cars per day in large cities.

Future Needs — Except for the largest and smallest cities, about one mile of freeway will be required for every 10,000 urbanites. Thus, by 1980, about 16,000 miles of such freeways will be needed to serve urban traffic within the continually expanding urban areas. Approximately 9,600 miles of Interstate system freeways will be within urban regions by 1980.

This means that in addition to about 800 miles of existing urban freeways and those being built under the Interstate system program, approximately 5,600 miles of further freeway development will be necessary in urban areas by 1980.

Future Use — With all needed freeways constructed by 1980, approximately one third of all annual travel will be on the nation's freeway systems.

By 1980, average daily traffic on urban Interstate system routes will approximate 50,000 vehicles per mile, compared to 10,000 anticipated on rural Interstate freeways. Many urban Interstate routes will be operating at capacity whereas most of the rural Interstate routes will have surplus capacity for future traffic growth.

Interstate System Cost Savings

Aside from the numerous general benefits that the Interstate system will produce in the form of higher property values and new business and industrial development, the system will also yield large savings for U. S. motorists.

Although the system has only about 1.2 per cent of total U. S. road and street mileage, it will carry about 24 per cent of all motor vehicle travel when completed. Moreover, nearly 40 per cent of all motor vehicle owners in the nation will make daily use of the system.

Because of the superior safety and traffic-carrying capacity of modern freeways as compared to ordinary streets and highways, the Interstate system also will save motorists more than two cents per mile in urban sections as a result of lower accident, fuel and vehicle maintenance costs, and about one cent per mile in rural sections. The accident reduction also means an annual saving of more than 9,000 lives when the entire system is completed.

Total Savings — By 1980, the system will be producing yearly savings to motorists of $5 billion in the form of reduced traffic accidents and other vehicle operating costs. Thus, the motoring cost savings will equal the total cost of the system in about eight years.

In addition, some four billion vehicle-hours will be saved yearly by motorists using the Interstate system. If a monetary value of about $1.65 per hour were placed on this time saving, it would amount to over $6.5 billion per year.

Net Savings — The accumulative net benefits to motorists that will result from completion of the remaining portions of the Interstate system on schedule between 1961 and 1972 will total $98 billion over the next 20 years. A total of 75,000 lives will be saved in this same period.

Stretch-out Costs — A three-year delay in completing the Interstate system — from 1972 to 1975 — would mean a cost of as many as 10,000 lives through traffic accidents, and aggregate road-user penalties of about $10 billion prior to completion of the system.

Freeways in Urban Development — Transportation plans will adapt to the size, shape, function, past history, and future mission of each city. Planning and growth of the metropolitan area will necessarily be on a regional basis for each particular urban complex, and will involve a system of *total* transportation integrated with urban land uses.

The critical past lag in urban freeway development has handicapped most large cities in their efforts to make needed adjustments to motor vehicle transportation.

Freeway programs now planned and under construction in many urban areas can provide a prerequisite framework for urban development and revitalization. Freeways are a logical first step for needed land-use readjustments in older urban areas and a stabilizing factor for new urban developments.

Properly coordinated with other elements of a total urban transportation system — parking areas, arterial routes, and transit facilities — the freeway program will help to preserve productive land use, assist in urban renewal, and assure that future traffic congestion will not minimize the benefits of urban development.

Where topographic interferences are not critical, the average spacing of freeways will vary directly with the number of lanes provided on each freeway — the greater the number of lanes, the wider the spacing. It will also vary inversely with the average length of freeway trip and population density.

Urban Freeway Systems — Freeway plans for large metropolitan areas usually include crosstown routes, radial routes converging on the downtown area, and downtown-fringe "loop" freeways linking the radial routes.

One objective of the downtown freeway loop is to remove from congested downtown streets about 50 per cent of all motor traffic — which in most cities is found to be merely passing through the downtown area to reach other urban destinations.

At the same time, it must be recognized that the urban freeway network is being planned to serve the entire region. In most large areas, no more than 10 to 20 per cent of total vehicle trips within the urban community are made to or from downtown.

The great bulk of motor trips in such areas is, therefore, to and from locations in other parts of the city. Neither a sharp increase in motor trips to the downtown area, nor a sharp decline in such trips, would have a marked effect on the *total* freeway mileage requirements of metropolitan regions.

In most communities the central business district is not attracting new visitors in proportion to over-all urban growth since the proportion of total urban travel to or from downtown decreases as cities get larger. This is because cities are experiencing rapid growth in their low-density suburbs which usually have the smallest per capita downtown attraction in the urban area.

Downtown will not generally increase in dominance because of growing competition from outlying areas. It will, however, be strengthened by improved highways, public transit and parking, and by the development of attractive high-density residential uses in surrounding areas.

The future market potentials of downtown retail districts will depend increasingly on the development of complete freeway systems that will substantially reduce driving time from outlying regions and enable downtown to more fully exploit its usually central location. Freeways will also make feasible the revitalization of downtown through selected street closures, pedestrian malls, and other pedestrian amenities.

Terminal facilities, especially in the central business district, must be provided to complete the total transportation system. Parking areas should be attractively designed and carefully related to Interstate and other freeways. In some cases, garages located near freeways may be connected to the core area by shuttle buses.

Public Transportation

Mass transit services in most urban areas have shifted primarily to motor bus operations in recent decades, except in the very large cities where subway systems and other fixed-rail rapid transit facilities were already extensively developed. Patronage declines that have occurred in recent years are expected to continue although transit use may stabilize in some of the largest cities.

But, while transit does not serve the majority of trips in any urban area, it is valuable for those particular movements or trip linkages that are concentrated in space and time, especially in high-density urban complexes. Thus, transit is a valuable adjunct to freeways in serving peak-hour movements along heavy travel corridors leading to and from the central business district, particularly in big cities.

Maximum development of rapid transit facilities, based on even optimistic forecasts of transit patronage, do not appear to effect *major* changes in *area*-wide freeway requirements.

Comparisons of the economic feasibility of alternate transit proposals usually indicate that new rapid transit routes should be carefully integrated with freeway construction, and that motor buses should be used. Rail rapid transit will be limited primarily to areas where it now exists or where it can be readily adapted to existing railroad lines.

Indicated Conclusions

The study has shown the overriding importance of good highway transportation to the total economy and well-being of the country, particularly the nation's rapidly expanding urban areas. It suggests the following principal actions:

- There is urgent need for rapid completion of the 41,000-mile National System of Interstate and Defense Highways. Completion of the urban components of the system at the earliest possible date is essential to the economy and mobility of the nation and for the vitality of its cities.

- Interstate highways now programmed will not be sufficient to meet the nation's future freeway needs. Accordingly, a continued and accelerated program of express highway construction, particularly in urban areas, should follow completion of the Interstate system in 1972.

- Urban transportation needs will usually require that highways be augmented by public transit and that transit be fostered even though, at best, it will but hold its present levels.

- Savings to the American public in lives, dollars, and time will far exceed the cost of the Interstate highway system. Hence, it is imperative that the necessary financing be provided for on-schedule completion of the Interstate system by 1972.

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INTRODUCTION

THE continuing 20th Century expansion of the American city has made the daily movement of people and goods a complex and difficult problem despite significant technological advances. Suburbanization, or "city sprawl", and traffic congestion are both a consequence and a stimulus of the new metropolis. Increased dependence on the private automobile, the shift away from public transportation, and the trend toward country living — all have altered the urban setting.

Individually, and nationally, there is a vital dependence on motor vehicle transportation. Paradoxically, however, the popularity of the motor vehicle has, in many instances, limited its efficiency, particularly in large cities. Its acceptance and use have outpaced the building of roads and parking facilities. Changes in land-use and travel patterns have further aggravated the problem.

Existing urban freeways have had a tremendous impact on patterns of urbanization and travel: they have served the expanding metropolis, often guiding growth and stimulating travel by improving mobility, tapping new areas, and reducing street congestion. In turn, they have often become overloaded during peak hours and have intensified parking problems.

As cities grow and urban decentralization continues, new patterns of land use and travel emerge. Highway accessibility becomes increasingly important to the welfare of the metropolitan community with freeways evolving as the backbone of the urban transportation system.

INTERSTATE HIGHWAYS

The importance of good highway transportation to the national economy and to urban mobility has long been recognized. This nationwide awareness of the need for good roads has become crystallized in the National System of Interstate and Defense Highways.

In 1939, the Public Roads Administration studied two nationwide free-road systems: one of approximately 14,200 miles, and the other of about 26,-700 miles — the latter was proposed as an interregional system.[1] This study was followed in 1941 by enlargement of the interregional system to about 29,300 miles, and by the selection of a network of strategic defense routes.

In 1944, the Public Roads Administration made studies of additional systems — one embracing approximately 98,400 miles, one 36,000 miles, and one 33,920 miles. The latter was subsequently recommended as an Interstate system.[2] The Federal Aid Highway Act of 1944 laid the groundwork by authorizing the Interstate System, and by providing a balanced federal aid program of primary, secondary, and urban improvements.

Objectives — The philosophy of the Interstate highway system was clearly set forth in the Interregional Highway Report of 1941:

"The cities and metropolitan areas of the country are known to include the sources and destinations of much the greater part of the heavy flow of traffic that moves over the Nation's highways. The system of interregional highways proposed, within the limit of the mileage adopted, connects as many as possible of the larger cities and metropolitan areas regionally and interregionally. For this reason, although in miles it represents scarcely over one per cent of the entire highway and street system, it will probably serve not less than 20 per cent of the total street and highway traffic.

In the selection of all of these systems, one common objective prevailed: To incorporate within each of the several mileage limits adopted, those principal highway routes which would reach to all sections of the country, form within themselves a complete network, and jointly attract and adequately serve a greater traffic volume than any other system of equal extent and condition.

"All facts available to the Committee point to the sections of the recom-

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[1]*Toll Roads and Free Roads,* House Document No. 272, 76th Congress, 1939.

[2]*Interregional Highways,* Message from the President of the United States Transmitting a Report of the National Interregional Highway Committee, Outlining and Recommending a National System of Interregional Highways. House Document No. 379, 78th Congress, Second Session.

mended system within and in the environs of the larger cities and metropolitan areas as at once the most important in traffic service and least adequate in their present state of improvement. These sections include routes around as well as into and through the urban areas. If priority of improvement within the system be determined by either the magnitude of benefits resulting or the urgency of need, it is to these sections that first attention should be accorded."

Present System — The present National System of Interstate and Defense Highways is an outgrowth of the Federal Aid Highway Act of 1956. As defined today, it encompasses a 41,000-mile network of limited-access highways. The system, shown in Figure 1, will connect 42 state capitals and about 90 per cent of cities with more than 50,000 population.

It has been designed to:

Join major centers of population;

Connect primary centers of industrial activity and natural resources with labor and material supply centers and major shipping points;

Provide access to important military installations and defense activities;

Provide access to major recreational and historical areas;

Connect as many seats of county government as economically feasible;

Provide for continuity of travel into, through, and around urban areas from rural freeway approaches;

Provide for large traffic movements between population and industry within urban areas;

Provide for needed capacity in the traffic corridors;

Connect with major highways of adjacent states; and

Provide an integrated system, with a minimum of stubs or spurs, to permit general traffic circulation.

The enabling legislation calls for construction of highways to standards adequate for 1975 traffic needs, and thereby sets forth a forward-looking pattern for future federal highway aid.

The act clearly states that traffic congestion in cities can no longer be tolerated and that immediate steps must be taken by both federal and state highway administrators to program highways on the basis of use or need. Equal emphasis is given to urban and rural needs.

The Interstate system will be the most important road network in the country, carrying more traffic per mile than any comparable national system.[3] It

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[3]American Association of State Highway Officials, *A Policy on Design Standards* (Interstate System, Primary System, Secondary, and Feeder Roads), Revised, Washington, D. C., September 1, 1956.

Figure 1
National System of Interstate and Defense Highways

will include the roads of greatest significance to the economic welfare and defense of the nation, and therefore will be designed to high standards. Control of access will insure safety, permanence, and utility, and will provide flexibility for future expansion.

Because of their nature and extent, Interstate highways involve changes in design, fiscal concepts, conventional planning procedures, relations between government departments, and co-operation among diverse public and private bodies. More important, they require careful integrated planning with respect to other transportation facilities and adjoining land uses.

Interstate Highways and Urban Mobility — The 6,700 miles of Interstate highways currently programmed for urban areas will substantially contribute to urban mobility. In many communities it will be necessary to supplement Interstate routes with other urban freeways, and in some cases new transit arteries.

Sound urban transportation planning will require a logical sequence of priority based on travel demands, land uses and urban area growth, and a balance between local, state and federal participation. It follows that slowdowns in urban highway construction, or deemphasis of urban Interstate highways, will have a detrimental effect on the entire urban economy.

PURPOSE AND SCOPE OF STUDY

This study analyzes the usage and impacts of the National System of Interstate and Defense Highways, particularly as related to urban areas. Its purpose is threefold: First, it indicates transportation needs of future urban areas; second, it predicts the use and effects of the Interstate system on urban and rural travel; and third, it determines the benefits to be derived from the system and the penalties resulting from a halt or delay in construction.

Accordingly, it has been necessary to investigate the alternate approaches to urbanization and urban transportation. In this regard, consideration has been given to many questions that commonly arise: What is the most likely form of future metropolitan areas? What will be the role of the future central business district? What will be the function of public transportation? How can Interstate highways and other freeways be most effectively used? What complements to urban Interstate highways will be required? What are the economic implications and benefits accruing from Interstate highway improvements?

Many opinions and predictions relative to future growths and distribution of population have, therefore, been reviewed. The role of urbanization and the preferred forms of metropolitan areas have been anticipated, since future transportation plans must be based on these assumptions.

While the study is concerned primarily with highway development, it is obvious that in many areas highway transportation alone will not suffice. Accordingly, the potentials of transit, especially rapid transit, have been thoroughly investigated, particularly as they relate to highway and freeway development.

The extent to which the Interstate system will satisfy urban area transportation needs has been indicated. Attention was also given to the traffic that this system will serve, the impacts it may have on the development, growth, and stability of communities, and the urgency of its completion. In most of these analyses, it was necessary to deduce and generalize from studies-in-depth of selected cities, and from a series of specially conducted impact studies.

Obviously, new arteries of travel must be adequately supplemented by terminal facilities and attractive means for dispersal and concentration of volumes. Accordingly, consideration has been given to the proper integration of freeways and transit with off-street parking facilities and collector-distributor routes.

Finally, the economic values of the Interstate system have been explored. Particular emphasis has been placed on benefits to motorists and others that will be derived from the urban and rural segments of the Interstate system.

Conversely, losses or penalties that would result if the system is not completed on schedule also are discussed.

The background information on urban growth and travel presented in the early chapters of this study is essential for a thorough understanding of future transportation needs. These exploratory analyses of city developments, population growths and distribution, travel patterns and characteristics, and transit usage provide a sound framework for evaluation of the specific problems discussed in subsequent chapters.

CHAPTER 1

GROWTH OF URBANIZATION AND TRAVEL

SUMMARY

TWENTIETH century technology — symbolized by electric and atomic power, the telephone, the automobile and the highway — has exerted a strong centrifugal influence on the American city. The metropolis is exploding in every direction both with respect to population and area. Areas formerly considered remote are now being occupied by people who work, shop, or visit in the urban center and its environs.

Strong social and economic forces have motivated the trend toward suburban living and the accompanying regional urbanization, despite a lag in urban freeway development. The automobile and the highway link suburbia with its environs just as the established city was linked to its central business district by mass transit.

About two thirds of America's 180 million people live in urban places, and the number is constantly increasing. By 1980, three out of four of the nation's anticipated 245 million people will be urbanites.

Urban areas are decentralizing as they expand, with most expansion taking place outside the central cities. Approximately half of all urbanites lived in suburbia surrounding central cities in 1960, compared with one out of three in 1950. New growth will be at densities of about 2,500 people per square mile, about doubling the amount of land within urban limits by 1980.

This continuing decentralization has substantial impact on the patterns of land use and transportation needs of the nation's cities. Central business districts have not generally been increasing in size and focus in proportion to metropolitan area growth — they have en-

countered substantial competition from satellite commercial and industrial centers that are developing to serve the suburban populace. There is greater reliance on automobile travel as mass transit riding continues to decline — the number of transit riders reduced from 17 billion in 1929 to about 10 billion in 1959.

Approximately three of every four families in the United States own cars. Some 74 million registered vehicles travel more than 720 billion vehicle miles annually over the nation's 3.5 million miles of streets and highways.

Commensurate with a rise in living standards and the national economy, increases in automobile ownership and use are expected to continue throughout the country, particularly in urban areas. The ratio of private cars to persons will probably increase about 20 per cent by 1980 with one passenger car registered for about every 2.4 persons.

Transit riding will continue to decline. New highway facilities will be required to serve the expanding motor vehicle travel. Because of the continued "urban sprawl" and population dispersion, it is apparent that Interstate highways and other urban freeways will be of paramount importance in the total metropolitan transportation system.

WITHIN the twentieth century, the United States has evolved from a rural to an urban nation. Advances in the personal transportation of man and his goods, together with increasing industrial progress, have been instrumental in the urbanization and evolution of the nation's great cities. Within the last generation, urban transportation has become dominated by motor vehicle transportation.

The American city is gradually adapting to this new mobility and personal independence. Residential areas, commercial centers, and industrial developments, both within the established central city and the surrounding areas, have gradually become oriented to automobile accessibility. An understanding of these basic trends and patterns in urban growth and travel is prerequisite for the anticipation of future urban transportation needs and freeway use.

POPULATION

The population of the United States is steadily becoming more urban in character – cities have grown in number, area, and population. Trends in rural and urban population, shown in Figure 2, clearly denote the increasing urbanization of the country.[1]

[1]Additional population trends are detailed in Tables A-1 through A-8, Appendix C.

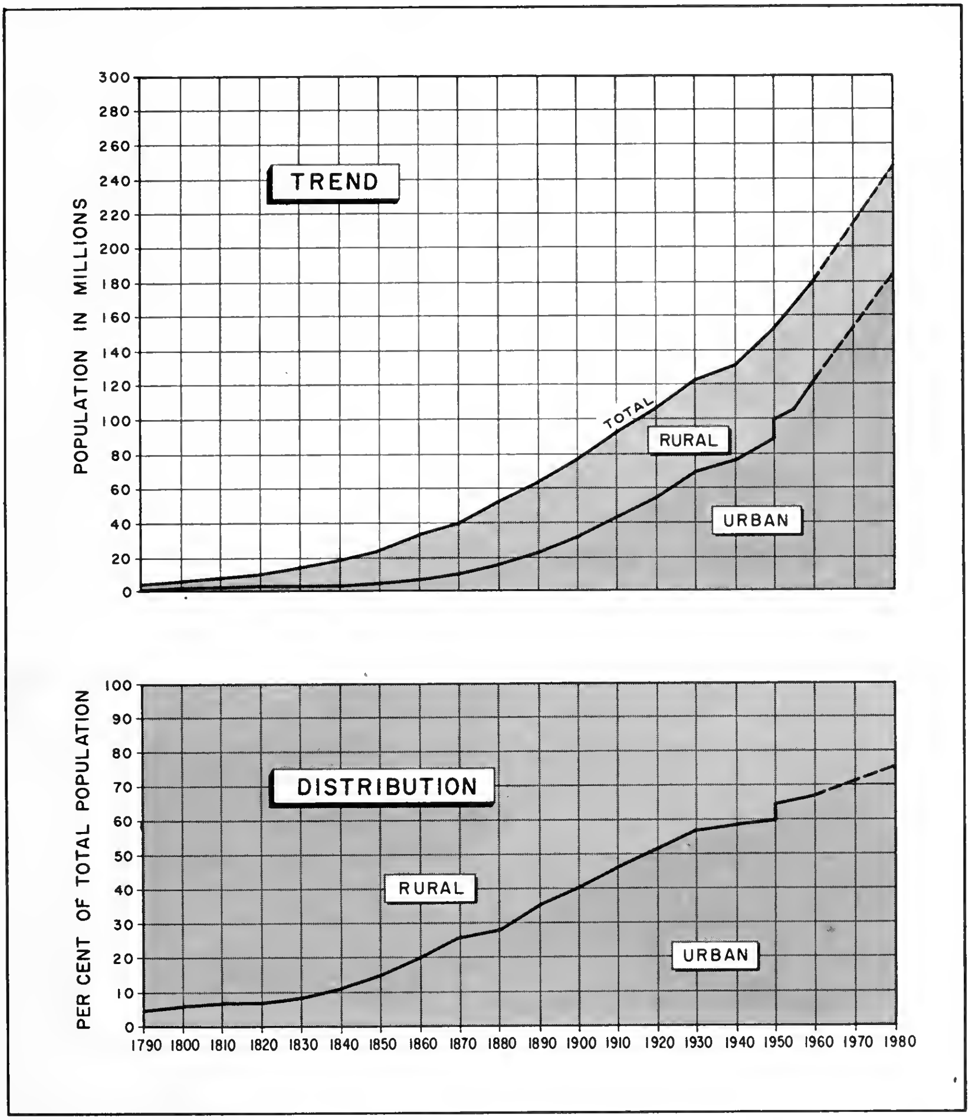

Figure 2
POPULATION TRENDS
UNITED STATES
1790-1980

In 1900, when the nation's population totaled approximately 76 million people, about 40 per cent lived in urban places. Each successive decade showed an increase in both urban and rural population, with the greatest increases occurring in urban areas. In 1950, about 60 per cent of the nation's 150 million residents lived in urban areas.[2] Preliminary 1960 census figures indicate a national population of approximately 180 million, with about two thirds urban.

In 1900, there were only six cities in this country with populations of more than 500,000; together they accounted for about 11 per cent of the total population. All were built around dominant central cores where employment and retailing were concentrated. In 1960, twenty-one cities of more than a half million people accounted for approximately 16 per cent of the nation's total population.

The urbanization trend will continue. By 1980, the total population is expected to approximate 245 million, with three out of every four Americans living in urban places.[3] The 1980 urban population will approximately equal the present (1960) total population. By 2000, it has been estimated that about 85 per cent of the nation's inhabitants will live in urban areas.[4]

The growth of the nation's metropolitan areas has been similar. As depicted in Figure 3, the proportion of the nation's population residing in metropolitan areas rose from about 32 per cent in 1900 to nearly 59 per cent in 1956. The proportion living in central cities increased from about 21 to 31 per cent during this period, whereas the proportion living in adjacent suburban areas increased from 11 to 27 per cent. The number of metropolitan areas grew from 52 in 1900 to 168 in 1956.[5]

Urban "decentralization" is not new and has consistently been related to city size. New York City was decentralizing as early as the 1850's and, by the turn of the century, nine other cities had begun to disperse.[6] However,

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[2]The "old" census definition of urban population showed 59 per cent urban, and the "new" definition, 64 per cent.

[3]U. S. Department of Commerce, Bureau of the Census, "Current Population Reports, Series P. 25," reported in *Statistical Abstracts of the United States*, 1958, p. 6. Projections of the total population of the United States by age and sex, 1955 to 1980. The cited estimate is based on the Series III Projections.

[4]Pickard, Jerome P., *Metropolitanization of the United States*, Urban Land Institute, Washington, D. C., 1959.

[5]Bogue, Donald J., *Population Growth in Standard Metropolitan Areas, 1900-1950*, U. S. Housing and Home Finance Agency, Washington, D. C., 1953, pp. 61-71.

[6]Schnore, Leo F., "The Timing of Metropolitan Decentralization," *Journal of the American Institute of Planners*, Vol. XXV, No. 4, November, 1959. The nine cities are Cincinnati, San Francisco, New Haven, Boston, Albany, Baltimore, St. Louis, Scranton, and Duluth.

it was not until the 1920's that the pace intensified – 60 cities decentralized between 1920 and 1940. This deconcentration followed intensive city-building in the 40-year period between 1880 and 1920.

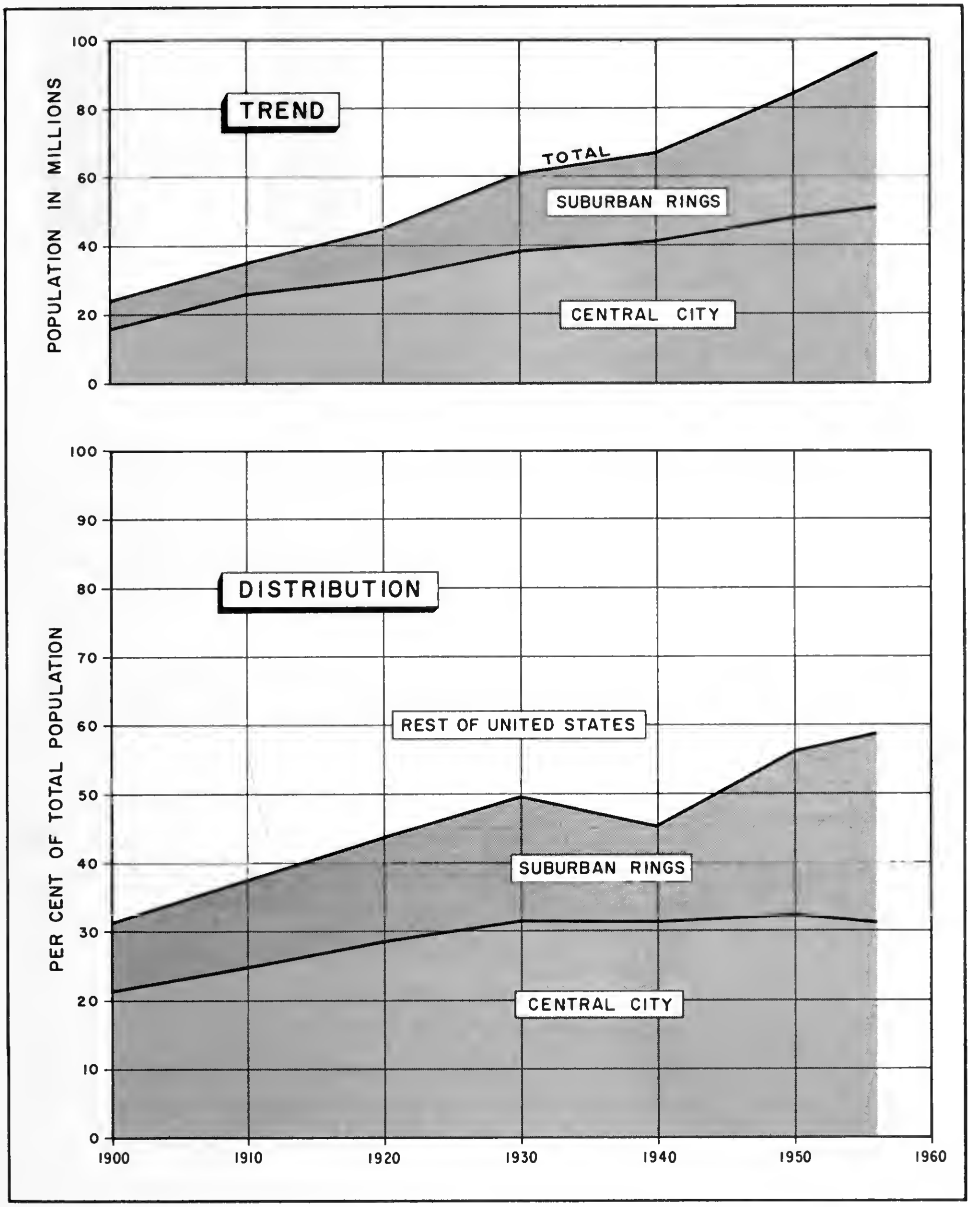

Figure 3
GROWTHS IN POPULATION OF STANDARD METROPOLITAN AREAS
1900-1956

Recent Growths – Growths in metropolitan area population between 1950 and 1956, depicted in Figure 4, denote the rapid growth of suburbia in recent years. In 1956, more than 96 million lived in 168 standard metropolitan areas, (counties with central cities of over 50,000 population), an increase of about 12 million over 1950. The number living in central cities was up approximately two million, from about 49 million in 1950 to 51 million in 1956. The number of people living in satellite cities and other parts of suburbia increased from about 35 million in 1950 to 45 million in 1956.

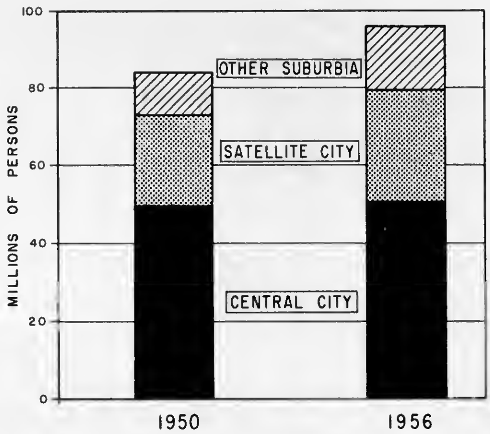

Figure 4
GROWTH OF
METROPOLITAN AREA POPULATION
1950-1956

The population of central cities increased about five per cent, whereas areas outside of cities gained 29 per cent. The greatest increase, percentage-wise, was in the "rural" parts of the metropolitan rings surrounding central cities which grew 56 per cent, compared with a 17 per cent increase in the "urbanized" parts of suburbia.

The rapid growth of suburbia in the six-year period has reduced the proportion of metropolitan area population residing in central cities. As shown in Figure 5, this proportion decreased from 59 to 53 per cent.

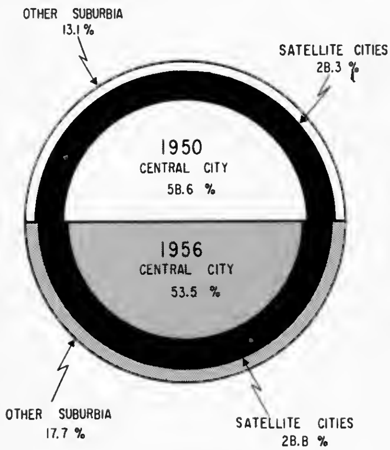

Figure 5
DISTRIBUTION OF
METROPOLITAN AREA
POPULATION
1950 and 1956

Decade growths in population between 1950 and 1960 in the nation's 27 largest metropolitan areas, shown in Table 1, clearly reflect the continuing trend toward urban decentralization. Some population decreases occurred in the old established cities whereas all metropolitan areas expanded. For example, Buffalo's population declined nine per cent, yet its metropolitan area grew 20 per cent; Pittsburgh lost 11 per cent while its metropolitan area gained eight per cent; St. Louis was down 14 per cent, whereas its metropolitan area increased 19 per cent. Central cities that gained population either extended their corporate limits, or were

TABLE 1

POPULATION CHANGES 1950-1960 FOR THE 27 LARGEST METROPOLITAN AREAS IN THE UNITED STATES[1]

PLACE	METROPOLITAN AREA			CENTRAL CITY		
	1950	*1960*	*Per Cent Increase (1950-1960)*	*1950*	*1960*	*Per Cent Change (1950-1960)*
New York	9,555,943	10,545,300	10.4	7,891,957	7,660,000	− 2.94
Los Angeles-Long Beach	4,367,911	6,690,069	53.2	1,970,605	2,448,018	+24.24
Chicago	5,177,868	6,150,532	18.8	3,620,962	3,492,945	− 3.54
Philadelphia	3,671,048	4,081,827	11.2	2,071,605	1,959,966	− 5.39
Detroit	3,016,197	3,761,220	24.7	1,849,568	1,672,574	− 9.57
San Francisco-Oakland	2,240,767	2,721,045	21.4	775,357	715,609	− 7.71
Boston	2,410,372	2,561,450	6.3	801,444	677,626	−15.45
Pittsburgh	2,213,236	2,394,623	8.2	676,806	600,684	−11.25
St. Louis	1,719,288	2,040,188	18.7	856,796	740,424	−13.58
Washington, D. C.	1,464,089	1,968,562	34.5	802,178	746,986	− 6.88
Cleveland	1,456,511	1,780,263	21.5	914,808	869,867	− 4.91
Newark	1,468,458	1,726,862	17.6	438,776	396,252	− 9.69
Baltimore	1,405,399	1,706,076	21.4	949,708	921,363	− 2.98
Minneapolis-St. Paul	1,151,053	1,477,080	28.3	521,718	481,026	− 7.80
Buffalo	1,089,230	1,304,581	19.8	580,132	528,387	− 8.92
Houston	806,701	1,234,864	53.1	596,163	932,680	+56.45
Milwaukee	956,948	1,186,875	24.0	637,392	734,788	+15.28
Seattle	844,572	1,096,778	29.9	467,591	550,525	+17.74
Dallas	743,501[2]	1,074,756	44.6	434,462	672,117	+54.70
Cincinnati	904,402	1,059,026	17.1	503,998	487,462	− 3.28
Kansas City	814,357	1,027,562	26.2	456,662	468,325	+ 2.55
Atlanta	726,989	1,014,349	39.5	331,314	485,425	+45.52
San Diego	556,808	1,003,522	80.2	334,387	547,294	+63.87
Denver	612,128[2]	923,161	50.8	415,786	489,217	+17.66
Miami	495,084	917,851	85.4	249,276	282,600	+13.37
New Orleans	685,405	860,205	25.5	570,445	620,979	+ 8.86
Portland	704,829	815,745	15.7	373,628	370,339	− 0.88
TOTAL	51,259,094	63,124,372	23.1	30,093,524	30,553,478	+ 1.53

[1]Source: U. S. Census of Population, 1950 and 1960 (Preliminary Reports).
[2]1950 figures for Dallas and Denver include all counties embraced by the currently defined "metropolitan area."

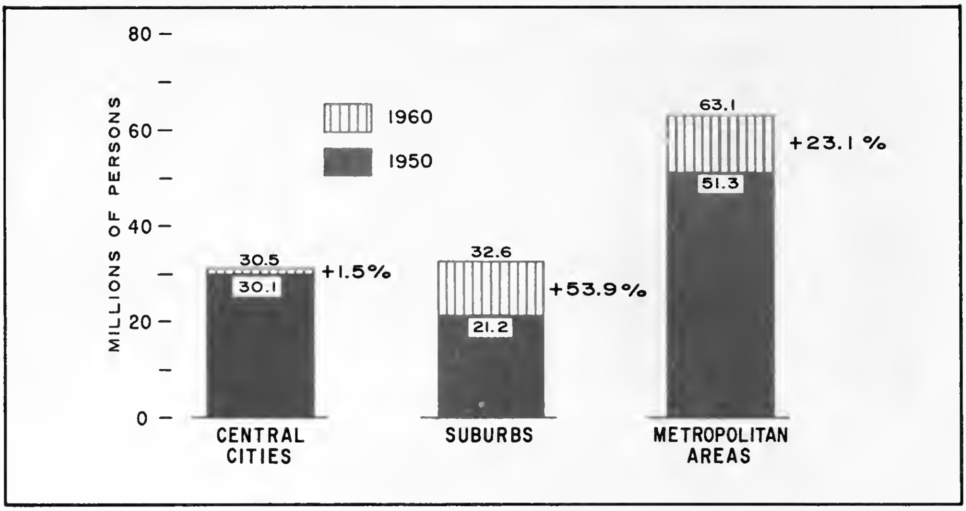

Figure 6
POPULATION GROWTHS
1950-1960
27 LARGEST METROPOLITAN AREAS

not fully developed in 1950. For example, Houston, where most of suburbia is located within the city limits, grew 55 per cent.[7]

The total growth within the 27 metropolitan areas is portrayed in Figure 6. In aggregate, these areas contained approximately 63 million people in 1960, of which 30.5 million or 48 per cent resided in the central cities. In 1950, 59 per cent of the 51.4 million population lived in central cities. Within the last 10 years, the central cities grew 1.5 per cent, the suburbs 53.9 per cent, and the metropolitan areas 23.1 per cent.

Population Dispersion — The shift of people to suburbs has been accompanied by corresponding movements within the central city itself. An increasing proportion of urban residents live in outlying sections of the central city, whereas the number of inhabitants in old, core areas has declined. The patterns of population distribution within Chicago, Philadelphia and Washington, shown in Figure 7, denote this trend.[8]

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[7]Census figures are as of September, 1960.

[8]Adapted from the following sources: *Growth and Redistribution of the Resident Population in the Chicago Standard Metropolitan Area,* a Report by the Chicago Community Inventory, University of Chicago, to the Office of the Housing and Redevelopment Coordinator and the Chicago Plan Commission; Blumenfeld, Hans, "The Tidal Wave of Metropolitan Expansion," *Journal of the American Institute of Planners* (Winter, 1954); Silver, Jacob, "Trends in Travel to the Central Business District by Residents of the Washington, D. C., Metropolitan Area, 1948 and 1955," Bulletin 224, *Trip Characteristics and Traffic Assignment,* Highway Research Board, Washington, D. C., 1959.

In 1900, some 21.5 per cent of Chicago's 1,698,375 residents lived within two miles of the central business district; 43.2 per cent lived within four miles; and 94.2 per cent lived within eight miles. In 1950, 24.6 per cent lived within four miles of downtown; and 75.7 per cent lived within eight miles. The median distance of the population from downtown increased from 3.4 miles in 1900, to 5.9 miles in 1950.

In 1948, 24.5 per cent of the 1,109,851 residents of the Washington area lived within two miles of the central business district, compared with 18.4 per cent in 1955, when its population was 1,454,437. The per cent living over eight miles away increased from 2.9 to 6.1 in the seven-year period.

Approximately 24 per cent of Philadelphia's 1,293,697 residents in 1900 lived within two miles, and 72.6 per cent within five miles of its central business district. By 1950, when its population had increased to 2,071,605, 3.1 per cent lived within two miles and 14.1 per cent within five miles of downtown. The median distance from downtown increased from 3.6 miles in 1900 to five miles in 1950. Urban redevelopment may be expected to further reduce population densities; close-in areas (three to five miles from City Hall) are expected to lose one fifth of their population by 1980.[9]

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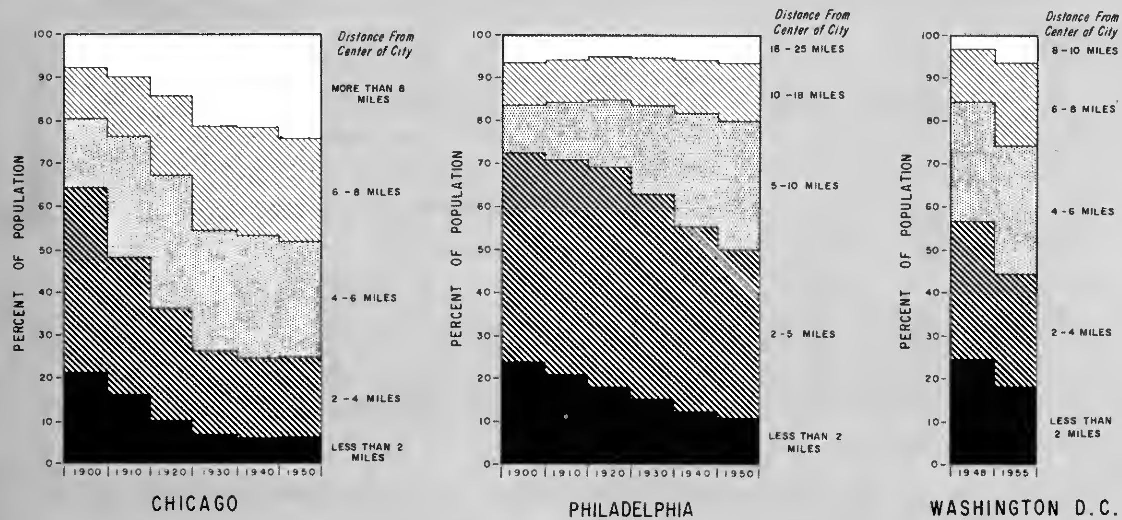
[9]Information obtained from Philadelphia Urban Traffic and Transportation Board.



TOTAL POPULATION

YEAR	CHICAGO	PHIL.	WASH.D.C.
1900	1,698,575	1,243,697	
1910	2,185,283	1,549,008	
1920	2,701,705	1,823,779	
1930	3,376,438	1,950,961	
1940	3,396,808	1,931,334	
1948			1,109,851
1950	3,620,962	2,071,605	
1955			1,454,437

MEDIAN DISTANCE

YEAR	CHICAGO	PHIL.	WASH.D.C.
1900	3.4	3.6	
1910	4.1		
1920	5.3	3.9	
1930	5.7		
1940	5.8	4.6	
1948			3.6
1950	5.9	5.0	
1955			4.4

Figure 7
DISTRIBUTION OF POPULATION
BY
DISTANCE RINGS FROM CITY CENTER

In the New York metropolitan area, dispersal of the populace continues. Manhattan and Brooklyn have remained almost stationary, population-wise, whereas outlying areas have grown. The fringe counties, with only eight per cent of the metropolitan population in 1910, accounted for 24 per cent in 1954. During this period, the population of Manhattan declined in relative importance, comprising 31 per cent of the metropolitan total in 1910; 16 per cent in 1930, and 14 per cent in 1954.[10]

Present Densities — Relative declines in net residential densities as distance from the central business district increases, are illustrated in Figure 8 for five typical urban areas.[11] In all cities, there is a consistent decrease in densities between the city center and the periphery of the area. In Chicago, for example, the density at four miles is about 60 per cent of that at one mile, whereas at 10 miles it is about 20 per cent. As densities decrease in inner

[10]Regional Planning Association, Inc., *Population 1954-1975 in the New Jersey — New York — Connecticut Metropolitan Region,* Bulletin 85, November, 1954.

[11]Figure 8 was compiled from data contained in Chicago, Pittsburgh, and St. Louis metropolitan area transportation studies, from "Land-Use and Traffic Models," *Journal of the American Institute of Planners,* Volume XXV, No. 2, May, 1959, and from data in *Public Roads,* Volume 30, No. 2, April, 1959.

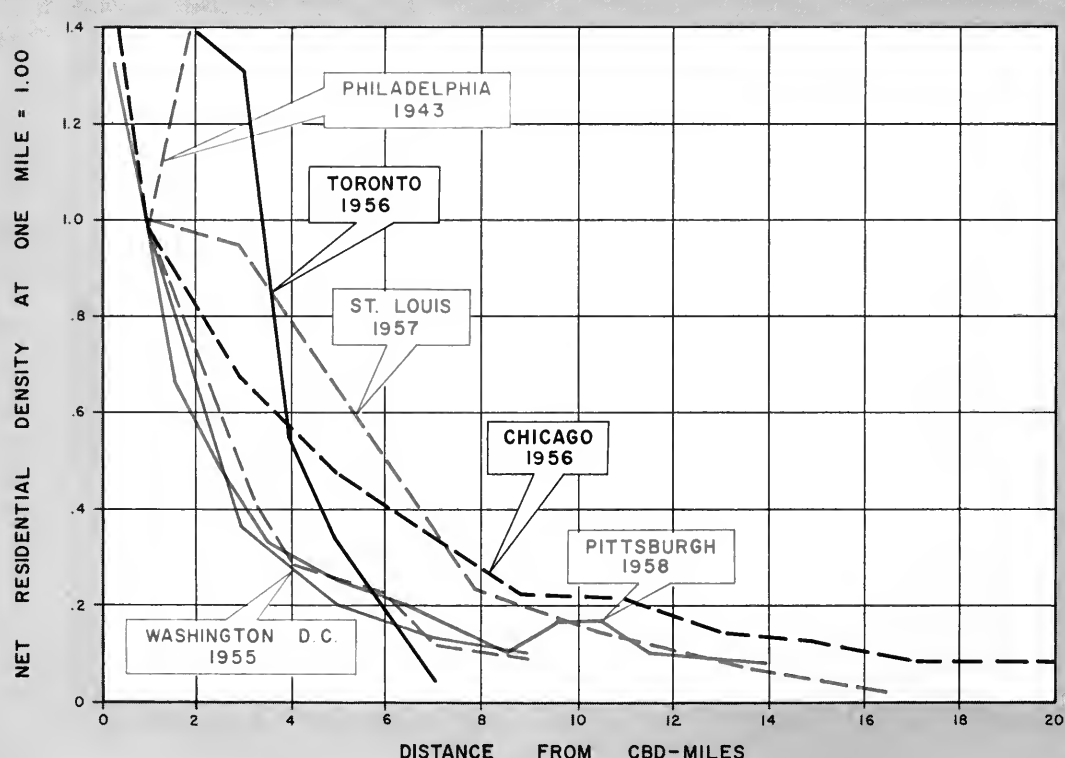


Figure 8
Population Densities Related to Distance From Central Business District

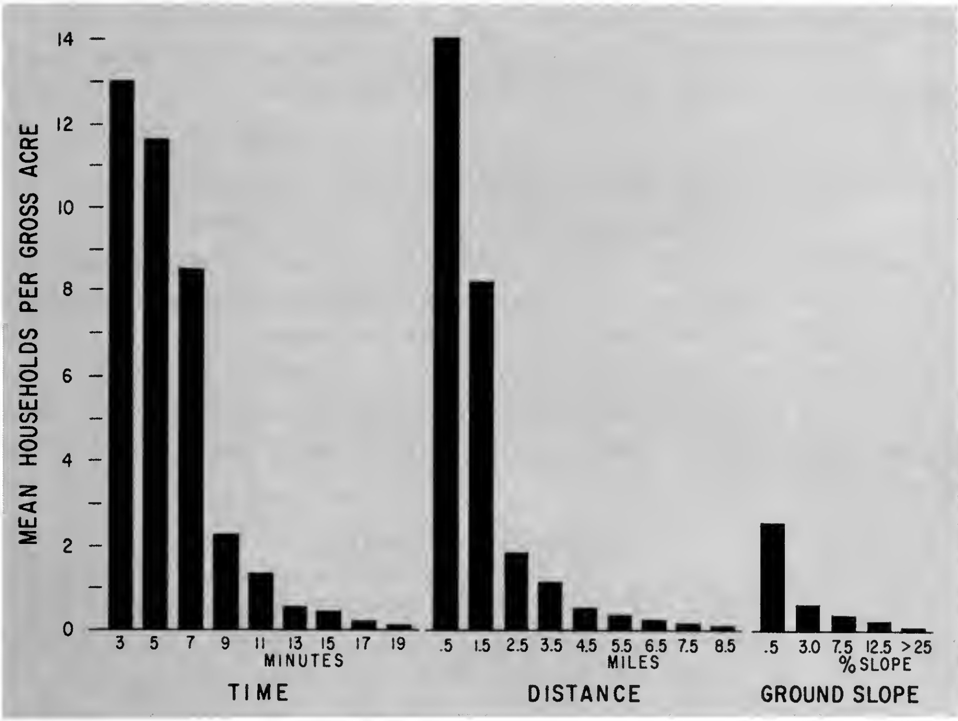


Figure 9
FACTORS INFLUENCING POPULATION DENSITY
TYPICAL CONNECTICUT TOWN

zones and increase in outer zones, there is a tendency for the curves to level off over a period of time.

The patterns are strikingly similar for the Philadelphia, Pittsburgh and Washington areas, and for Chicago and St. Louis. In all five cities, densities diminish rapidly for the first eight to ten miles, where they are about 10 to 20 per cent of the one-mile densities. Beyond the eight-to-ten mile radius they diminish gradually. Toronto, Canada, unlike the other cities, has comparatively uniform densities for the first few miles.

Terrain and time-distance from the central business district affect population density.[12] These effects, depicted in Figure 9 for a Connecticut city, show patterns similar to those found in other cities. Density, however, depends slightly more on time from the central business district than on distance. There is also some tendency toward higher densities on level ground.

The shifts in population do not represent complete dispersion. Much of the suburban expansion is a result of new growth in peripheral areas where

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[12]Pushkarev, Boris, "Population and Space in an Urban Region: The Atlantic Urban Region," *City Planning at Yale,* No. 2, 1955.

developable land is still available. This growth is generally taking place at a lower concentration, thereby accelerating the trend toward a more homogeneous density within the metropolitan community.

Future Densities — Lower over-all densities can be anticipated in the future because of the greater residential "holding capacities" of suburbia. Most new growths are expected to develop an average density of about 2,500 persons per square mile, in contrast to central cities with densities that often exceed 10,000 persons per square mile. Land devoted to urban development will probably double by 1980. Thus, the total population of the urban complex will increase, but it will be spread over a larger area. By 1980, urban areas in the United States will occupy nearly 58,000 square miles compared to about 24,000 square miles in 1950; they will comprise about two per cent of the nation's land area.

TRENDS IN LAND USE

Strong economic and social forces have motivated the trend toward suburban living despite a lag in urban freeway development. Accompanying the pattern of residential suburbanization has been the relocation of retail outlets and a dispersal of commercial service and industrial activity. Greater work opportunities now exist in suburban areas. Consequently, relative reductions in downtown retail sales and employment have occurred.

Residential Decentralization — The move to suburban areas has been influenced largely by improved educational and economic levels, increased emphasis on "family" living, and the desire to own a home. The typical suburbanite — unlike many central city dwellers — is a home-owner.

A study of attitudes and practices of residents in Providence, R. I., in 1956, clearly indicated the views of city dwellers toward suburbia.[13] It showed that "there is a compulsive urge among residents of the city to move to the suburbs or to the country, and there is little compensating urge among residents of the suburbs or the country to move to the city." Fifty-three per cent of the city residents interviewed thought of moving out of the city, and 76 per cent of these thought they might actually do it.

Industrial Areas — Changes in the patterns of non-residential land use have also resulted from population shifts. In recent years, most industrial expansion has occurred in and around established urban areas rather than in areas distant from large employment markets.

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[13]Pratt, Robert W., "Attitude and Practices of Residents of Greater Providence Concerning Downtown Providence, 1956," as reported in *Trade, Transit and Traffic, Providence, Rhode Island,* Wilbur Smith and Associates, 1958.

This is not a new transition; almost as soon as railroads became established, industries began to decentralize by seeking locations in suburban areas. More recently, the growing use of trucks has made factories less dependent on sites near railroads.

Changing technology has created decentralized industrial parks to replace the multi-storied loft buildings of the old cities. Industry has moved out of the central city to take advantage of low-cost sites with ample space for assembly lines on a single level and for expansion and parking; accessibility to labor force has also been a factor. The government's policy of permitting war industries to write off costs of new plants in a five-year period has also likely encouraged many corporations to build outside cities.

For example, as shown in Figure 10, Route 128, the perimeter freeway circumscribing the Boston metropolitan area, is flanked by a series of new industrial parks and several regional shopping centers. As of September, 1957, there were 99 new industrial and commercial plants located along the highway, costing over $100 million and employing 17,000 persons; more than 70 plants were previously located within a four-mile radius of Boston.[14]

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[14]Bone, A. J. and Wohl, Martin, "Massachusetts Route 128 Impact Study," *Highways and Economic Development*, Bulletin 227, Highway Research Board, Washington, D. C., 1959.

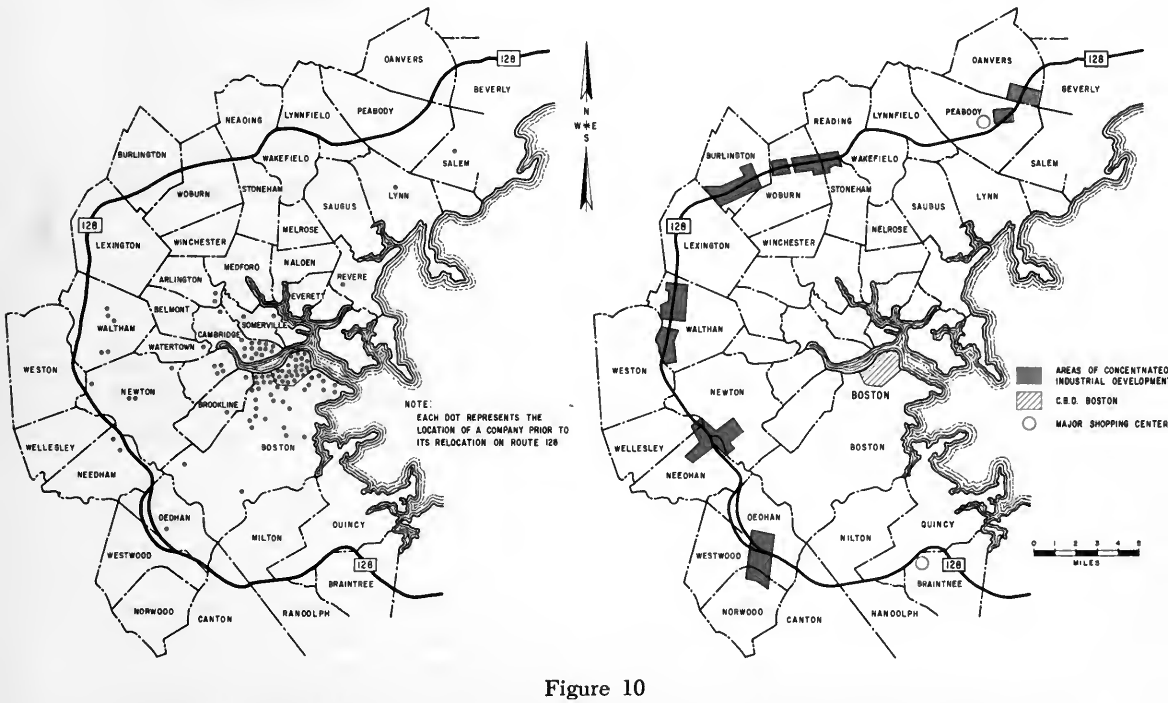

Figure 10

INDUSTRIAL RELOCATION AND DEVELOPMENT ALONG MASSACHUSETTS ROUTE 128

Commercial Areas — The integrated regional shopping center has become an integral part of the American scene. Based on planned, constructive decentralization, it has adapted to the suburbs and the automobile. Its location at key focal points within the suburban trade areas places it in a strategic position with respect to purchasing power.

Shopping center development in the United States and Canada increased rapidly in the years following World War II. Since 1947, almost 1,300 shopping centers have been built, aggregating about 62 million square feet in regional centers and 150 million square feet outside of centers.[15]

As of October, 1960, shopping centers in the United States totaled 3,800, with an estimated 423 million square feet of floor area. They are shown by number and size in Table 2.

Today, there are approximately 100 large regional shopping centers in the country, each with 400,000 square feet or more of store building area; all are located on sites of from 40 to 100 acres, and have at least one major department store of 150,000 square feet or larger.

Existing shopping centers have completely altered old retail patterns. These centers, with a future physical life of 40 years or more, must be considered in any long-range metropolitan area plan.

Central Business District — Trends in retail sales in urban areas, summarized in Table 3, clearly reflect the growing economy and metropolitanization in the nation. The largest percentage increases in retail sales volumes between 1948 and 1954, (both in 24 large metropolitan areas and in the entire country), have occurred in the "suburban rings" surrounding the central city, whereas the central business district appears to be declining in relative importance as the center of retail trade transactions.[16]

Between 1948 and 1954, retail sales in suburban areas increased 53 per cent compared with a 21 per cent increase in central cities and a one-per-cent increase in central business districts. During this period, the proportion of retail sales in central business districts decreased about 25 per cent as a result of shifts in the location and purchasing power of the populace and greater mobility.

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[15]Hoyt, Homer, "The Status of Shopping Centers in the United States," *Urban Land,* Vol. 19, No. 9, Urban Land Institute, October, 1960. See Table A-9, Appendix C.

[16]McMillan, Samuel C., "Changing Position of Retail Trade in Central Business Districts," *Traffic Quarterly,* July, 1957, p. 357. See Table A-10, Appendix C, for detailed changes in various metropolitan areas.

Table 2

NUMBER AND SIZE OF SHOPPING CENTERS
IN THE UNITED STATES
OCTOBER, 1960[1]

SIZE OF CENTER (*Square Feet of Floor Area*)	*NUMBER*	*TOTAL FLOOR AREA* (*Square Feet*)	*AVERAGE SIZE* (*Square Feet*)
1,000,000 and over	19	21,565,000	1,135,000
700,000 - 999,000	17	12,876,000	757,000
600,000 - 699,000	10	6,315,000	632,000
500,000 - 599,000	12	6,330,000	528,000
400,000 - 499,000	37	16,650,000	450,000
350,000 - 399,000	35	12,250,000	350,000
300,000 - 349,000	61	19,825,000	325,000
250,000 - 299,000	67	18,425,000	275,000
200,000 - 249,000	145	32,625,000	225,000
100,000 - 199,000	503	75,450,000	150,000
50,000 - 99,000	415	31,050,000	75,000
Under 50,000	477	16,695,000	35,000
Total Reporting	1,798	270,056,000	150,197
Estimate for shopping centers not reporting store area	2,043	153,225,000	75,000
TOTAL	3,841	423,281,000	110,200

[1]Source: Compiled by Hoyt, Homer in "The Status of Shopping Centers in the United States," *Urban Land*, Vol. 19, No. 5, Urban Land Institute, October, 1960. Tabulations based in part on information in *Directory of Shopping Centers in the United States and Canada*, 1961 Edition, National Research Bureau, Inc., Chicago, Illinois.

TABLE 3

TRENDS IN RETAIL SALES IN
SELECTED METROPOLITAN AREAS[1]

AREA	PERCENTAGE CHANGE 1948-1954
United States Total	+32
24 Standard Metropolitan Areas	+32
Central Business Districts	+ 1
Central Cities	+21
Surrounding Areas	+53

[1]Source: McMillan, Samuel C., "Changing Position of Retail Trade in Central Business Districts", *Traffic Quarterly,* July, 1957, p. 357.

A general decline in downtown retail sales from 1948 to 1954 is evident when dollar values for the two years are standardized. These decreases usually ranged from one to two per cent in urban areas of 100,000 people, up to 14 per cent in areas of one million or more population.[17] A substantial decrease has also occurred in core-area sales per capita, ranging from 14 per cent in areas of 100,000, to 28 per cent in areas of three million population.

The proportion of retail sales in the central business district decreases as the size of the city increases. The decrease is most rapid as cities grow to 100,000 population, but is only slight thereafter. As cities get larger, the proportion of competitive commercial facilities in outlying and suburban areas increases.

"Interceptor" rings of retail outlets have been a consequence of the decentralization trend started in the 1920's at intersections of radial and concentric travel routes, and are a competitive influence on the established retail center.[18] Chicago is now starting on its fifth interceptor ring; Detroit has three; in Los Angeles, interception of trade started before downtown was firmly established. Even smaller urban areas, as Omaha and Charlotte, are developing satellite shopping areas. The new, post-war interceptor rings often locate along circumferential highways — particularly where they intersect major radial routes.

[17]Horwood, Edgar M., and Boyce, Ronald R., *Studies of the Central Business District and Urban Freeway Development,* University of Washington Press, Seattle, Washington, 1959, p. 34.

[18]Nelson, Richard L., *The Selection of Retail Locations,* F. W. Dodge Corporation, New York, 1959.

As urbanization continues, a larger proportion of shopping will be done in outlying areas. Therefore, the size of the city, and the inter-relationships between the core and surrounding areas, often measured by accessibility, are primary influences on downtown retail sales.

The distribution of sales in consumer trade, hotels, motels, and movie theaters in selected parts of the New York Metropolitan Region verify the changes that are taking place. As shown in Table 4, there were relative declines in Manhattan, Essex County and Brooklyn, and gains in 19 other counties. In 1948, 29 per cent of the total sales were in Manhattan compared to about 25 per cent in 1954; outlying counties had about 50 per cent of the total sales in 1948 and 56 per cent in 1954.

Office Space – In the last few decades, downtown office space has remained about the same; per capita office space has consistently decreased although there have been some increases in central office space, with the concentrations and shifts varying from city to city. Insurance companies, for example, have

TABLE 4

DISTRIBUTION OF SALES IN CONSUMER TRADE AND HOTELS, MOTELS, AND MOVIE THEATERS IN SELECTED AREAS OF NEW YORK METROPOLITAN REGION

1948 AND 1954[1]

AREA	*PER CENT OF TOTAL*	
	1948	*1954*
Manhattan, Total	28.9	24.6
Central Shopping Area[2]	17.0	14.1
Rest of Manhattan	11.9	10.5
Essex County, Total	6.8	6.7
Newark Central Shopping Area[2]	2.0	1.7
Rest of Newark	2.1	2.1
Essex Outside Newark	2.7	2.9
Brooklyn, Total	14.6	12.7
Central Shopping Area[2]	2.1	1.5
Rest of Brooklyn	12.5	11.2
Region's Other 19 Counties	49.7	56.0
SALES OF ENTIRE REGION	100.0	100.0

[1]Source: U. S. 1954 Census of Business, Series on *Retail Trade, Selected Services,* and *Central Business District Statistics,* supplemented the estimates.

[2]Central business district as defined by U. S. Bureau of the Census.

decentralized considerably since 1956, although many have been prevented from moving to the suburbs by their ownership of central buildings that are difficult to liquidate.[19]

Land Values and Real Estate – During the first 150 years of this country's growth, urban real estate, rents, and prices followed a cyclical pattern of speculative activity, followed by a collapse and slow recovery.[20] Since 1933, urban real estate prices, and particularly costs of urban lands, have moved upward precipitated by changes in the economy, expansion of the population, and the trend toward higher dollar income. Between 1933 and 1959, the national income rose from $87 billion to $400 billion.

Many factors improve suburban land values. Rapid growth must be anticipated in suburban population in single-family home areas on the edges of cities, particularly in states such as Florida, California, Texas, Arizona, New Mexico and Colorado. The number of young people reaching marriageable age in the 1960's as a result of the high birth rate that began in 1945 will increase. There are greater space requirements for homes, shopping centers, schools, airports, and highways. The movement of factories and office buildings to the suburbs helps create new communities on land previously vacant. Traffic congestion in old central cities has undoubtedly been a stimulus to decentralization.

Other factors tend to enhance central city land values and may thereby reduce the demand for new suburban areas. The construction of apartments near downtown, occurring in New York, Chicago, Kansas City and other large cities, as families, many without children seek to move closer to central offices, theaters and stores, may increase. (The number of new apartment units built in the United States in 1959 increased 40 per cent over 1958.)[21] Redevelopment of central city areas will provide new open-area communities in the midst of downtown, as in Chicago, and Pittsburgh, and as planned for Los Angeles and other cities.

Downtown retail land values have generally declined or have failed to offset the decreasing purchasing power of the dollar. However, in virtually all cases, old structures have been valued upward, as the constant rise in the construction costs of new buildings has offset depreciation. Many

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[19]University of California, *Proceedings of First Annual Meeting,* Conference in City and Regional Planning, Berkeley, 1954, p. 6.

[20]Hoyt, Homer, "The Urban Real Estate Cycle – Performances and Prospects," Urban Land Institute, *Technical Bulletin No. 38,* June, 1960.

[21]Hoyt, Homer, "The Urban Real Estate Cycle – Performances and Prospects," Urban Land Institute, *Technical Bulletin No. 38,* June, 1960.

old structures, valued on the basis of current-cost-less-depreciation, now sell for more than when they were new.[22]

The relative decrease in downtown land values is apparent from the trends in assessed valuation for Los Angeles shown in Table 5.[23] Since 1945, the total city assessed valuation has increased about three times; from $1.1 billion, to $3.5 billion, and has reflected the growth within the entire metropolitan area. In the same period, the assessed valuation downtown grew about 50 per cent, from $116 million to $173 million, but decreased from about 11 per cent of the city's total in 1945 to about five per cent in 1960.

The movement of retired people, industries, and tourists to Florida, California, Arizona and New Mexico will continue to increase land values in cities within these states.

In recent years, the chief areas of rapidly rising land values have been relatively large tracts on the fringes of growing cities, where the provision of sewer and water lines has made the land desirable for residential building, shopping centers or new industry.

New concentrations of buildings and changes in land uses brought about by the use of the automobile will determine areas of future high land values. Peak downtown land values will probably not be obtained in new concentrations because land uses will spread over greater areas to provide for parking.

[22]Hoyt, Homer, "The Urban Real Estate Cycle – Performances and Prospects," Urban Land Institute, *Technical Bulletin No. 38*, June, 1960.

[23]Information compiled by Automobile Club of Southern California.

TABLE 5

TRENDS IN ASSESSED VALUATION – DOWNTOWN LOS ANGELES[1]

FISCAL YEAR	*DOWNTOWN ASSESSED VALUATION*	*PER CENT OF TOTAL CITY*	*TOTAL CITY ASSESSED VALUATION*
1945-46	$116,000,000	10.6	$1,100,000,000
1950-51	172,000,000	9.0	1,900,000,000
1953-54	165,000,000	7.4	2,200,000,000
1954-55	166,000,000	7.0	2,400,000,000
1955-56	168,000,000	6.7	2,500,000,000
1956-57	168,000,000	6.3	2,700,000,000
1957-58	173,000,000	5.7	3,000,000,000
1958-59	173,000,000	5.0	3,500,000,000

[1]Source: Automobile Club of Southern California; Downtown Los Angeles Business Men's Association.

HIGHWAY TRANSPORTATION TRENDS

Highway transportation has been an important catalyst to the changing metropolitan community. Its prodigious expansion within the twentieth century is unparalled, and has been implicit in all population and land-use changes.[24]

The nationwide attitude toward automobile ownership is best set forth in *Middletown in Transition:*[25] "Car ownership in Middletown was one of the most depression-proof elements of the city's life in the years following 1929, far less vulnerable, apparently, than marriages, divorces, new babies, clothing, jewelry and most other measurable things, both large and small – while, therefore, people were riding in progressively older cars as the depression wore on, they manifestly continued to ride . . . All of which suggests that, since about 1920, the automobile has come increasingly to occupy a place among Middletown's 'musts' close to food, clothing and shelter."

Development of Highway System – Although highway origins may be traced to the trails of Colonial America, the modern road system, for the most part, has been developed since World War I. The great stimulus to highway building was the Federal Aid Road Act of 1916 which initiated joint federal and state highway construction (with apportionment to states on a basis of population, area, and mileage). In 1921 federal aid was limited to a selected system of interstate and intercounty toll-free highways.

Road Mileage – Trends in roadway and street mileage, Figure 11, depict the progressive improvement of the nation's roads. In 1904 there were over 2,000,000 miles of roads, yet only about 150,000 miles (six per cent) were surfaced; excluding city streets, only 144 miles had high-type pavement. By 1921, about 13 per cent of the 2,925,000 miles were resurfaced, whereas today, over 70 per cent of the 3,478,787 miles of roads and streets are surfaced.[26]

Statistically, there is one mile of road (two thirds of which is surfaced) for every 48 persons and every square mile of area in the United States; nearly the entire population of the country lives within a few miles of a surfaced road; about 145,000 miles of roads are numbered and marked with U. S. route shields; and, two thirds of all farms are accessible via hard-surfaced roads.[27]

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[24]Highway transportation trends, based on information compiled from the U. S. Department of Commerce, Bureau of Public Roads, are detailed in Tables A-11 to A-14, Appendix C.

[25]Lynd, R. S., and H. M., *Middletown in Transition – A Study in Cultural Conflicts*, Harcourt, Brace and Company, New York, 1937.

[26]U. S. Department of Commerce, Bureau of Public Roads, *Highway Statistics.* Present mileage is as of December 31, 1958.

[27]U. S. Department of Commerce, Bureau of Public Roads. *Highway Transportation*, Background Information Prepared for National Academy of Sciences, National Research Council, Transportation Research Study, Woods Hole, Massachusetts, August, 1960.

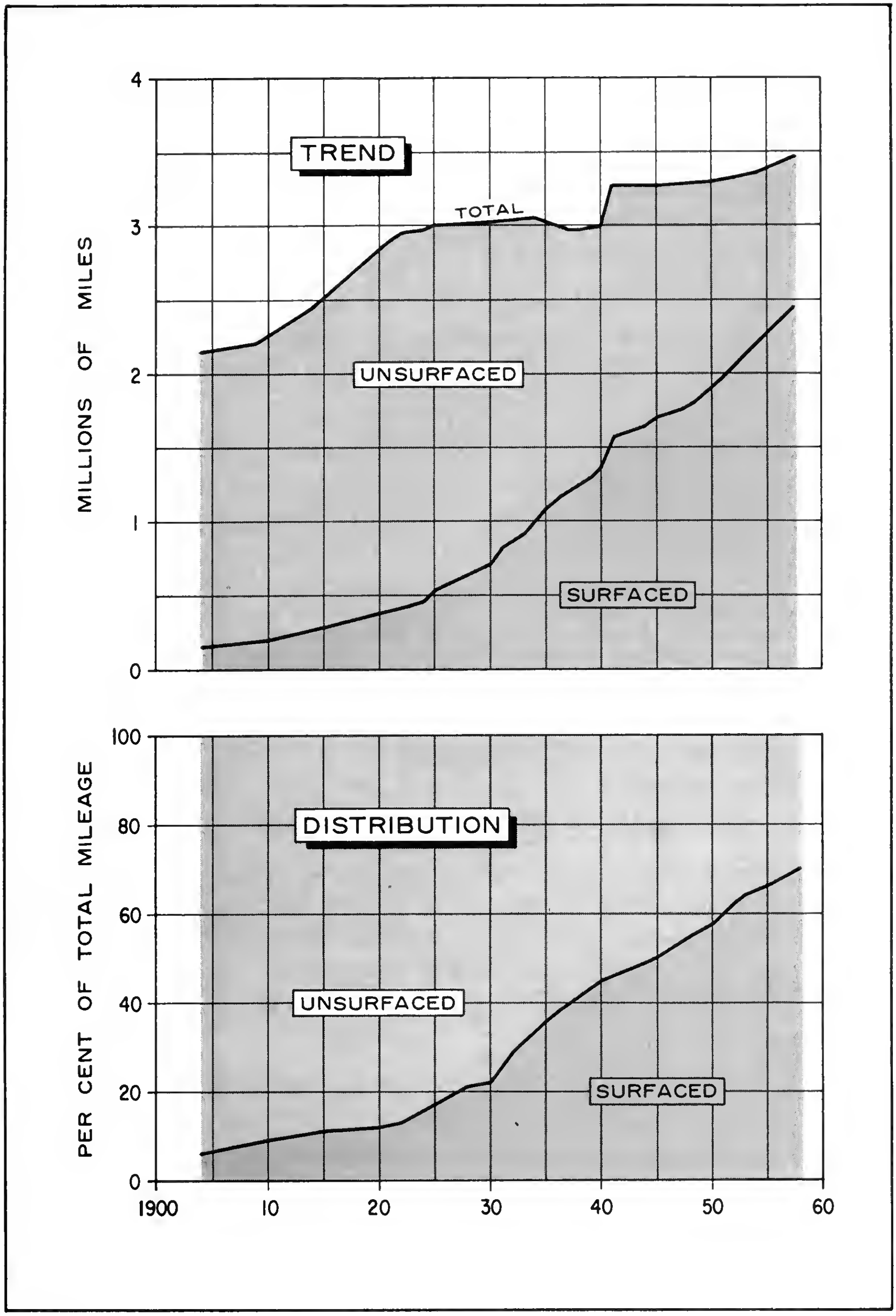

Figure 11
GROWTH OF ROAD AND STREET MILEAGE
UNITED STATES

Land Areas Used For Highway Purposes — The nation's 3,500,000 miles of highways have been estimated to occupy about 22,000,000 acres — an average of six acres of land per mile of road. The authorized 41,000 mile National System of Interstate and Defense Highways will require about 1,500,000 acres, of which about three quarters (1,150,000 acres) will be located on new rights-of-way. Thus, the Interstate System, which will serve more than 20 per cent of all travel will require only a 5 per cent increase in the amount of land presently used for roads.[28]

The proportion of land devoted to streets in urban areas is considerably larger than the national figure because of the greater concentration of population. As shown in Table 6, streets occupy from 25 to 30 per cent of all urban land.[29]

Vehicle Registration — Motor vehicle registrations have grown continually from 4 in 1895 to about 74 million in 1960. As shown in Figure 12, registrations have increased rapidly in recent years, and have almost tripled since 1930.

28U. S. Department of Commerce, Bureau of Public Roads, *Highway Transportation*, Background Information Prepared for National Academy of Sciences, National Research Council, Transportation Research Study, Woods Hole, Massachusetts, August, 1960.

29Bartholomew, Harland, "Land Uses in American Cities", *Harvard City Planning Series*, Volume XV, Harvard University Press, 1955.

TABLE 6

LAND USES IN URBAN AREAS[1]

TYPE OF AREA	*PERCENTAGE OF TOTAL DEVELOPED AREA* In 53 Central Cities	In 33 Satellite Cities	In 11 Urban Areas
Residential	39.6	42.2	28.0
Commercial	3.3	2.5	2.6
Industrial	6.4	7.8	5.7
Railroads	4.8	4.6	6.2
Streets	28.2	27.6	27.6
Public and Semi-Public, Including Parks	17.7	15.3	29.9
TOTAL	100.0	100.0	100.0

1Source: Bartholomew, Harland, "Land Uses in American Cities", *Harvard City Planning Series*, Volume XV, Harvard University Press, 1955.

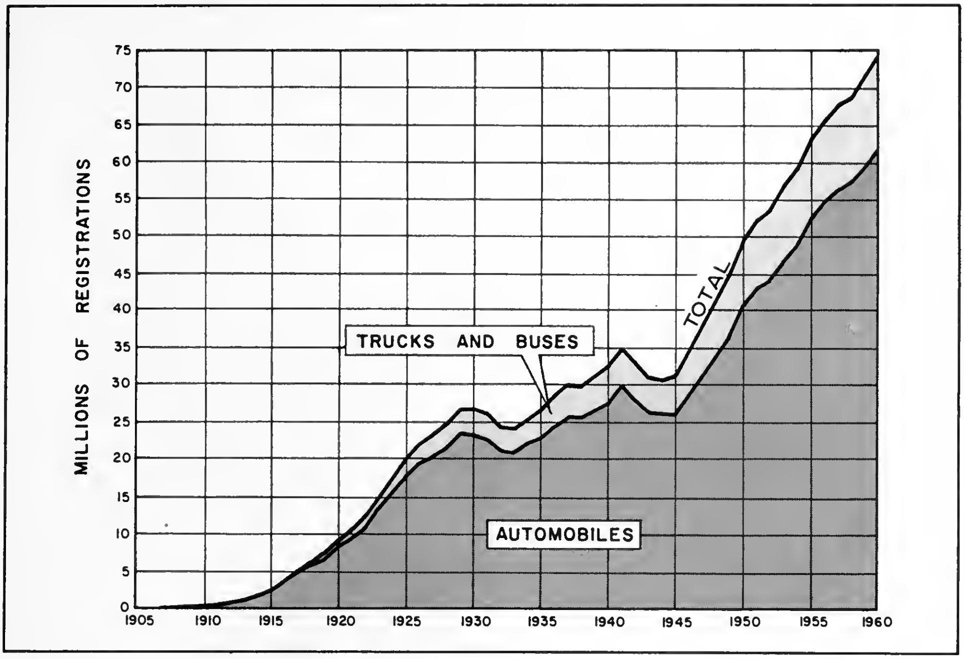

Figure 12
MOTOR VEHICLE REGISTRATION TRENDS
UNITED STATES

Passenger car registrations in 1960 totaled 61.6 million, and commercial vehicles 12.3 million.[30] Three out of every four U. S. families – (almost 40 million) own at least one car; seven million have more than one.

Projections of automobile ownership and use (detailed in Chapter VI), anticipate a twenty per cent increase in the ratio of private cars to people by 1980. By this year, there will probably be about one passenger car registered for every 2.4 people. Registrations in 1980 should approximate 120 million vehicles. Approximately seventy per cent of all cars will likely be owned in urban areas.

Vehicular Travel and Related Trends – Highway travel has kept pace with the expanding economy and the increased automobile ownership. It has surpassed 720 billion vehicle miles in 1960, compared with 696 billion in 1959 and 665 billion in 1958.

As shown in Figure 13, there have been consistent increases in vehicle miles of travel, gross national product (GNP), and highway expenditures.[31]

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[30]In 1958, 56,870,684 passenger cars, 270,163 buses, and 11,187,499 trucks totaled 68,328,346 vehicles. In 1959, 58,591,000 passenger cars and 11,855,000 trucks and buses totaled 70,446,000 vehicles.

[31]Source: U. S. Department of Commerce, Bureau of Public Roads. Also see Table A-12, Appendix C.

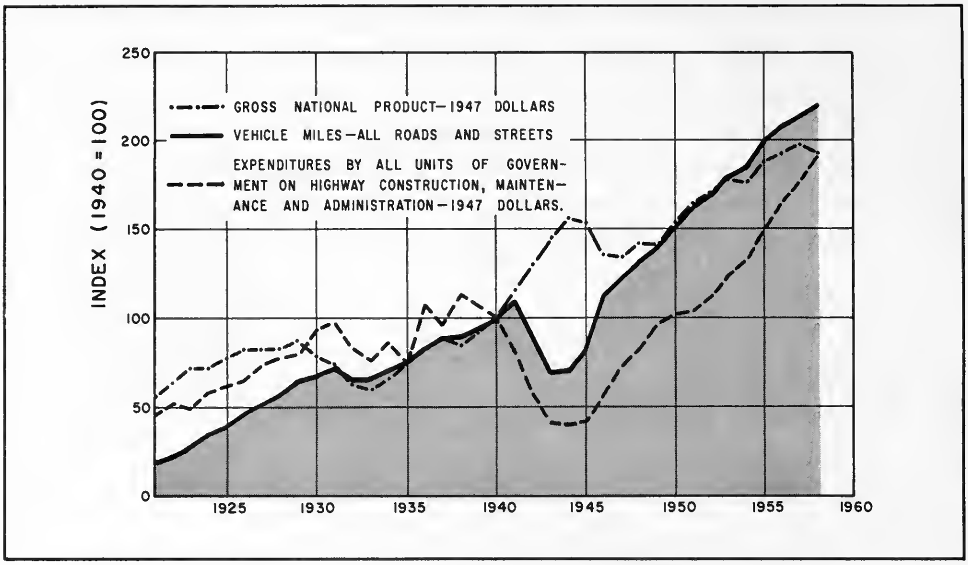
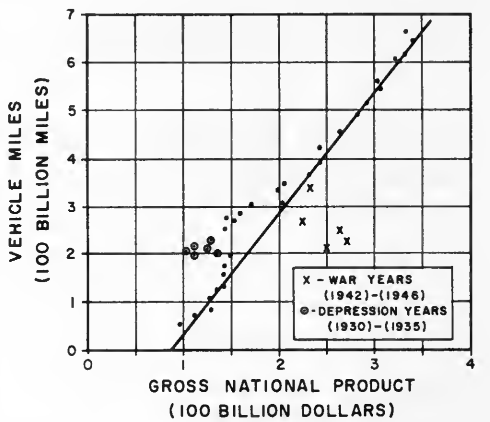


Figure 13
ANNUAL VEHICLES MILES OF TRAVEL RELATED TO ECONOMIC FACTORS

Prior to 1931, vehicle mileage increased more rapidly than GNP; between 1931 and 1953, both increased at about the same rate, except for the war and post-war years, 1940-1949, when highway travel fell below GNP. Since 1953, highway travel has increased somewhat faster. Highway expenditures have lagged behind travel since 1940. Between 1940 and 1958, highway travel increased 120 per cent, GNP 93 per cent, and highway expenditures 91 per cent.

The consistent relationship between GNP and vehicle miles of travel is also apparent from Figure 14. Except for the war and depression years, there have been about two vehicle miles per 1947 dollar of GNP.

Rural and Urban Travel — Recent trends in rural and urban travel are depicted in Figure 15. Between 1936 and 1958, annual vehicle miles on all



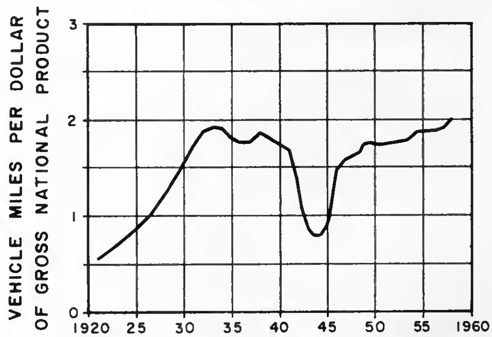


Figure 14
VEHICLE TRAVEL AND GROSS NATIONAL PRODUCT

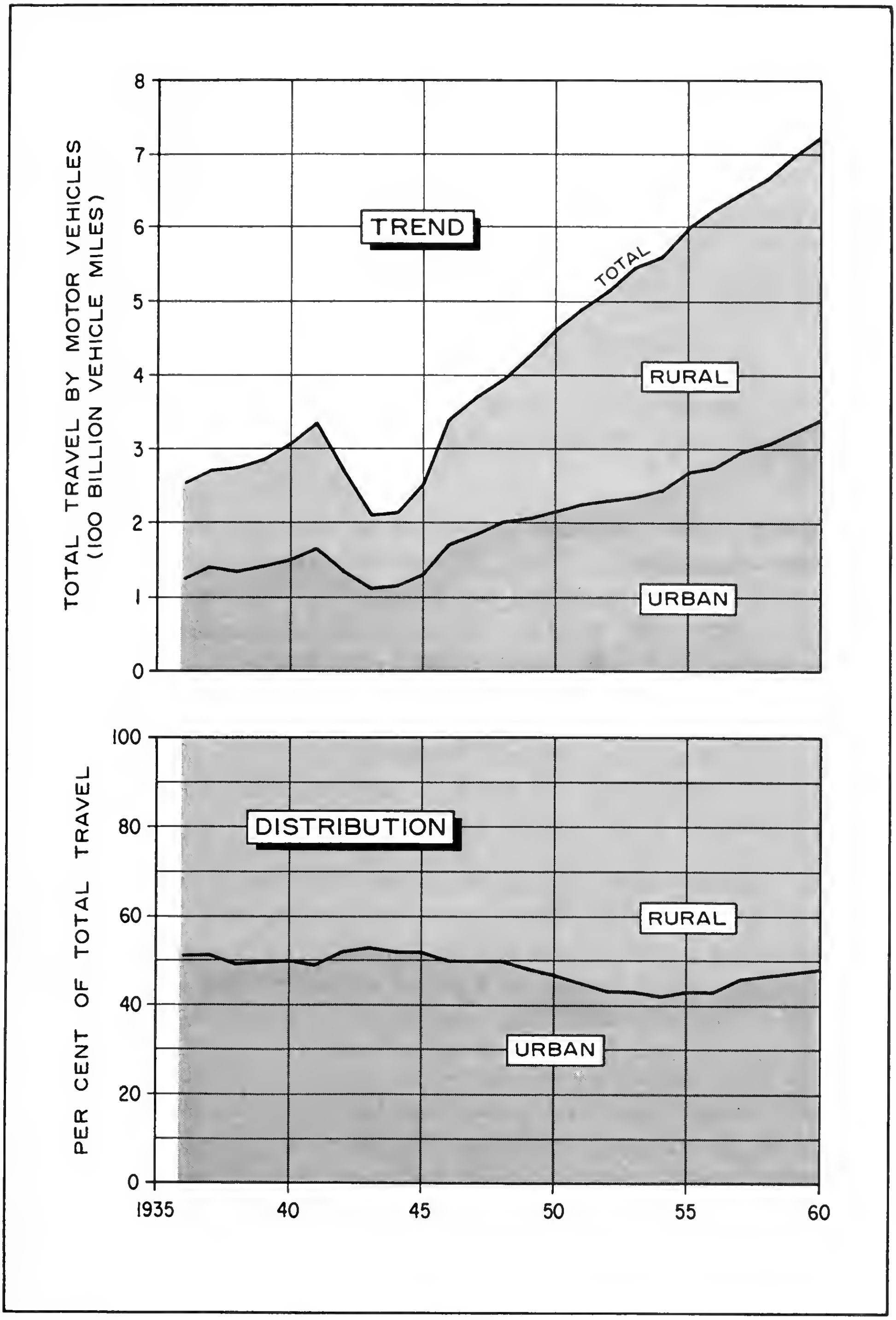


Figure 15
Rural and Urban Travel in United States

roads and streets increased 164 per cent, (from 252 billion to 665 billion).[32] The urban percentage of total travel declined from 51.3 per cent in 1936, to a low of 43.4 per cent in 1954 and 1955, and then increased to 46.2 per cent in 1958. Passenger cars accounted for more than 82 per cent of all 1958 travel.

Intercity Travel – Intercity travel in 1959 totaled an estimated 729 billion passenger miles. Automobile and bus travel were more than double the pre-war rate and accounted for 93.1 per cent of this total. The remainder was distributed among airlines, 3.9 per cent; and railroads, 3.0 per cent.[33]

PUBLIC TRANSPORTATION TRENDS

General trends in public transportation and commuter railroad riders are related to changes in urbanization, economic levels, and vehicle ownership in Table 7.

Although urban areas have increased in size and population, public transportation continues to decline. Factors conducive to increased automobile usage – the desire for individual transportation and the greater dispersion of urbanized areas – have, generally affected public carriers adversely. Because of urban scatteration, people prefer to make their trips entirely by private car.

Since 1940, urban population has increased about 61 per cent; automobile registrations, 128 per cent; and vehicle miles of travel, 138 per cent. Transit riding has decreased about 27 per cent, and commuter railroad passengers, three per cent.[34]

Local Transit – The use of public transportation has declined from about 17 billion annual riders in 1929 to about 10 billion in 1959. There were 102 rides per capita in 1959, compared with 252 about 30 years ago – a reduction of 60 per cent. These declines are expected to continue, but at a slower rate, as car ownership rises and urban area population densities reduce.

Commuter Railroads – The number of commuter railroad passengers has declined in recent years, but at a somewhat lesser rate than transit passengers. The 221 million passengers carried in 1959 were about 35 per cent less than the number carried in the peak year, 1947, and about 50 per cent less than during the 1925-1930 period. Passenger miles in 1959 totaled about 4.5 billion, and were about 25 per cent less than in 1947 and about 30 per cent less than the 1925-1930 average.

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[32] U. S. Department of Commerce, Bureau of Public Roads.

[33] Interstate Commerce Commission.

[34] Transit trends are further discussed in Chapter IV.

TABLE 7

SUMMARY TRANSPORTATION INDICES IN RELATION TO ECONOMIC GROWTH

1940 - 1959[1]

(1940 = 100)

YEAR	Total Population[2]	Urban Population	Gross National Product[3]	Manufacturing Employment	Total Vehicle Registrations	Vehicle Miles of Travel	Transit Riders	Commuter Railroad Passengers
1940	100	100	100	100	100	100	100	100
1941	101	101	116	113	108	110	108	101
1942	102	101	130	124	102	89	137	125
1943	103	102	145	131	95	69	168	136
1944	105	100	156	129	94	70	176	139
1945	106	100	153	125	96	83	178	141
1946	107	111	136	129	106	113	178	149
1947	109	113	135	136	117	123	172	150
1948	111	114	142	139	127	132	163	145
1949	113	116	141	135	138	140	145	135
1950	115	119	154	140	151	152	132	99
1951	117	120	165	148	160	163	123	117
1952	119	122	171	151	164	170	115	114
1953	121	122	178	155	173	180	106	112
1954	123	124	176	151	181	186	95	109
1955	125	125	188	156	193	200	88	108
1956	127	139	193	161	201	208	84	108
1957	130	146	198	163	207	214	79	109
1958	132	153	193	157	211	220	74	104
1959	135	159	206	162	217	230	73	97
1960[4]	136	161	212	165	228	238	NA[5]	NA

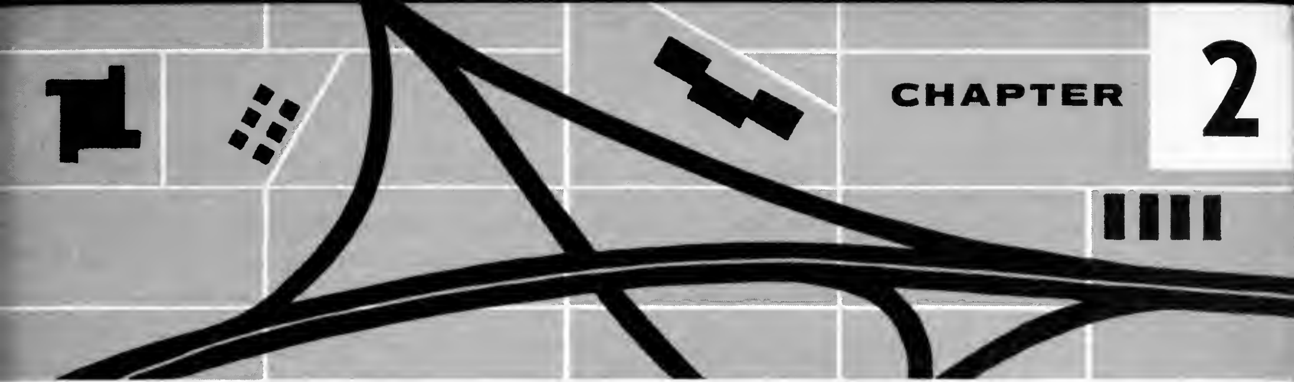
[1]Sources: Automobile Manufacturers Association, *Automobile Facts and Figures — 1959;* American Transit Association, *Transit Fact Book, 1960;* Association of American Railroads, *Statistics of Class 1, Railways of the United States;* U. S. Department of Commerce, Bureau of Public Roads, *Highway Statistics;* Bureau of the Census, *Statistical Abstracts of the United States, 1958.*

[2]Includes Armed Forces

[3]In Constant 1947 Dollars

[4]Preliminary

[5]NA — Not Available.



CHAPTER 2

TRANSPORTATION and URBAN DEVELOPMENT

SUMMARY

CITY growth and structure have continually adapted to available transportation facilities. Within the past several decades, American cities have evolved to a form made possible by the motor vehicle.

Freeways are catalysts in shaping the land-use patterns within the modern metropolis, and exert a positive influence on land uses: they stimulate new, carefully planned developments; they stabilize land uses by delimiting basic long-range patterns, and by giving an aspect of permanence to new freeway-oriented developments. In built-up areas, they effectively aid community development by containing residential units, and serving as buffers between conflicting land uses. Freeways also serve to improve the accessibility, and hence competitive position of the central business district.

Impacts of alternate land-use patterns on traffic volumes, as determined from a series of growth "models" in Nashville, Tennessee, show that changes in the levels of downtown attraction developed no substantial changes in over-all freeway loadings. With an extremely concentrated downtown, arterial streets in and on the immediate approaches to downtown show considerable increases (up to 25 per cent), although no significant changes were noted along outlying sections of arterials. *The model seems to indicate that an area's over-all freeway needs are relatively independent of the degree of concentration downtown.*

Planning the growth and pattern of the metropolitan area is essential since otherwise suburbia will continue to develop without waiting on a total plan. Obviously, no single stereotyped plan can be used for all urban areas, each has its own particular character —

geographically, economically, and culturally — that must be recognized. The balance between centralization and decentralization will vary from area to area. Intelligent arrangement of land uses with respect to travel facilities is more important than "city form" per se.

The multi-centered community, however, appears to be meeting the needs of the 20th Century city. Its dispersal of functions helps to promote more efficient travel and reduce the problems inherent in providing access and parking facilities for an extremely concentrated core area.

The patterns of present central cities will remain essentially the same for many years, although marked changes will take place in surrounding areas. The trend toward a leveling of central city population density will continue, although in a few cases, higher densities may result from urban renewal and redevelopment.

Downtown will not generally increase in dominance because of growing competition from outlying areas. It will, however, be strengthened by improved highways, public transit and parking, and by the development of attractive high-density residential uses in surrounding areas.

CITIES have traditionally been the centers of culture and commerce. The sources, linkages, and magnitudes of their travel patterns depend on the kind, amount, location, and intensity of the activities that generate movement. Each land use has its own particular spatial locational requirements. These activities are usually physically separated, thereby requiring travel from one to another.

The growths, internal structures, and functions of cities have continually adapted to available transportation facilities. The number and kind of trips, and their mode of travel depend upon the type, focus, and technology of an urban society; the number, emphasis, and mode may change, but the similarities will probably be greater than the differences because human wants are basically the same.

Changes in land-use patterns will, therefore, influence travel. Similarly, changes in access facilities will affect the utilization of land. This interaction has been paramount since the onset of urbanization.

Urbanization of the United States has attracted much thoughtful study during the past decade. Demographers are in broad agreement on the probable range of national population growth during the remainder of the 20th Century, the over-all dispersion of people according to region or geographic area, and the extent to which they will congregate in urban areas. It is recognized that natural laws are at work reshaping the conventional city and adapting it to take better advantage of technological improvements in transportation and many other functions of urban living.

There are, however, divergent views regarding the optimum forms of urban development and transportation — as to the impact of freeways on community organization, the merits of centralization versus dispersion of activities, and the effects of alternate land-use patterns on freeway and transit needs.

The recent trend toward "city-regions" requires new concepts and bold approaches to urban transportation planning. As freeway development continues, knowledge of the interactions between land use and transportation becomes essential. Accordingly, an urban "growth model" has been analyzed to explore the impact of land use on freeway needs.

CITY FORM

The development of cities has, from earliest times, been related to the movement of people and goods. Transportation has successively dominated the location of cities at ocean ports, river landings, railroad stations, and other locations where trade routes intersect or converge, or transshipment is required.[1] Within the city, converging points of subways, streetcar lines and transfer points, and more recently, highway interchanges, have influenced growths.

Internal city structure has been strongly influenced by the time-distance relationships made possible by alternate travel modes. The horsecar, electric street railway, rapid transit and automobile have, in turn, increased the effective radius of the urban area. Suburbia traces its origins to the suburban railroad station where clusters of residential areas developed within short walking distances; today, these clusters are centers of many flourishing communities.

In the days of horsecars, a commuting distance of between two and three miles limited the city's area to about 20 square miles. Streetcar, railroad, and rapid transit lines later expanded the radius of urban movement to five miles, and the urban area to about 80 square miles. The automobile, however, has made a commuting radius of 25 miles more feasible, encompassing an urban

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[1]Chicago, for example, was developed at a portage point; Pittsburgh at the confluence of two rivers; New York, in a fine natural harbor.

area of over 2,000 square miles; express highways will further reduce driving times and thereby enlarge the size of the urban area.[2]

Mass transportation concentrated people in downtown areas with unprecedented efficiency, and was soon followed by high-density developments of both working and living areas. During the late 19th and early 20th Centuries, these high-density regions were necessarily dependent on mass transit facilities, and, in turn, sustained transit. It was not unusual in the late 1920's to find cities still largely influenced by mass transportation with as much as 30 to 40 per cent of all employment located within one mile of the city center.

Today, American cities are evolving to a form that is directly related to the personal mobility made possible by the automobile and are adjusting to the automobile as they once adjusted to mass transportation. Cities are at different stages in this metamorphosis, depending on the amount of urban growth that has taken place in and around them within the past 30 to 40 years. Cities that were large at the beginning of this era have changed the least, while newer areas — including such large cities as Houston and Phoenix — have grown-up with the private car and have almost completely adapted to it.

New building types are evolving and are encouraging automobile usage just as the elevator and skyscraper once stimulated the use of public transportation. Symbolic of the new city are the two-car family, the single family subdivision, the shopping center, the one-story factory, the motel, and the drive-in restaurant.

The new flexibility of movement has facilitated the transition from mass to private carrier, as urban land uses disperse. New patterns of travel have evolved. Instead of flowing radially between homes in the suburbs and jobs in the city center, traffic now flows over wide areas. This diffusion is a direct result of the increase in job and living opportunities made possible by automobile travel.

Classical Patterns of Regionalism — Transportation and accessibility have been important elements in all rationalizations of urban growth and structure. The better known patterns of regional structure are shown in Figure 16.

Von Thunen's "Isolated State" — First published in 1826, this concept related the intensity of land development to marketing and transportation costs. A single city in the center of a uniform plain was surrounded by an agricultural economy. With only wagon transportation and no well-defined highways, the cost of bringing specific farm products to the city was equal for

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[2]Bartholomew, Harland, "Planning for Metropolitan Transportation", *Planning and Civic Comment,* Vol. 18, September, 1952, p. 1.

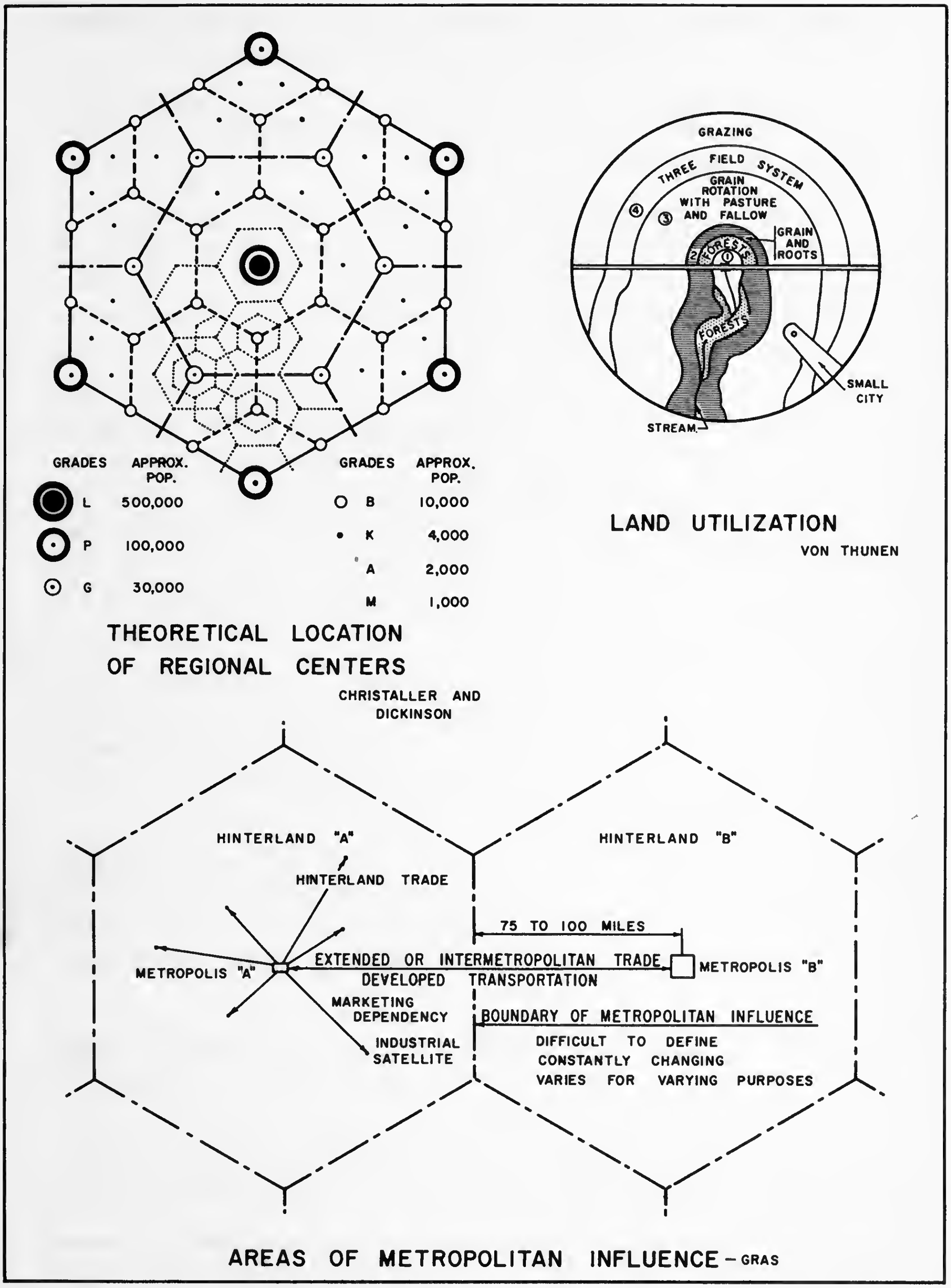

Figure 16
PATTERNS OF REGIONALISM

all points equidistant from the market. The result was a system of concentric belts or zones about the central city, each of decreasing intensity.[3]

This over-simplified concept of land utilization had no rural-urban fringe such as those that exist today. Urban life was contained by the city boundary, while all surrounding areas were agricultural.

Gras' "Metropolitan Hinterland" – In 1922, Gras set forth the metropolis, as the center of commercial dominance over an adjacent territory termed the "hinterland."[4] Commercial functions of the metropolis included (1) "hinterland trade" between the metropolis and its hinterland, and (2) "extended trade" between the various metropolises.

Christaller's Theory – Christaller, like Von Thunen, assumed a hypothetical agricultural economy.[5] However, the various community services were located at certain centers and formed hamlets evenly distributed over a uniform area. In this manner, a hierarchy of urban centers was built around the "central city" of Von Thunen's "Isolated State." Each urban concentration became the basis for a series of belts and zones just as the central city, with the larger cities tending to develop "fringe" areas. The smallest central place served an area with a radius of about two miles.

Christaller assumed a pattern of hexagonal zones of influence around each class of urban center. The central city exists because essential services must be performed for the surrounding land. Wholesaling, large-scale banking, specialized retailing and other services are among its functions. As the communities decrease in size, their service functions become simpler.

The transportation requirements were determined by the distribution and position of urban centers. Each hamlet was connected with the rural area it served, and in turn, was linked with the village or city next in rank, resulting in a system of primary, secondary, and local roads and railways, which carried traffic volumes in proportion to the size of the cities connected.

Comparisons – All of these patterns are obviously modified by natural factors, locational advantages, and transportation facilities. Whereas, Von

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[3]Wehrwein, George S., "The Rural-Urban Fringe", reprinted from *Economic Geography*, Vol. XVIII, July, 1942.

[4]Gras, N. S. B., *An Introduction to Economic History*, New York, Harper and Brothers, 1922.

[5]Christaller, Walther, *Die Zentralen Orte Suddeutschelands*, Gustav Fiseher, Jena, 1933. Extensively cited by Dickinson, R. E., *City, Region, and Regionalism; Geographical Contribution to Human Ecology*, Kegan Paul, London, 1947; and by Ullman, E., "A Theory for the Location of Cities" – *The American Journal of Sociology*, XLVI, 1940-41, pp. 853-864.

Thunen's "Isolated State" was perhaps more closely depictive of the 19th Century metropolis, Christaller's theory is exemplified by the changing automobile metropolis — for example, the increasing primary trading area. In older cities, such as Chicago, many of the subcenters are linked to transit routes. In newer areas, like Phoenix, subcenters are generally in suburbia, oriented to the automobile and serving many functions previously or otherwise provided by the central business district. In some areas, the various centers appear to be equalizing in importance.

Patterns of Internal Growth — Three generalizations of city structure — the concentric zone, sector, and multiple-nuclei patterns — are shown in **Figure 17.** Although examples of each growth pattern can be cited, most American cities are composed of varying proportions of all three types. The actual distribution and functional classification of land use in American cities is far more complex than the simple sum of the three types — the present metropolis more closely resembles the agglomerated development pattern also shown in Figure 17.

Concentric Zones — Burgess found that social-economic status increased with distance from the central city.[6] The urban area was divided into five concentric zones: Zone 1 is the central business district; Zone 2, the "transition zone", surrounds downtown, with its residential areas rapidly deteriorating because of business and industrial encroachment. Zone 3, the "zone of independent working men's homes", includes families who have moved from the zone of transition, but still desire to live close to work. Zone 4 contains better residences, usually single-family homes. Zone 5, the "commuters zone," is often located beyond city limits in suburban areas or in satellite cities.

Analysis of population distribution, densities, and traffic capacities in an urban area are often consistent with the concept of concentric zones.

Sectors — This concept of axial development assumes that growth takes place in wedge or sector form along the main transportation routes radiating outward from the central business district.[7] Growth along a particular axis of transportation usually consists of similar types of land use; thus, a high-rent residential area in a given quadrant tends to migrate outward along a specific

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[6]Burgess, Ernest W., "The Growth of the City" in *The City*, ed. by R. E. Park, E. W. Burgess, and R. D. McKenzie, University of Chicago Press, Chicago, 1925, pp. 49-62.

[7]Hoyt, Homer, "City Growth and Mortgage Risk", *Insured Mortgage Portfolio*, Vol. I, Nos. 6-10, U. S. Federal Housing Administration, Government Printing Office, Washington, D. C., Dec., 1936 — April, 1937.

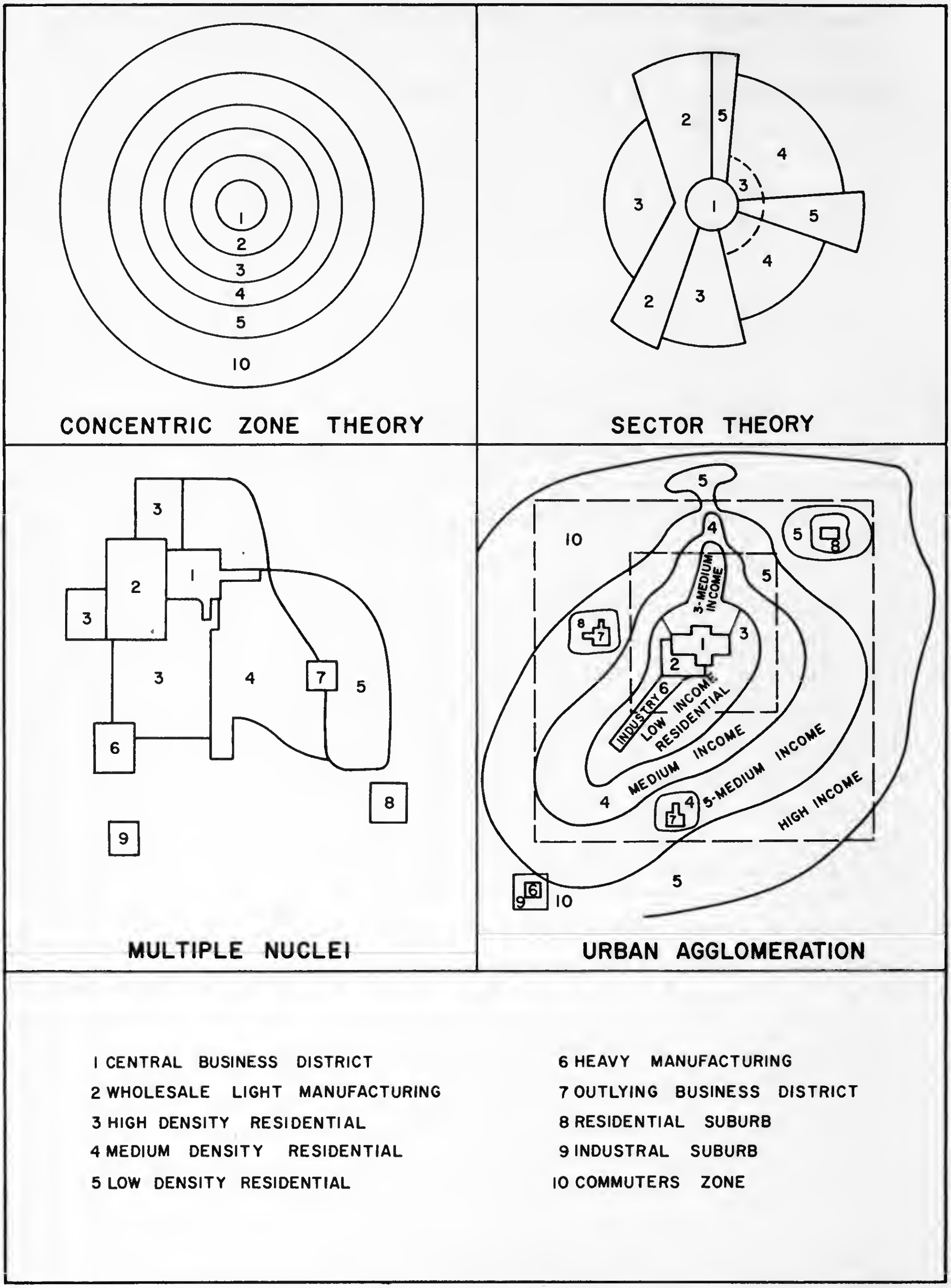

Figure 17
Theoretical Internal Structure of Cities

avenue or radial line, whereas a low-quality housing area, if located in another quadrant, tends to extend outward to the very margin of the city in that sector. Illustrative examples include the lake fronts in Chicago and Cleveland, Fairmount Park in Philadelphia, Wilshire Boulevard in Los Angeles, Lindell Boulevard in St. Louis and Monument Ave., Richmond.

Multiple Nuclei – In many cities, the land-use pattern is built around several nuclei rather than a single center.[8] In some cities, the nuclei have existed since the city's origin; whereas in others they have developed as growth has stimulated migration and specialization, or as the convergence of highway or transit routes has tapped new market areas. This pattern, illustrated by the multi-centered Los Angeles area, is in many respects a prototype of the future region.

The rise of separate centers for urban development often reflects four factors: certain activities require specialized facilities; certain like activities group together because they profit from cohesion; certain unlike activities are detrimental to each other; and certain activities are unable to afford the high rents of the most desirable sites.

Composite Pattern – When all three growth patterns are superimposed, a close approximation to the actual pattern of urban development is obtained. Land uses develop concentrically about a multiplicity of nuclei. In some areas, the pattern is distorted by a series of wedges that penetrate the urban area and are linked to access routes, topography or other localized factors.

IMPACTS OF TRAVEL FACILITIES

Historically, the development of transportation facilities has tapped new areas and intensified land use, with consequent increases in land values along major routes. Thus, the Gulf Freeway in Houston, the Shaker Heights rapid transit in Cleveland, the subway in Toronto, the seaport of New Bedford, and the river ports of Cincinnati and St. Louis have all stimulated development and affected land values within their zones of influence.[9] Most transportation facilities have, however, tended to outlast the land values and uses they created.

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[8]Harris, Chauncey D. and Ullman, Edward L., "The Nature of Cities", *Annals of the American Academy of Political and Social Science,* CLXII, November, 1945, pp. 7-17.

[9]Hoyt, Homer, *One Hundred Years of Land Values in Chicago,* University of Chicago Press, Chicago, Illinois, 1933. For example, land values in the Chicago Loop, as a percentage of total city values, reflect changes in transportation and building technology over a period of 90 years. The development of the horsecar and steam railroad lines in the suburbs reduced central land values from 28 to 12 per cent of the total city value between 1856 and 1873. Construction of the central elevated rail loop and subsequent downtown activity raised the figure to 40 per cent in 1910. Similarly, highway transportation will likely change central city land values.

Thus, availability of transportation will necessarily modify the type and intensity of land use: for example, two communities, separated by a deep canyon, and, without land communications, would grow as individual entities. When linked by a trans-canyon crossing, they become two subcenters of an over-all complex. The new interplay between the two communities would change land use and land values; the "generated" traffic could soon overload the facility and again alter land-use patterns.

Highway Orientation of Land Use — The mobility of automobile transportation has facilitated a reorientation of land uses within the urban area. "Ribbons" of commercial development have fronted along all-purpose highways. Freeways, like railroads and transit lines, have stimulated and become magnets for new land-use developments.

Illustrative examples of planned auto developments that contribute to land values and intensity include freeway-linked Roosevelt Field Shopping Center, Long Island; Century City, Los Angeles, with a planned site population of 60,000; the planned downtown Tulsa Civic Center with almost 2,000 parking spaces; Lloyd Center, Portland, Oregon; and industrial development along Routes 128 in Boston and 401 in Toronto. In the Metropolitan New York area, a series of super shopping centers have located on or near the parkway and expressway system, completely circumscribing the established commercial districts.

Stabilizing Influence of Freeways — The question naturally arises as to whether freeways stabilize land use or precipitate change. There can be no doubt that freeways have been instrumental in the more intense utilization of land, but even in these cases, there is an aspect of permanence. Once the change has been made, the "turnover" in use is usually far less than along other highways.

Freeways also stabilize land uses by delimiting basic long-range patterns. The reasons are quite apparent: access to and from freeways is limited to designated interchange points; and ribbon-type developments cannot be constructed. Freeway related developments must, therefore, be carefully planned and integrated with arterial streets. Often, larger sites are required to provide the desired ingress and egress.

The Merritt-Wilbur Cross Parkways in Connecticut, and their continuation, the Berlin Turnpike, illustrate this point. Both routes are four-lane divided facilities; the former is controlled access whereas the latter has no access limitations. Both have stimulated land development. Along the Parkways, several modern, well-planned industrial developments have been built. Conversely, the Berlin Turnpike has almost exclusively stimulated "highway-oriented" business — e. g., restaurants, service stations, and motels.

Freeways in built-up areas can effectively stabilize land uses by containing residential communities, and serving as buffers for conflicting land uses. Experiences along the Westchester parkways in New York, the Santa Ana Freeway in Los Angeles, and the John C. Lodge Expressway in Detroit show no adverse effects on the majority of residential properties.[10]

Effects of Alternate Transportation Improvements — Planning of urban transportation facilities must, therefore, consider impacts on land use. These impacts may often be most pronounced on established central business districts, where attractive access is essential for continued vitality.

Provision of express highways and related downtown parking areas will tend to increase the market potentials of downtown, afford more selective competition with outlying shopping centers, and encourage more orderly arrangement of outlying commercial areas. Improved transit will further strengthen downtown, particularly in high-density cities.

Without improvements in accessibility, there will likely be some weakening of the established central business districts, increasing obsolescence downtown, and the haphazard development of outlying areas.

Where cars are prohibited from entering downtown, auto-borne travelers would soon shift to other commercial centers, thereby adversely affecting downtown. In addition, new sites would develop on the perimeter of the prohibited areas.

A city linked only by transit would have a strong downtown with ribbon-like high-density apartment clusters along each route, subcenters where routes intersect, and voids or low-density uses in between; its downtown would, however, have difficulty competing with outlying "auto-oriented" centers.

A city served only by express highways (no transit) could develop many nucleations and could encourage a widespread "broad-acre" development.

The fact that transportation can achieve such opposite effects makes it the key to future urban development. The proper juxtaposition of various transportation forms must, however, depend on what is technologically feasible and publicly acceptable.

Change and Obsolescence — Land values reflect changes in city growth; however, the rate of change has not been constant for each of the many com-

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[10]Land-use benefits are detailed in Chapter X.

ponents of the evolving city. The useful structural life of a house, a factory, an office building, a street, or a car is vastly different, but useful structural life, per se, is not an adequate measure for buildings and streets that are reaching technological obsolescence long before they are worn out or even paid for. Consequently, in every city there is a need for modernization — the demolition or rejuvenation of outmoded "but not necessarily outworn" facilities and the addition of street capacity and vehicle reservoir space. All of this should be done concurrently with the building of new homes, factories and shops for new urban growth.

Transportation facilities generally outlive land-use functions. Changes in rates of obsolescence tend to complicate the provision of an efficient transportation system designed to serve specific land uses. A freeway system may still be serviceable when adjacent land uses become obsolete and occasionally near-blighted.

Technological obsolescence of industries and old residences will tend to depreciate land values along a specific travel corridor. In certain areas, such as near downtown districts, revitalization and renewal will take place. However, because of the basic costs involved, most areas will not be revitalized and a hierarchy of lower land uses may take place through time.

GROWTH "MODELS"

Alternate patterns of land development and growth were tested for this study in Nashville, Tennessee, to evaluate the possible impacts of extreme centralization and dispersion on urban travel requirements.[11] Nashville was selected as a "model" because it typifies medium-sized metropolitan areas, because of the extensive urban Interstate system programmed for the community, and because of the availability of current origin-destination data. Its downtown is centrally located and will be served by a network of radial freeways interconnected by a downtown loop, as shown in Figure 18.

In 1959, there were about 648,000 daily vehicle trips within the metropolitan area. Movements wholly within any of the 130 zones were classified as "intrazone" trips and totaled about 108,000. Approximately 467,000 trips were interzone and about 73,000 more had external origins or destinations. When stopping points incidental to basic trips were removed by "linking" trips to and from the incidental stops, 490,000 basic non-intrazone trips remained, of

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[11]The Nashville origin-destination data are based on comprehensive studies now in progress, sponsored by the Tennessee Department of Highways and Public Works in conjunction with the Bureau of Public Roads.

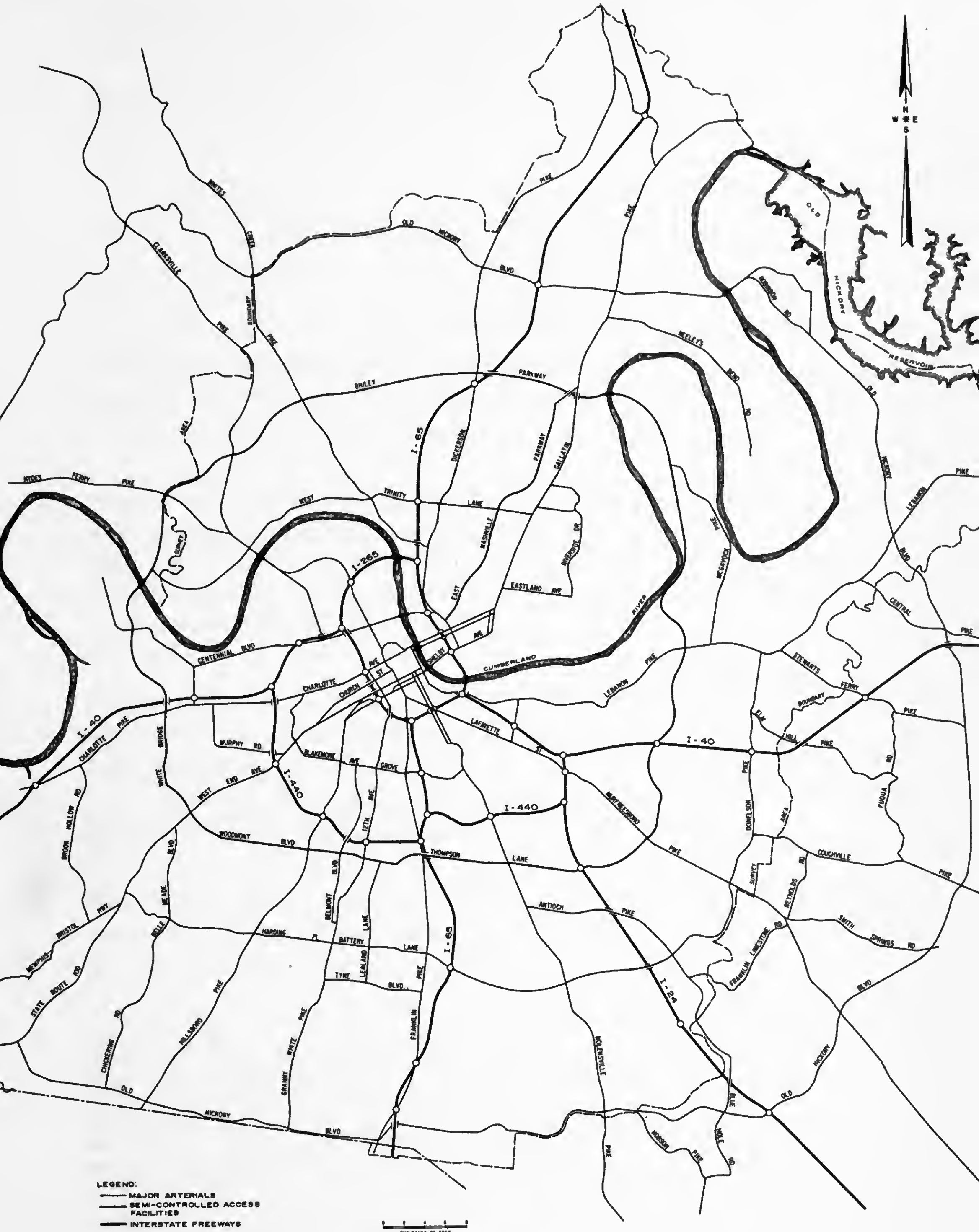

Figure 18

PROPOSED FREEWAY AND ARTERIAL SYSTEM

NASHVILLE, TENNESSEE

which approximately 15 per cent had origins or destinations in the Nashville central business district.

Basic Conditions — Three possible growth conditions were analyzed and programmed on high-speed computers. These conditions reflect, in a relatively crude way, extremes of centralization and decentralization in the central area.[12] In all three conditions, the same total number of interzone vehicle trips within the metropolitan area (about 490,000) has been assumed; however, the proportions generated in the CBD have been varied.

The existing (1959) travel pattern was considered as "Condition A" and served as a reference for the other two conditions.

The "centralized" model, "Condition B", assumed that the passenger vehicle trips to and from the central business district, for work and shopping purposes would double. Increases were assumed to be generally proportional to existing CBD trip patterns.

Since the total number of trips in the system remains the same, increases in CBD travel were compensated for by reducing non-CBD movements. This was done by revising the origin-destination pattern of trips at the "home"; since "Condition B" called for a doubling of the home-based work and shopping trips generated in the CBD, the non-CBD trips in each home zone were reduced accordingly.[13]

The "decentralized" model, "Condition C", assumed that the central business district would diminish in importance to such an extent that it would continue to attract only about half of its present passenger vehicles. Home-based CBD work and shopping trip generation was reduced in half. The reduction was in proportion to existing interzone movements, and resulted in a corresponding increase in movements between non-CBD zones.

The total number of trips to the CBD, and the total vehicle miles of travel for each condition were calculated. In addition, traffic assignments were made to the proposed freeway and arterial system for each of the three cases.

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[12]Many assumptions can be made with respect to the distribution of urban land use and population growth: most new growth may take place in centrifugal areas — the present "normal" growth pattern, or occur in close-in areas oriented toward the CBD with respect to land uses and employment concentrations. Similarly, downtown may increase in dominance, remain essentially the same, or reduce in status to one of several regional foci. Centers of employment may locate adjacent to centers of residence, thereby minimizing travel; locate at opposite ends of the community; or locate to take advantage of natural sites in proximity to rail, water, and highway access and labor force. In Nashville, these diverse assumptions were reduced to three basic conditions, e. g. the present CBD land-use pattern, approximately doubling the CBD's attraction, and almost reducing it by half.

[13]For example, suppose that 20 per cent of the work and shopping trips made by residents of one of the suburban zones presently terminate in the CBD. By doubling CBD attraction, 40 per cent of such trips would be expected to terminate there, reducing non-CBD trips from 80 per cent to 60 per cent of the total. All non-CBD work and shopping movements would be reduced to 60/80 of their present values to keep the trip pattern in balance.

Total Trips — The total vehicle trips into and out of Nashville central business district are compared in Table 8. The present CBD presently generates about 15 per cent of the total vehicular movement (Condition A). The centralized model (Condition B) generates about 22 per cent and the decentralized model (Condition C), about 10 per cent.

Parking Demands and Needs — Downtown parking requirements will be significantly influenced by the changes in traffic attraction of the Nashville central business district. Accordingly, the parking demands for extreme concentration and dispersion of activities in the Nashville area are summarized in Table 9. An increase in the level of generation in the downtown area will necessitate proportionate increases in downtown parking facilities; similarly, a decrease in activity would develop a surplus of downtown spaces.

There are presently about 15,100 parking spaces downtown; 3,100 at curbs and 12,000, off-street. When corrected for efficiency of usage, these represent about 13,000 "effective" spaces. The present maximum accumulation of parkers (11:30 a.m.) approximates 11,200 cars — 86 per cent of the effective parking supply.

When the downtown attraction is increased (Condition B), about 15,700 spaces would be required — 121 per cent of the effective parking supply.

TABLE 8

COMPARISON OF TRIPS TO AND FROM DOWNTOWN NASHVILLE, 1959 WITH ALTERNATE CBD GENERATION[1]

	CONDITION					
	A Existing		*B Centralized*		*C Dispersed*	
TYPE TRIP	*No.*	*Per Cent*	*No.*	*Per Cent*	*No.*	*Per Cent*
To or From Central Business District	75,000	15.4	105,000	21.6	46,000	9.5
Non-CBD Origin and Destination	413,000	84.6	383,000	78.4	442,000	90.5
TOTAL	488,000	100.0	488,000	100.0	488,000	100.0

[1]Source: Origin-destination study now underway.

TABLE 9

COMPARISON OF 1959 PARKING DEMANDS IN DOWNTOWN NASHVILLE WITH ALTERNATE CBD GENERATION[1]

ITEM	CONDITION A Existing	CONDITION B Centralized	CONDITION C Dispersed
Present Spaces	15,100	15,100	15,100
Effective Spaces[2]	13,000	13,000	13,000
Peak Accumulation	11,200	15,700	6,900
Per Cent of Effective Spaces Used	86	121	53
ADDITIONAL SPACES REQUIRED	1,800 (surplus)	2,700	6,100 (surplus)

[1]Source: Parking study in downtown Nashville conducted Summer, 1960.
[2]At about an 85-per-cent efficiency factor.

Substantial increases in the total downtown parking capacity, as well as parking facilities within key core blocks would be required.

A decrease in downtown attraction (Condition C) would increase the number of surplus spaces; less than 7,000 spaces would be required compared to an effective supply of 13,000.

Corridor Movements — The movements from a typical corridor, Sector "I", in Nashville to downtown and to other sections in the city are shown in Figure 19. In each condition, there were about 18,000 trips having origins in Sector "I", located south of downtown.

Despite changes in interzonal trip linkages, the over-all patterns of travel show striking similarities. An increase in downtown attraction results in reduction of travel to other sectors, and conversely, certain trip lengths are increased and others are reduced in each case.

Vehicle Miles — The total travel for each of the three conditions was about the same, and approximated 2.4 million vehicle miles daily. As shown in Table 10, the proportions of travel on freeways, arterials and local streets were approximately equal for each condition: about 62 per cent of all urban area travel was on arterials; 31 per cent on freeways, and seven per cent on local streets.

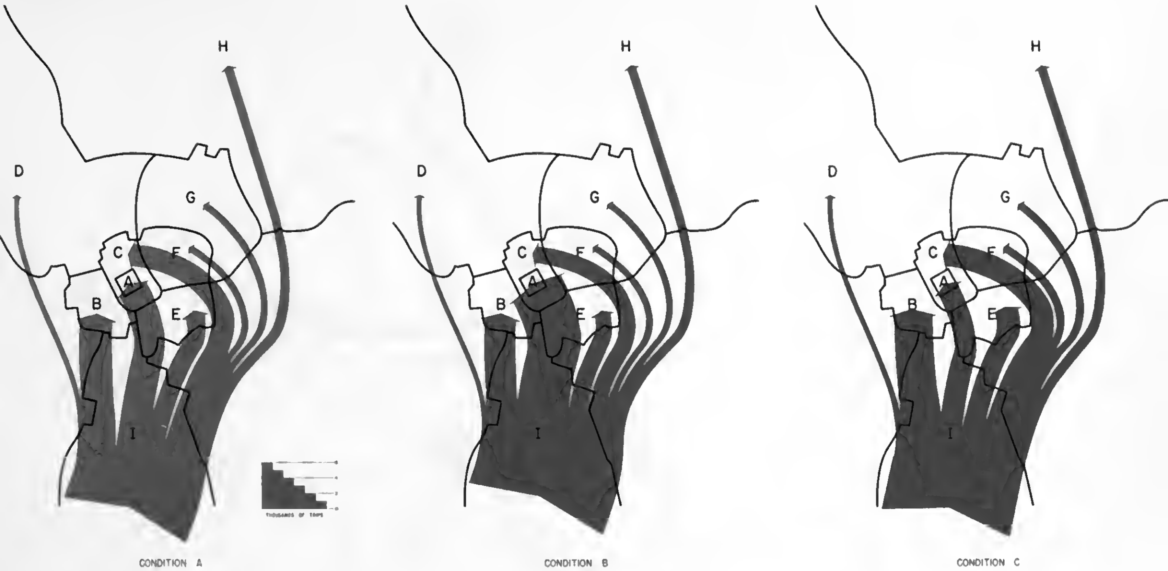

Figure 19
CORRIDOR TRAVEL PATTERNS IN A SELECTED CORRIDOR
NASHVILLE, TENNESSEE
1959

TABLE 10

COMPARATIVE 1959 TRAVEL ASSIGNMENTS NASHVILLE WITH ALTERNATE CBD GENERATION[1]

	PER CENT OF TOTAL TRAVEL IN SURVEY AREA[2]		
	CONDITION		
STREET SYSTEM	*A Existing*	*B Centralized*	*C Dispersed*
Local Streets	6.2	6.3	6.6
Arterial Streets	62.2	62.4	62.2
Freeway	31.6	31.3	31.2
TOTAL	100.0	100.0	100.0

[1]Source: Origin-destination study now underway.
[2]Total travel is approximately 2,400,000 vehicle miles daily excluding intrazone trips.

Figure 20
Assigned 1959 Traffic Volumes to Proposed Freeway and Arterial System
Nashville, Tennessee

Traffic Volumes – Traffic was assigned to the proposed street and freeway system for each of the three conditions. The traffic flow map, Figure 20, graphically depicts the 1959 usage of this system, based on the present (1959) origin-destination pattern. Traffic volumes on all routes increase rapidly as they approach the central business area. The heaviest volumes – approximately 30,000 vehicles per day – are usually found on the downtown freeway loop and on adjoining radial portions of the freeway system.

The changes in area-wide traffic volumes, resulting from increasing and decreasing the levels of activity downtown, are portrayed in Figures 21 and 22, respectively. Freeway traffic volumes throughout the system are approximately the same for all three conditions; there are no substantial changes in over-all freeway loadings. With a concentrated downtown – Condition B – a *few* radial sections of freeway, mainly on approaches to downtown, show increases of over 15 per cent; outlying sections show decreases up to about 15 per cent. With a dispersed downtown – Condition C – certain sections of radial freeways generally on approaches to downtown, show decreases up to about 15 per cent.

Changes in arterial street volumes are somewhat more apparent. With increased CBD generation (Condition B), volumes on radials approaching downtown are consistently higher – often over 15 per cent – than under present conditions, and virtually all circumferential movements show decreases. When downtown traffic generation is reduced, radial streets show reductions up to 25 per cent; whereas many circumferential movements show increases of approximately this amount.

The greatest changes in arterial street volumes are in the central business district itself and, as shown in Figure 23, are almost directly proportional to changes in the levels of generation within the area. With an extremely concentrated CBD (Condition B), traffic volumes are consistently over 25 per cent greater than "normal" conditions. With downtown attraction reduced (Condition C), traffic volumes are consistently about 25 per cent less.

Significance of Findings – It is evident that changes in the intensity of land use will exert a corresponding influence on traffic volumes. The Nashville study has shown that many of these changes may not affect freeway traffic volumes to the extent that may have been otherwise anticipated.

In Nashville, traffic was assigned to freeways and arterials for three distinct levels of downtown traffic generation. A review of these assignments shows no substantial change in over-all freeway loading from one set of conditions to the next. Changes in the levels of downtown attraction did not change the over-all freeway system needs in terms of system location, coverage, and extent.

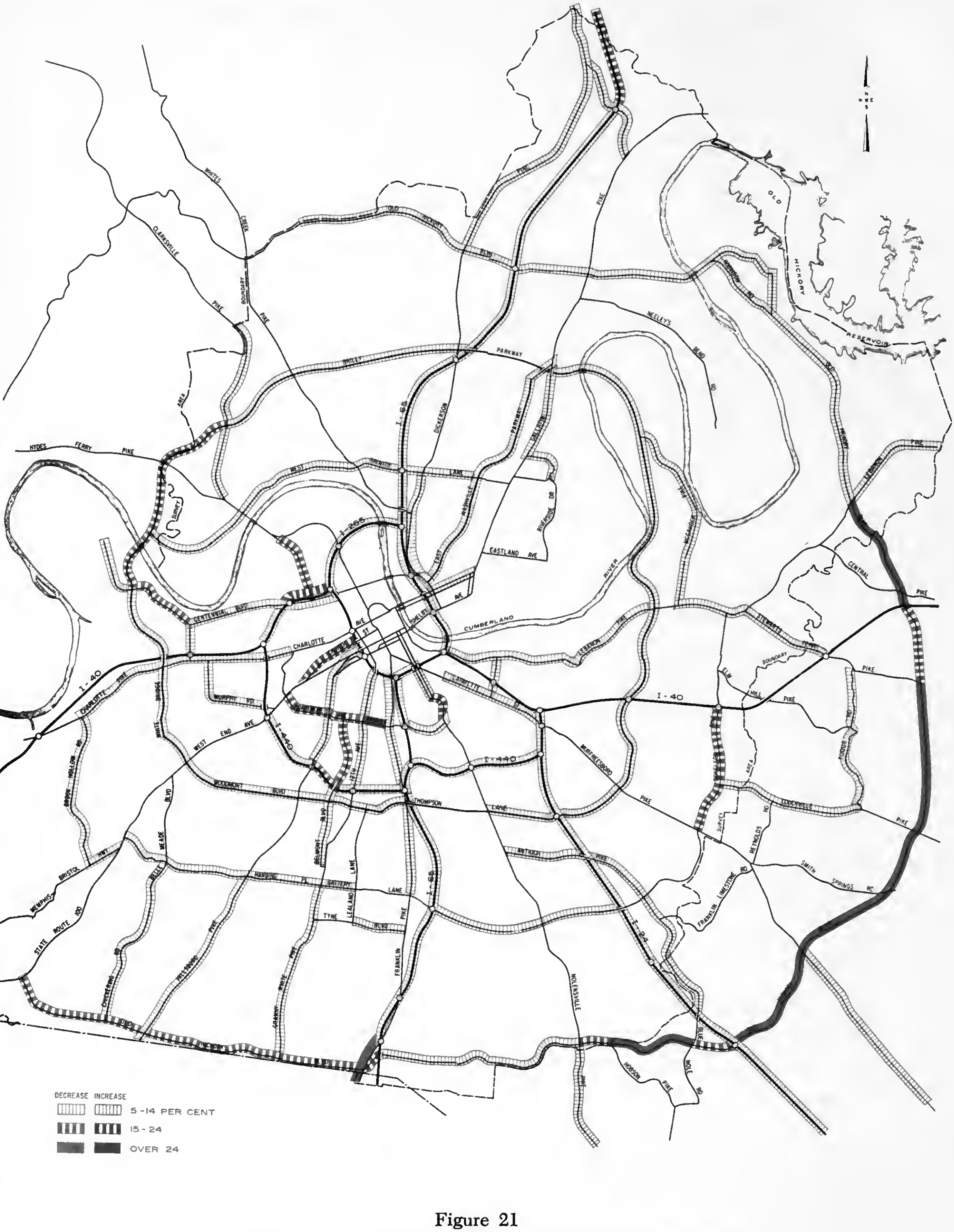

Figure 21

CHANGES IN 1959 FREEWAY AND ARTERIAL VOLUMES

CONDITION B

NASHVILLE, TENNESSEE

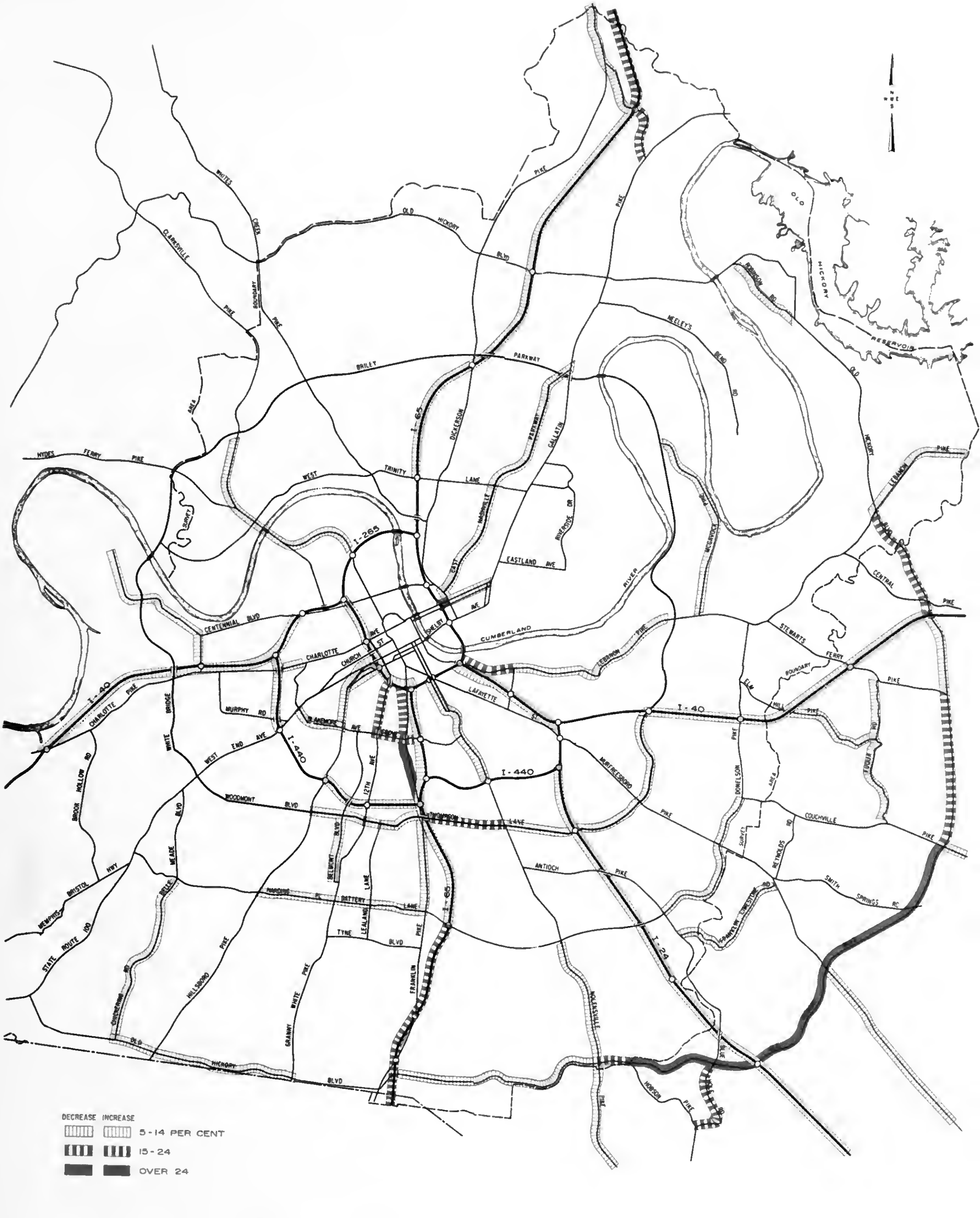

Figure 22
CHANGES IN 1959 FREEWAY AND ARTERIAL VOLUMES
CONDITION C
NASHVILLE, TENNESSEE

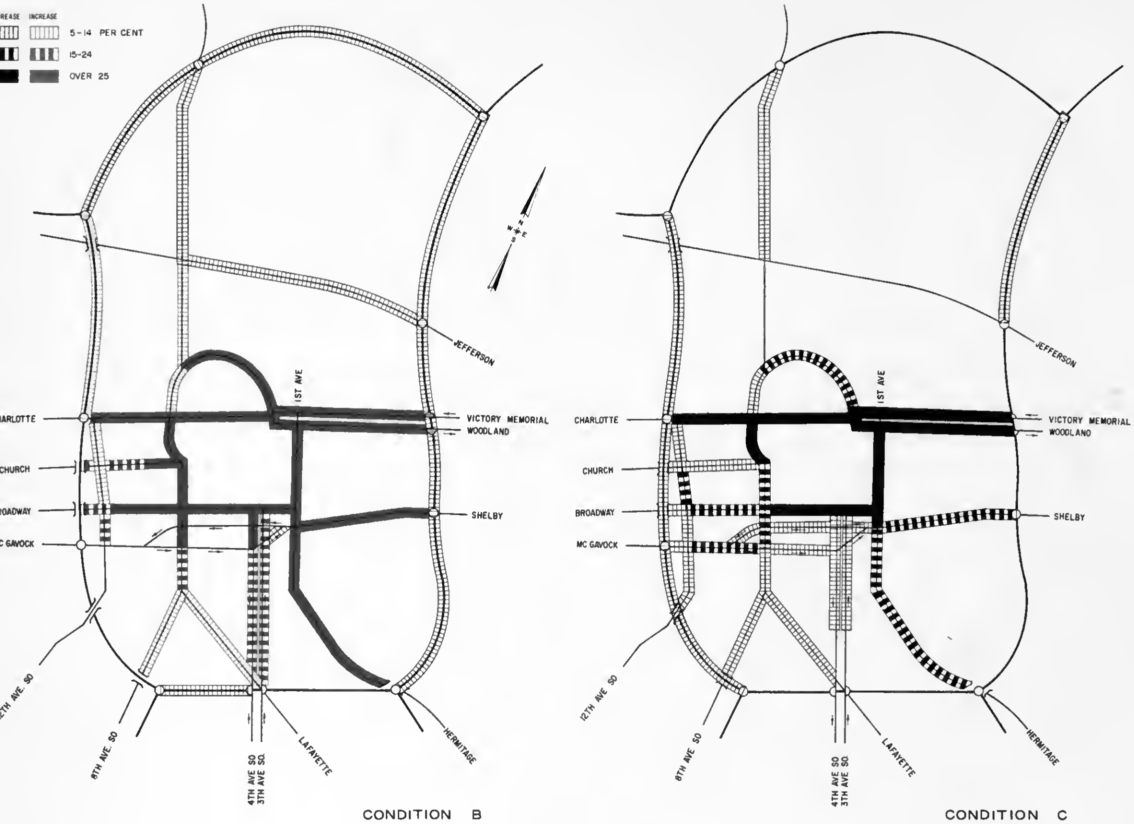

Figure 23
CHANGES IN 1959 DOWNTOWN TRAFFIC VOLUMES
NASHVILLE, TENNESSEE

With an extremely concentrated downtown (Condition B), arterial streets in and on the immediate approaches to downtown show considerable increases, although no significant changes are noted along outlying sections of arterials; somewhat the reverse is true with a decrease in CBD activity (Condition C).

In Nashville, the most significant changes in traffic loadings occurred within the core area encompassed by the freeway loop. The expansion of CBD activity will therefore tend to increase volumes within and on the approaches to downtown.

The results of the model must be considered as tentative since the assumptions represent some oversimplifications. For instance, if downtown decreases in importance, substantial decreases would likely take place in immediately surrounding areas.[14] The model, nevertheless, seems to indicate that an urban area's over-all freeway needs may be relatively independent of the degree of concentration downtown. Changes in the level of downtown activity do not appear to affect *total* freeway needs.

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[14]In the model, the methods of trip distribution resulted in an increase in these areas.

FUTURE CITY FORM

Cities will continue to adapt to scientific, technological and social progress, and to the mobility provided by the automobile and truck. Urban expansion will occur in auto-oriented suburbia because of strong social motivations, increasing personal incomes, and availability of home sites.

It is essential that sound and comprehensive transportation and land-use plans be provided, since suburbia is developing without waiting on a total plan. Transportation and land use should be complementary and in balance.

Optimum Form — The ideal form of an urban area would minimize travel and, at the same time, preserve the amenities of urban culture and suburban living. There is some merit to the containment of individual communities, i. e. "self contained towns" — and, in isolated cases, such towns have been successful. However, they are not always in accord with the desires of the people. Choice residential sites are not usually consistent with centers of employment, and reasons for living in a given community are often predicated on socio-economic factors which may be dissimilar to the reasons for working in a given place.

Extreme centralization requires a huge capital investment in transportation facilities and is often contingent on high-density living. Extreme decentralization could result in lack of downtown focus, and extensive urban sprawl. Sound urban area development, therefore, will require a balance between the extremes of decentralization and concentration. This balance might require a less extensive physical plant of transportation and terminal facilities, make optimum use of both highways and transit, and retain a satisfactory urban environment.

Long-range transportation and land-use plans must recognize the structure, economy and other particular qualities of each metropolitan area; no one type of plan can be successfully applied to all urban areas. Intelligent arrangement of land uses with respect to travel facilities is more important than city form, per se. An ecological equilibrium should be provided between human concentration and internal circulation.

The multiple-centered community appears, nevertheless, increasingly to be meeting the needs of the 20th Century city. Its dispersal of functions affords opportunities to foster more efficient travel and thereby reduces the problems inherent in providing access and parking facilities within extreme concentrated areas. It appears to be a natural consequence of urban expansion.

In some areas, small integrated communities will emerge with all activities within walking distance; in other communities, decentralization will take place to such an extent that public transportation may cease to exist. In a few large areas, transit may complement the automobile. Obsolescence or replacement of the automobile is unlikely in the foreseeable future; even if the car were suddenly superseded by a new form of transportation, at least a generation would be required for transition.

Urban growth in the next 20 years will mainly develop densities similar to those in the new suburban communities surrounding the larger cities, about 2,500 persons per square mile. The additional areas brought within the urban definition during the next 20 years will about double present urban area.

Interurbia — Diffusion between urban areas will continue to take place as cities, suburbs, and metropolitan regions overlap. Planners envision 18 urban regions encompassing one third of the nation's populace by about 1980, with distinctions between town, suburb, and country disappearing. Freeways will continue to open up the countryside.[15]

Figure 24
POPULATION DISTRIBUTION
1950
ATLANTIC URBAN REGION

One such region, the "Atlantic Urban Region", extends from Maine to Virginia and fulfills the prediction of Patrick Geddes, a 19th Century British sociologist and biologist. The population distribution within this "supercity", depicted in Figure 24, shows relatively little undeveloped countryside remaining in the broad complex; highway transportation is helping to fill in the existing voids.

Central City — The patterns of present central cities will remain essentially the same for many years, although marked changes will take place in the

[15]Tunnard, Christopher, "The Landscape of the Big Street", *City Planning at Yale,* No. 2, Yale University, 1957, p. 2.

surrounding areas. The trend toward a leveling of central city population density will continue, although in a few cases, higher densities may result from urban renewal and development.

Employment in central cities may increase, but will probably tend to be a lesser proportion of all employment within the metropolitan area. In many central cities, the movement of middle-income people to suburbia may be encouraged by increasing obsolescence of residential areas, and by some reorientation of employment centers.[16]

To counter this move, modernization within the central city will be required. Where cities recentralize, they must provide the amenities of suburbia, and at no greater cost. Considerable ingenuity and skill in planning, design, economic, and community organization will be required to maintain comparatively high densities and make city living attractive. Large-scale redevelopment will be essential, but it will be predicated on total obsolescence of present city structures and economic feasibility. The prospect of such central city revitalization en masse does not appear likely within the near future.

Perhaps as suburbia becomes somewhat obsolete, (both functionally and socially) the move back to the cities will take place. However, this shift is not anticipated within the next 20 years on any large scale, except in select corridors of certain large cities. To the extent that it occurs, some increases in transit usage may be anticipated.

Central Business District — The central business district will not generally increase in dominance and will be subject to growing competition from outlying commercial areas. It will remain, nonetheless, the vital and dominant focal point of the area, and will increase as a cultural and social center. In certain cities, downtown office functions will likely increase.

The stabilization and decline in relative importance of the central business district will result from the continued urban population dispersion, the consequent proximity of competitive outlying areas, and the shift of non-essential activities to new, modern, low-cost sites.

Downtown will be strengthened by improved highways, public transit and parking, and by the development of attractive high-density residential uses in the surrounding areas.

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[16]Vernon, Raymond, *The Changing Economic Function of the Central City,* Council for Economic Development, 1959.

The downtown "white collar" activity attracts from the new higher income suburbs beyond the ring of low and middle-income population groups that have occupied old homes near the city center. Redevelopment of many older residential areas to "luxury" apartments will, therefore, be in keeping with the changing functions of downtown.

Studies of central business district traffic generation show a direct relation between type of floor area in use and the attraction of persons.[17] Retail functions in the CBD attract the greatest number of people per unit area and warehouses, the least. An increase in office space will not offset a corresponding decrease in retail areas in terms of total person generation. Therefore, since retail space is stabilizing, and in some situations decreasing, the total generation in downtown will probably decrease.

Since the peak-hour generation of office areas is slightly greater than that of retail areas, the decrease in retail areas and increase in office space will tend to add slightly to the over-all peak-hour transportation needs of the central business district. This may be slightly offset as the close-in, loft building industrial areas recede in importance. As industries continue to seek new sites, areas are developed for other purposes, viz., multi-family residential.

Freeway Impacts – There can be no doubt that a modern, well-planned system of express highways will benefit both the central city and surrounding areas. First, it will improve accessibility throughout the area, and thereby improve the attractiveness of the central business district. Second, it will stimulate the *planned* development of the entire urban complex. Third, it will be an impetus to redevelopment of the older central city areas.

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[17]Harper, B.C.S., and Edwards, H. M., "Generation of Person Trips by Areas within the Central Business District", *Traffic Origin and Destination Studies, Appraisal of Methods*, Bulletin 253, Highway Research Board, Washington, D. C., 1960. An equation was fitted to the form; $y = b_1 x_1 + b_2 x_2 + b_3 x_3 + K$ in seven cities. An approximate generalized equation would be as follows:

$$y = 14x_1 + 5x_2 + x_3 - 1800$$

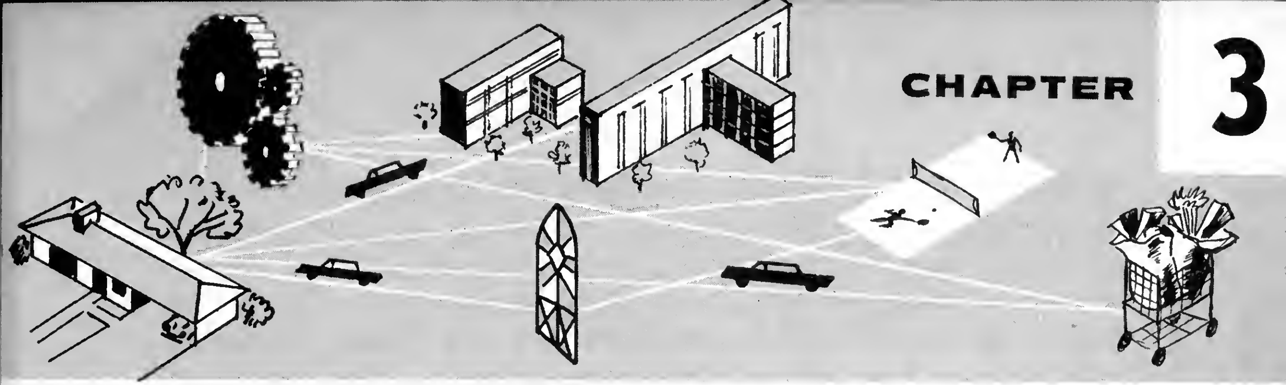
where:

y = number of persons destinations in a zone in the CBD in an average 24-hour period from within the metropolitan area.

x_1 = area of retail floor space in use in the zone expressed in thousands of square feet.

x_2 = area of service-office floor space in use in the zone expressed in thousands of square feet.

x_3 = area of manufacturing-warehousing floor space in use in the zone expressed in thousands of square feet.



CHAPTER 3

CHARACTERISTICS of URBAN TRAVEL

SUMMARY

THE characteristics of travel as measured in 12 dispersed study cities of various population sizes reflect the daily activities of American city residents and their adaptation to the automobile. They show that the automobile has become the primary mode of urban travel.

Today, more than three fourths of all urban travel is by car, except in a few of the nation's oldest and largest cities. The urban resident makes about two trips per day in a car or transit vehicle in large cities like Detroit and Chicago, and averages two and one half or more trips a day in smaller cities, such as Reno. In all cities, the resident travels about 10 miles each day in all pursuits.

A large proportion of urban trips — up to 80 per cent or more — begin or end at home. From city to city, the occupants of the average residence generate approximately the same number and type of trips each day. About 20 per cent are trips "to work"; 18 per cent "to business and shopping"; 12 per cent for "social and recreational" purposes; 40 per cent "to home"; 3 per cent "to school"; and 7 per cent for miscellaneous reasons.

Trips are generated by each land-use class in accord with certain characteristic patterns. In general, the rate at which trips take place between pairs of areas tends to decrease with distance and time. It is also affected by competition between areas providing similar types of attractions. Freeways will, therefore, facilitate a reorientation of urban travel.

The reasons for the increasing use of automobile transportation

are readily understandable. The choice of travel mode — private car or transit — has become closely related to car ownership and population density; car ownership and density, in turn, are usually related to family income. In most cities, low income and high density are related, with income increasing and density decreasing with distance from the central business district. The trends are toward lower population densities, higher family income and greater car ownership; therefore, transit riding will continue to decline and car use will increase.

Travel to the central business district is increasingly by car, although transit retains a substantial proportion of downtown trips. Automobiles carry more than half of all people who enter downtown areas, except for the few cities with established rapid transit systems.

Downtown has not been attracting new visitors in proportion to over-all urban growth since its relative attraction of travel decreases as the size of urban area increases; as cities get larger, a smaller proportion of total urban travel is to or from downtown. This is because cities are experiencing rapid growth in low-density suburbs which have the smallest per capita CBD-trip potential in the community. Improvements in accessibility, as provided by freeways, will reduce travel time and impediments to downtown travel, thereby increasing the market potentials and competitive position of the central business district.

Although the central business district is the largest generator of travel within the urban region, the great majority of automobile trips are dispersed throughout the metropolitan area. In most cities, less than 15 per cent of trips by car have origins or destinations within the central business district.

More than half of all automobiles entering most central business districts are merely passing through, and have destinations elsewhere in the urban region. These vehicles could be readily diverted to downtown freeway loops, thereby freeing other streets for local traffic.

The characteristics of travel clearly show that the city must fully integrate the automobile into its over-all structure. New express highway networks will be required to provide the needed urban mobility and urban Interstate routes will be essential segments of these freeway systems.

MOST travel generated within urban limits is created by the people who live there, and by people who are attracted to the area from surrounding localities. The patterns of travel reflect the movement of people engaged in the daily routines of making a living, provisioning their homes, and socializing with their neighbors.

Characteristics of urban trip generation explain the functioning of the modern city. They give a better understanding of the interrelationships between urban travel and city development, and provide the bases for anticipating urban travel needs.

Trip patterns are dynamic in character; they respond to competition, to changes in the direction of urban growth, and to transition from public to private transportation. Future urban transportation needs will be contingent upon the changes in land use and travel that are expected to occur. Analysis of present travel, therefore, is prerequisite to the projection of future travel and the evaluation of future express highway potentials.

STUDY CITIES

In this chapter, the interrelationships between land uses, trip generation, and mode of travel are analyzed in detail for 12 urban areas of varied size, wide geographic distribution, and diversified economic base. These study areas, shown in Figure 25, extend from Washington, D. C., to Phoenix, Arizona, and range in size from Reno (54,000 population) to Chicago (over 5 million population).

Selection of specific cities for "study-in-depth" was based on the ready availability of current travel information and on their diversity as to location and type.[1] Within the past seven years, a comprehensive home interview origin-

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[1]Analyses have been based on information contained in the following origin-destination studies, co-sponsored by the U. S. Department of Commerce, Bureau of Public Roads, the respective state highway departments, and local governments: *Chicago Area Transportation Study, Final Report, Volume I, Survey Findings,* December, 1959; *Detroit Metropolitan Area Traffic Study, Parts I and II,* 1955; *Mass Transportation Survey — National Capital Region, Traffic Engineering Study,* Wilbur Smith and Associates, 1958; *The Washington Metropolitan Area Transportation Study,* Regional Highway Planning Committee, 1948; *A Highway Planning Study for the St. Louis Metropolitan Area Volume I — Highway and Travel Facts* — Wilbur Smith and Associates, 1959; *Houston Metropolitan Area Traffic Survey,* 1953; *Kansas City Metropolitan Area Origin and Destination Survey, Volume I — Traffic Studies,* Wilbur Smith and Associates, 1959; *A Major Street and Highway Plan, Phoenix Urban Area, Maricopa County,* Wilbur Smith and Associates, 1960; *Traffic Study, Phoenix, Maricopa County, 1956-1957; A Major Highway Plan, Broward County, Florida* (Fort Lauderdale Area), Wilbur Smith and Associates, 1960; *A Master Highway Transportation Plan for the Charlotte Metropolitan Area,* Wilbur Smith and Associates, 1960; *Major Street and Highway Plan, Truckee Meadows Area, Washoe County, Nevada* (Reno Area), Wilbur Smith and Associates, Richardson Gordon and Associates, 1960; Pittsburgh Area Transportation Study — currently in progress; Nashville Metropolitan Area Transportation Study, Wilbur Smith and Associates — currently in progress.

Figure 25
STUDY CITIES

destination survey of travel habits, co-sponsored by the U. S. Bureau of Public Roads, state highway departments, and local, county and city governments, has been made in each city. Detailed analyses of present and future transportation needs, based on assumed growth and land-use development patterns, have been made or are currently underway in each survey city. Results of these analyses are presented in this chapter.[2]

TRAVEL GENERATION

Travel characteristics of residents within the 12 urban areas are summarized in Table 11. Some of the principal findings are as follows:

The number of daily trips per person ranges from about 1.6 in Pittsburgh to about 2.5 in Reno.

The number of persons per car ranges from about 2.4 in Reno to over 3.8 in Chicago.

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[2]The home-interview, origin-destination surveys recorded most travel performed by residents of a large sample of households in each city. In small cities (Reno), as many as 20 per cent of the homes were interviewed regarding weekday travel by residents. A 10-per-cent sample of households was obtained in cities of 150,000 to 300,000 population, and a five-per-cent sample in cities of half a million to one million population. In larger cities, samples were taken of at least one household in 30.

Table 11

GENERATION OF TRAVEL IN STUDY AREAS[1]

URBAN AREA	YEAR OF SURVEY	POPULATION IN STUDY AREA	TRIPS PER PERSON	PERSONS PER CAR	TRIPS PER DWELLING	PERSONS PER DWELLING	CARS PER DWELLING
Chicago, Ill.	1956	5,169,663	1.92	3.85	5.96	3.10	0.80
Detroit, Mich.	1953	2,968,875	1.77	3.51	5.88	3.31	0.94
Washington, D. C.	1955	1,568,522	1.67	3.75	5.05	3.02	0.81
Pittsburgh, Pa.	1958	1,472,099	1.61	3.75	5.26	3.26	0.87
St. Louis, Mo.	1957	1,275,454	1.94	3.48	6.05	3.12	0.90
Houston, Texas	1953	878,629	2.22	3.43	7.16	3.22	0.94
Kansas City, Mo.	1957	857,550	2.18	3.26	6.69	3.07	0.95
Phoenix, Ariz.	1957	397,395	2.29	2.87	6.88	3.01	1.05
Nashville, Tenn.	1959	357,585	2.29	3.35	7.52	3.28	0.98
Fort Lauderdale, Fla.	1959	210,850	1.69	2.72	3.63	2.15	0.79
Charlotte, N. C.	1958	202,272	2.36	3.28	8.10	3.43	1.05
Reno, Nev.	1955	54,933	2.48	2.43	6.87	2.77	1.14

[1]Source: The tables presented in this chapter have been compiled from the various summaries of origin-destination data for each study area. These source materials, prepared for various purposes, do not always add to the same totals; thus data have been slightly adjusted to achieve comparability wherever possible.

The number of trips per dwelling unit per day ranges from about four in Fort Lauderdale to more than eight in Charlotte.

The number of persons per dwelling unit ranges from about 2.2 in Fort Lauderdale, and 2.8 in Reno, to about 3.4 in Charlotte.

The number of cars per dwelling unit ranges from about 0.8 in Fort Lauderdale, Washington, and Chicago, to about 1.1 in Phoenix and Reno.

Effects of City Size – Individuals make more trips in small communities than in large ones. As shown in Figure 26, the number of daily trips in vehicles decreases as the size and/or density of the community increases. (In large cities like Detroit and Chicago, the urban resident makes about two trips daily, whereas in smaller cities like Reno, the average is two and one half or more trips per day.) These differences may be attributed to greater car ownership; almost total dependence on the private car for transportation; comparative availability of parking space; and shorter average trip lengths, which enable

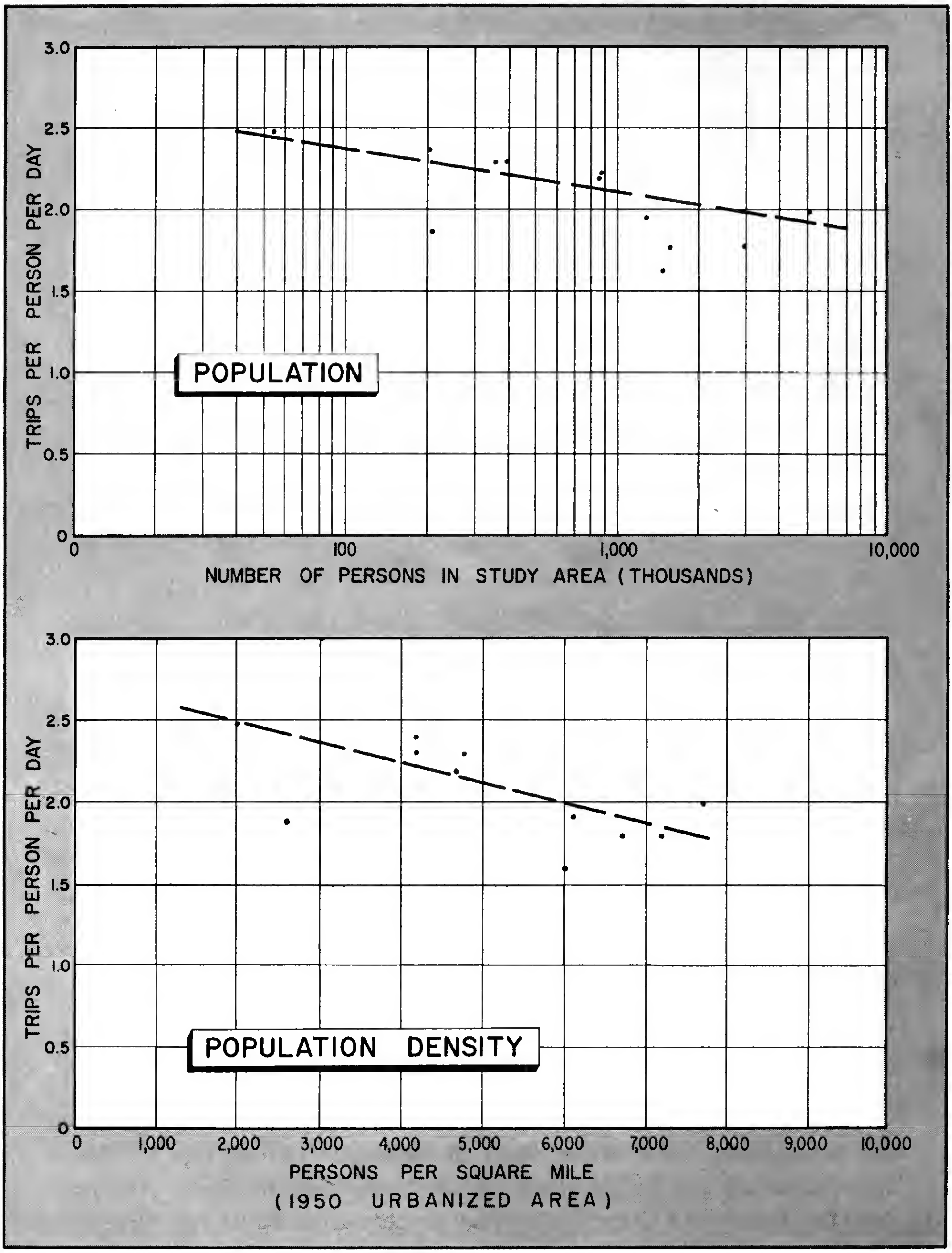

Figure 26
TRIP GENERATION RELATED TO CITY SIZE AND DENSITY

drivers to make more trips. In cities of every size, the resident travels about 10 miles per day in all pursuits.

Smaller cities generally have lower average land-use densities and relatively few destinations within walking distance. In old, densely populated central cities of the large metropolises, many trips are made on foot and are not reported in the origin-destination data. Trips to the corner drug store, neighborhood grocery, school or church do not require either bus or car; some trips to work are also made by foot.

Trip Generation by Mode — Travel modes, average car occupancies, and proportions of truck traffic are summarized in Table 12.

TABLE 12

TRIPS BY URBAN RESIDENTS ACCORDING TO MODE IN STUDY AREAS[1]

(Thousands)

		PERSON TRIPS				*PER CENT OF TOTAL PERSON TRIPS*				*TOTAL VEHICLE TRIPS (Auto Drivers and Trucks)*	
URBAN AREA	*YEAR*	*Driver*	*Passenger*	*Transit*	*Total*	*In Autos*	*In Transit*	*Average Car Occupancy*	*Truck Trips*		*PER CENT TRUCKS*
Chicago	1956	4,811	2,706	2,414	9,931	75.7	24.3	1.56	828	5,639	14.7
Detroit	1953	2,991	1,394	879	5,264	83.3	16.7	1.46	495	3,486	14.2
Washington	1955	1,278	709	639	2,626	75.7	24.3	1.56	219	1,497	14.6
Pittsburgh	1958	1,292	603	482	2,377	79.7	20.3	1.47	229	1,521	15.1
St. Louis	1957	1,359	731	387	2,477	84.4	15.6	1.54	280	1,639	17.1
Houston	1953	1,085	616	252	1,953	87.1	12.9	1.57	202	1,287	15.7
Kansas City	1957	1,108	577	185	1,870	90.1	9.9	1.52	181	1,289	14.0
Phoenix	1957	586	266	58	910	93.6	6.4	1.45	168	754	22.2
Nashville	1959	493	263	63	819	92.3	7.7	1.53	91	584	15.6
Ft. Lauderdale	1959	238	114	5	357	98.6	1.4	1.48	31	259	12.0
Charlotte	1958	303	140	35	478	92.7	7.3	1.46	52	355	14.6
Reno	1955	81	53	2	136	98.5	1.5	1.65	22	103	21.4

[1]Source: Origin-destination studies in each area.

Urban travel is predominantly by automobile. *In almost every American city, more than three fourths of all trips are made by car.* The proportion of travel by car in the study cities ranged from about 75 per cent in Chicago and Washington to more than 98 per cent in Reno and Fort Lauderdale. The car accommodated more than 90 per cent of all trips in cities under one million population surveyed after 1955.[3]

The average car occupancy in the study cities was relatively constant at approximately 1.5 persons per car. Car occupancy ranged from 1.4 persons per car in Phoenix to almost 1.7 in Reno.

Commercial vehicles were a substantial proportion of the travel in all cities, accounting for between 12 and 22 per cent of all vehicle trips. In most cities, trucks accounted for about 15 per cent of the total vehicular travel.

CAR OWNERSHIP AND USE

Car ownership and use are related to socio-economic status within the community. The lowest ratio of cars to population is in the low-income, high-density areas, whereas high-income, low-density areas have a high ratio of cars to population. Where people own fewer cars, they make fewer car trips.

Usually there are more car owners in single-family residential areas than in high-density apartment areas. Density and income being equal, fewer cars are owned and used by persons living near the central city than those in outlying areas. Quality of public transportation is a factor since areas with efficient and frequent public transit often have lower car ownership and use than areas with poor transit service. High-density areas are often in proximity to employment and commercial outlets, thereby minimizing the need for private transportation.

Car Ownership — Throughout the country, car ownership is greater in low-density urban areas than in high-density urban areas. For example, there were 2.4 people per passenger car in Los Angeles County in 1959 compared with 6.1 people per car in the five boroughs comprising New York City.

Within all strata of the urban community, car ownership has increased rapidly in recent years. For example, cars owned in Houston, (Harris County) Texas, increased from about 283 automobiles per thousand population in 1949, to approximately 350 in 1959; in Detroit (Wayne County), Michigan, ownership increased from 295 per thousand persons in 1949 to about 350 in 1959; in the

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[3]The relatively low proportion of auto travel in Houston in 1953 (86 per cent) is directly related to lower car ownership throughout the nation in the early 1950's; it has since been reported to have increased to about 94 per cent.

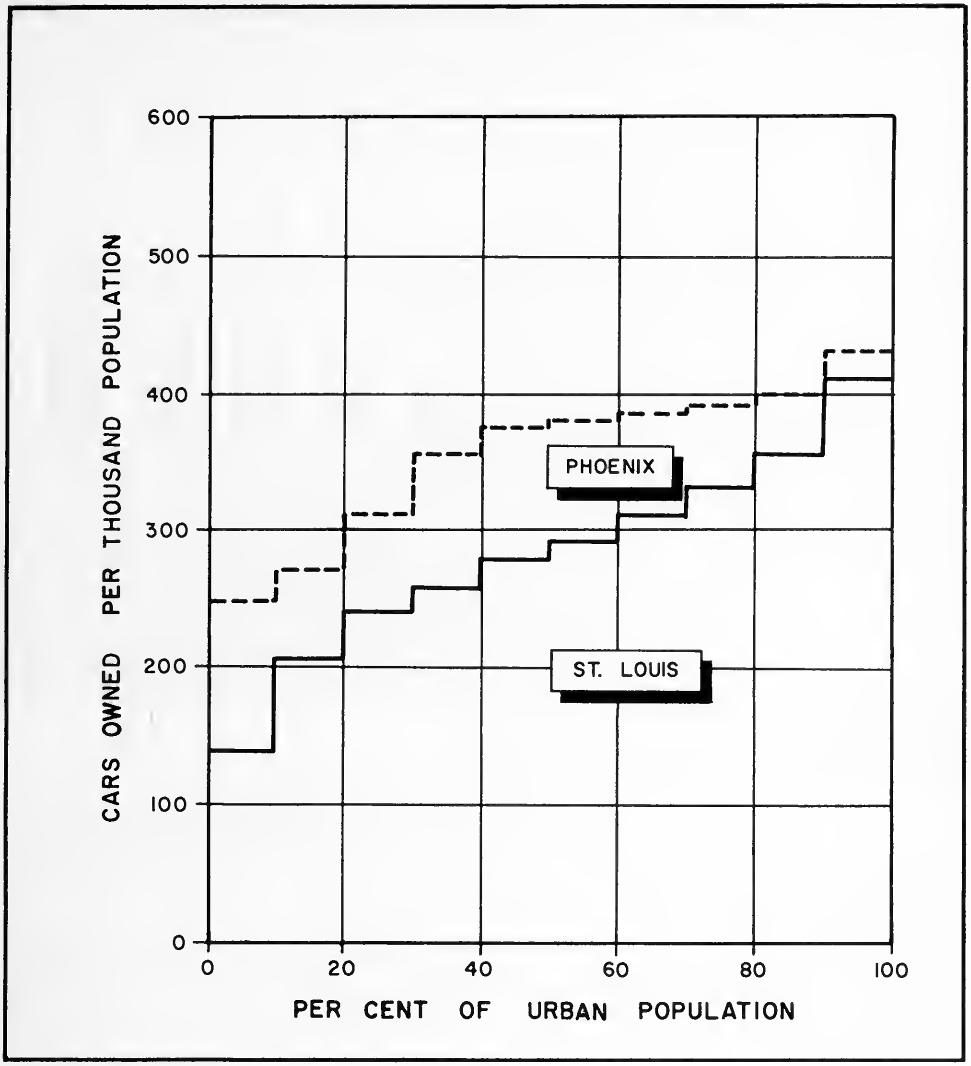

Figure 27
Automobile Ownership Related to Urban Population in St. Louis, Missouri, and Phoenix, Arizona

Chicago area (Cook County) of Illinois, the change was from 206 cars per thousand persons in 1949 to 285 in 1959.

To show how car ownership varies within a community, urban populations in Phoenix and St. Louis have been grouped by increments of 10 per cent (deciles) according to average level of car ownership in the various zones and the results plotted in Figure 27. In St. Louis, with relatively low car ownership, the rate of ownership rises steadily through successive deciles of population. However, in Phoenix, with a relatively high, over-all level of ownership, there is little difference in the number of cars owned by each tenth of the

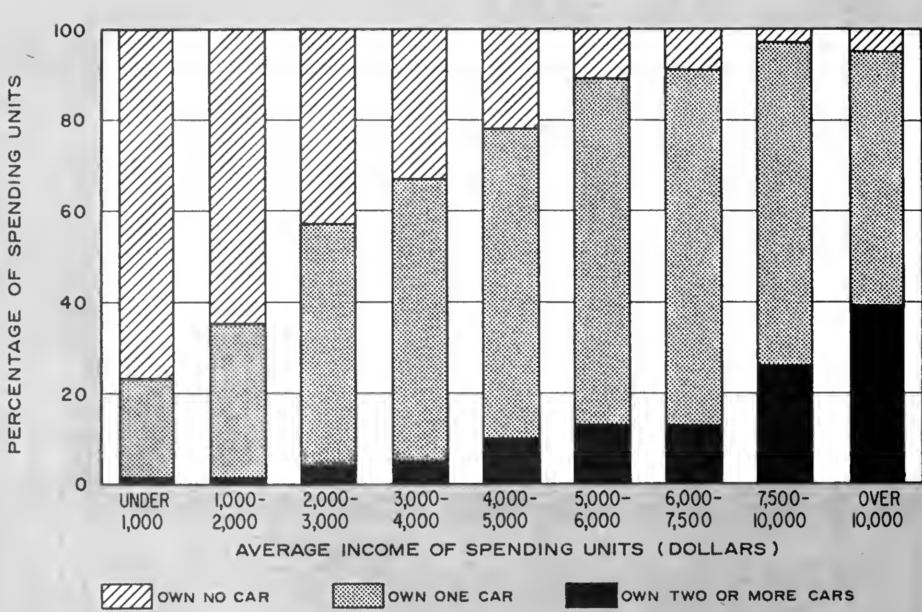

Figure 28
CAR OWNERSHIP RELATED TO FAMILY INCOME
UNITED STATES
1958

population above the 40-per-cent level. This may be interpreted to mean that car ownership in Phoenix is approaching a practical "saturation level" beyond this point. If this is the case, it would appear that an ownership ratio of about one car for every 2.5 persons represents a normal saturation level.

Income — About three fourths of all households in the United States own one or more passenger cars. As shown in Figure 28, low-income families own relatively few cars because they are expensive to buy and maintain; however, when family income exceeds $5,000 per year, 90 per cent or more of all families are found to own one or more cars. At income levels higher than $7,500, multi-car ownership increases rapidly.

The influence of family income on car ownership is clear from Figure 29, which shows how ownership relates to family incomes under $5,000 in Philadelphia (1947), Washington (1948 and 1955), Dallas (1950) and St. Louis (1957).[4] Car ownership varies according to the year of study, type of city, and incomes of residents. In all cities, car ownership increases as family incomes

[4]Sources: Origin-destination studies in study cities, also *Dallas Metropolitan Area Survey*, Texas State Highway Department in conjunction with U. S. Bureau of Public Roads, 1950, *Philadelphia-Camden Area Traffic Survey* — Pennsylvania Department of High ways and New Jersey State Highway Department in conjunction with U. S. Bureau of Public Roads, and Philadelphia City Planning Commission, 1950. The purchasing power of a given level of income varies markedly from year to year and from city to city. Thus, while the curves shown in Figure 29 are not entirely comparable, the trends, nevertheless, are significant.

increase: for average incomes of $5,000, there are about three to four persons per car owned, whereas for average incomes of $2,500, there are about five to 14 persons per car owned.

Rising living standards and higher family incomes will, therefore, contribute to higher car ownership in urban areas. Most of the continuing increases in ownership will, however, take place in lower-income families. In Washington, D. C., where the average car ownership increased from 5.5 persons per car in 1948 to 3.75 persons per car in 1955, the largest gains were made by the lowest income families.

Conversely, car ownership in the higher income populations was almost static. As median income levels approached $5,000 (based on 1950 census data), families were found to have nearly the same number of cars in all four cities, regardless of date. Evidently, car ownership is approaching saturation in these areas.

The curves for Dallas, Texas, and Washington, D. C. (1955), show what happens as area-wide ownership approaches the saturation level. In these cities, ownership is almost uniform except for the lowest income families who own appreciably fewer cars; additional car ownership will, therefore, be largely proportional to area-wide population increases. This is also true in some of

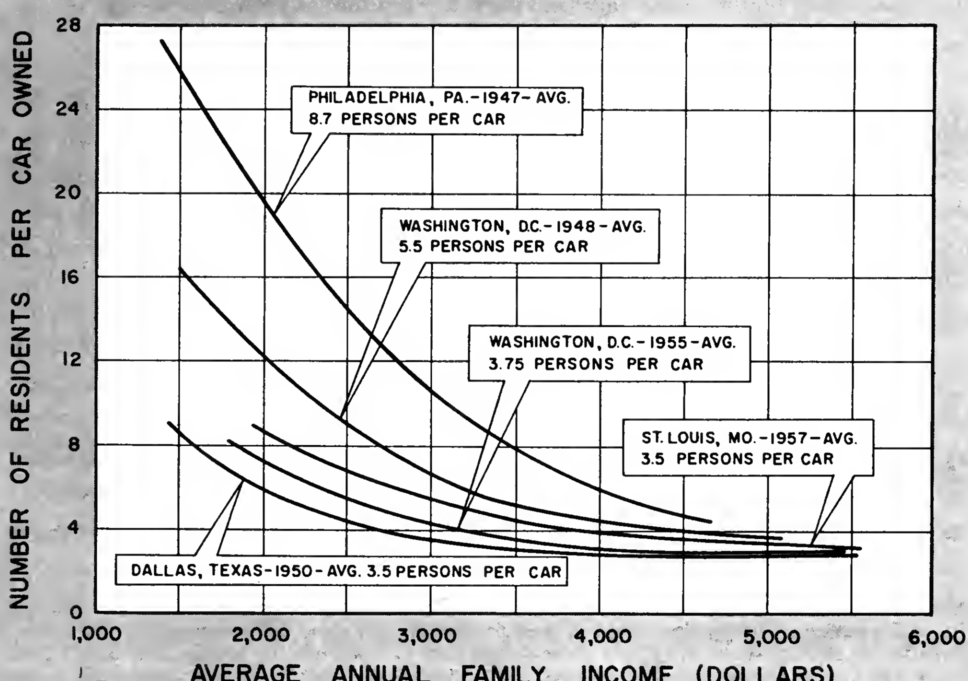

Figure 29
CAR OWNERSHIP RELATED TO FAMILY INCOME

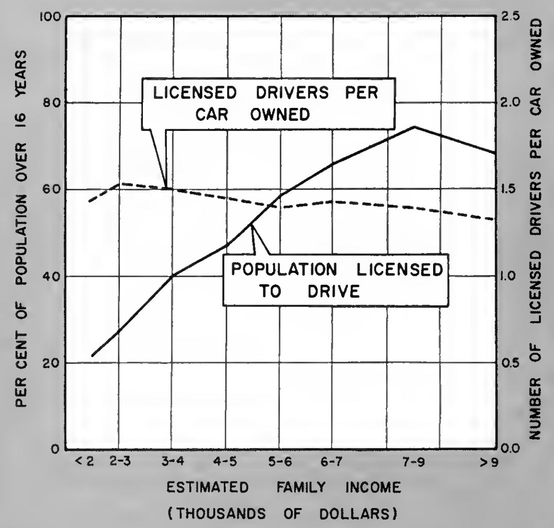

Figure 30
LICENSED DRIVERS RELATED TO MEDIAN FAMILY INCOME
ST. LOUIS, MISSOURI
1957

the study areas where, because of the year of survey and the nature of the area, the ratios of people to cars are appreciably lower than shown for Dallas and Washington.

Effects of income on licensed drivers in the St. Louis area are depicted in Figure 30. As incomes rise, the proportion of population over 16 years licensed to drive increases from about 30 per cent in low-income families to about 75 per cent in high-income families. Similarly, licensed drivers, per car owned, decreased steadily with increases in income from an average of 1.5 drivers per car in low-income groups to about 1.3 drivers per car for higher income levels.

Thus, where cars are few, the ratio of drivers to cars is high; where cars are many, the ratio of drivers to cars tends to approach one. It would appear, therefore, that high-income families may be gradually approaching an upper limit of car ownership (one licensed driver per car owned).

Family Size — Family size, and the number of job-holding members in the family are also significant criteria in determining car ownership. In Chattanooga, for example, families without cars were smaller in size than families with one, two or more cars.[5] As shown in Figure 31, the number of job-holding members averaged much less in families with no car than in families with one car. The number of cars owned, therefore, reflects the number of employed persons and increases as the number of job holders increase.

The implication is clear that car ownership increases as the average number of family members of driving age increases. This is further confirmed by the average number of licensed drivers per household in Chattanooga. One-car dwellings averaged 1.6 licensed drivers; two-car families, 2.2 drivers; three-car families, slightly more than three licensed drivers per household; and only

[5]Chattanooga Metropolitan Area Transportation Survey now in progress, by Tennessee Department of Highways and Public Works and City of Nashville in conjunction with U. S. Bureau of Public Roads, and Wilbur Smith and Associates. Data from this study have been analyzed in part herein.

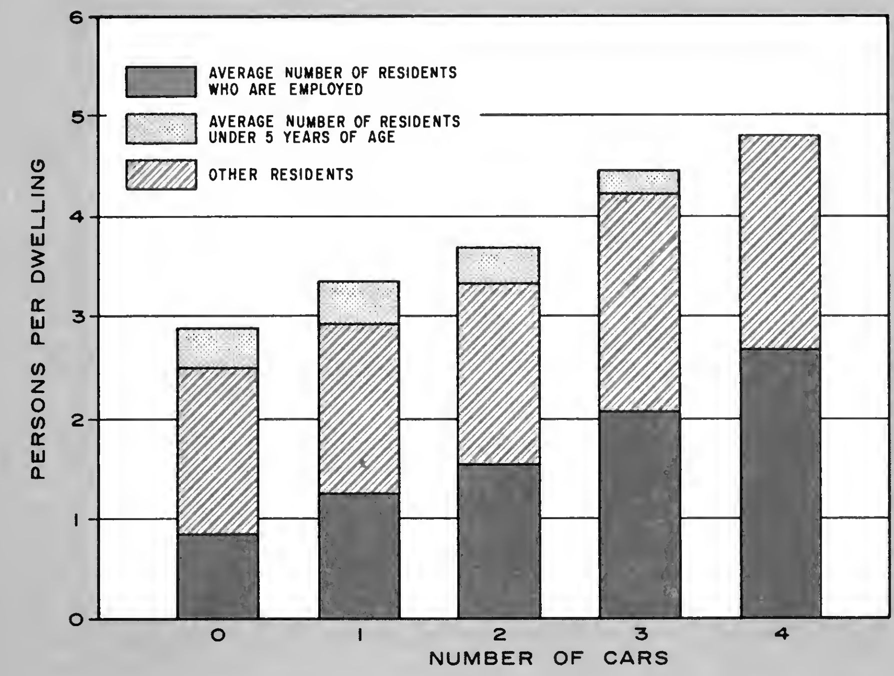

Figure 31
CAR OWNERSHIP RELATED TO FAMILY SIZE AND EMPLOYMENT
CHATTANOOGA, TENNESSEE — 1960

3.5 licensed drivers in the average four-car dwelling — an excess of cars over drivers.

Car Use — The amount of daily travel in an urban area is directly related to the availability of an automobile. Car use is greatest in areas of high income, and, therefore, high ownership. Low car ownership — many persons per car — generates low rates of trip production, whereas high-car ownership is consistent with high rates of trip production. Thus, the number of daily trips per person increases as car ownership increases; persons having the use of a car make more trips than those who must use public transportation.

The average number of trips per car is also greater in small cities than in large cities because of lower densities and less attractive transit service.

Total Trip Generation — The effects of car ownership on trip generation are clearly illustrated in Figure 32, which shows how total daily travel in the St. Louis area declines as car ownership decreases. Populations with only one car for eight or more persons averaged less than one trip per person per day in automobiles or public transit, whereas populations with one car for every three or fewer persons produced from two to three trips per person per day.

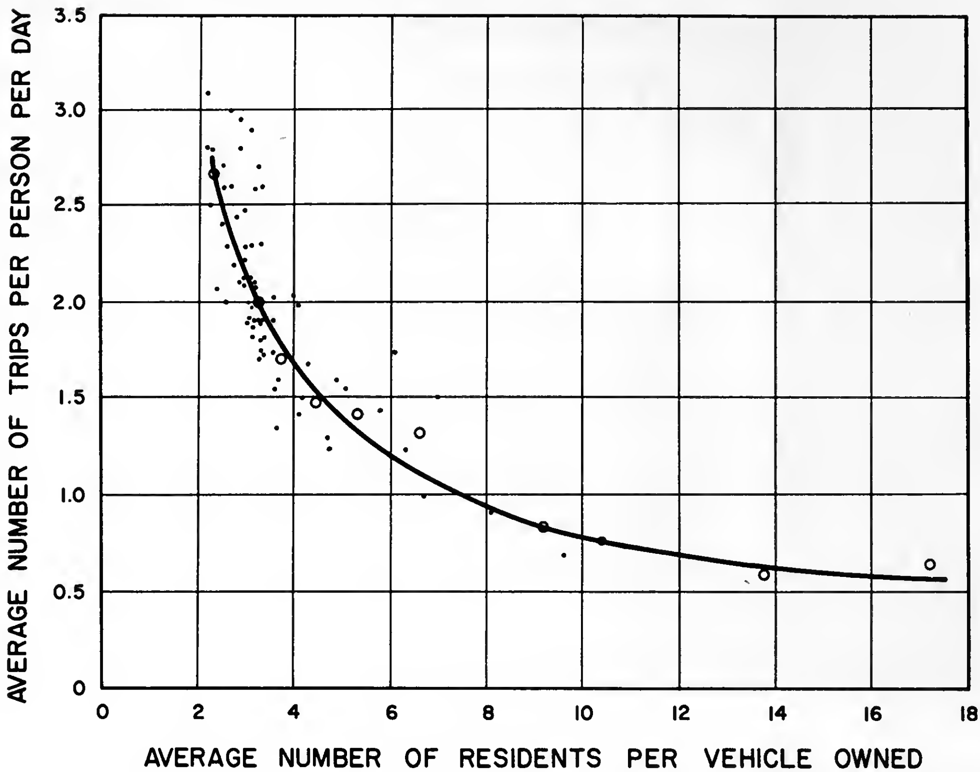

Figure 32
VEHICLE OWNERSHIP RELATED TO TRIP FREQUENCY
ST. LOUIS, MISSOURI – 1957

Expressed in terms of trips per household, the range of trip production varies from 2.5 trips per dwelling per day in the low-income, low-ownership brackets, to 10 trips per household per day in high-income, high car-ownership populations. The pattern is similar in other cities.

As shown in Table 13, daily trips per person by all modes of travel in Washington, Kansas City, Phoenix and Nashville decrease as car ownership becomes smaller.

Households that have no cars average less than one trip per resident per day (as in Nashville in 1959 and Chicago in 1956), whereas households with more than two cars average three or more trips per person per day.

The effects of car ownership on the number of people making trips are apparent from a review of Figure 33. More people make trips when car ownership is high. Where there are 1.5 persons per car, about 80 per cent of all people over five years of age make trips. This proportion decreases to about 60 per cent where car ownership exceeds four persons per car.

The number of trips by that proportion of the populace actually making

Table 13

TRIP GENERATION RELATED TO CAR OWNERSHIP[1]

Average Daily Trips Per Person

URBAN AREA	AVERAGE NUMBER OF PERSONS PER CAR 1.5-2.0	2.0-2.5	2.5-3.0	3.0-3.5	3.5-4.0	4.0-5.0	5.0-6.0	Over 6.0	AVERAGE TRIPS PER PERSON
Washington (1955)	–[2]	2.7	2.2	2.0	1.7	1.5	1.3	1.2	1.7
St. Louis (1957)	3.2	2.6	2.4	2.2	1.8	1.7	1.3	0.9	1.9
Kansas City (1957)	–[2]	2.9	2.6	2.3	1.9	1.4	1.4	0.9	2.2
Phoenix (1957)	3.4	2.8	2.5	2.0	1.6	1.5	1.2	1.1	2.3
Nashville (1959)	3.5	3.2	2.8	2.5	2.3	1.8	1.4	1.1	2.3
Charlotte (1958)	3.6	3.1	3.0	2.1	2.1	1.9	1.6	1.1	2.4

[1]Source: Origin-destination studies in each area.

[2]Data not indicated for this category.

trips also decreases from more than four trips per person for high levels of car ownership to three per person for low levels of car ownership.

Driver Trips Per Car – The average number of auto driver trips generated by residents in zones within Charlotte, Nashville, Washington, Detroit, and Pittsburgh are shown in Figure 34. In each city, the average use of cars owned is generally commensurate with ownership – use is low wherever car ownership is low. Greatest use of each car (average number of driver trips per car each day) occurs in zones where car ownership averages between 1.2 and 1.5 cars per household.

The curves for all five cities follow consistent patterns with vertical spacing on the curves reflecting the varying use of public transportation. Daily car use at every level of ownership averaged more than in cities where transit received less patronage. Charlotte and Nashville, where transit accommodates about eight per cent of the daily travel, have high car use and strikingly similar patterns. Detroit, Pittsburgh, and Washington, all more transit-oriented with about 20 per cent of all trips by this mode, have similar patterns and lower car use.

Several factors contribute to the patterns of car use depicted in Figure 34. The zones of low car ownership usually represent low-income populations in high-density areas near the center of the city where many destinations are within walking distance and where transit is most convenient. Accordingly, a

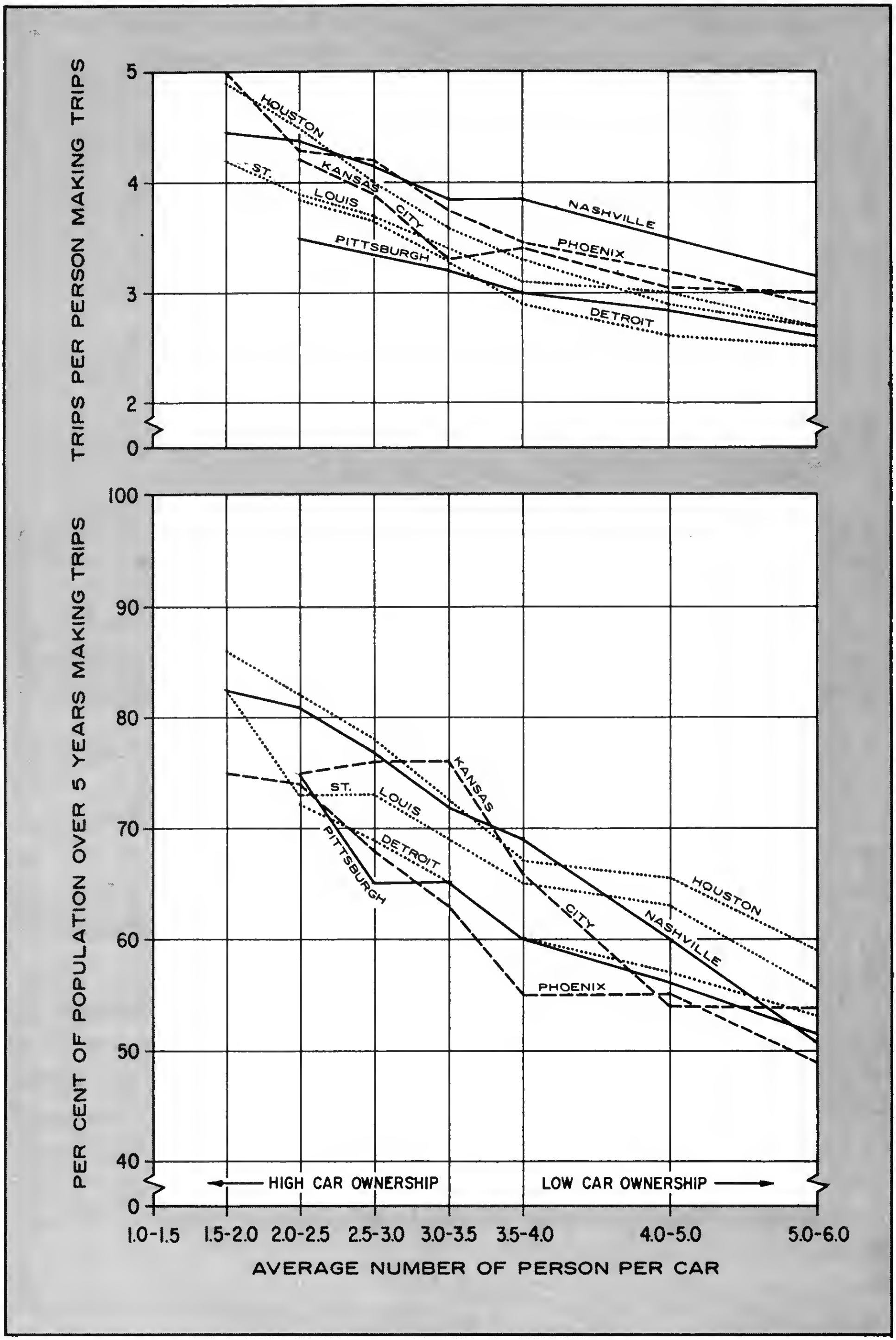

Figure 33
TRIP GENERATION RELATED TO CAR OWNERSHIP

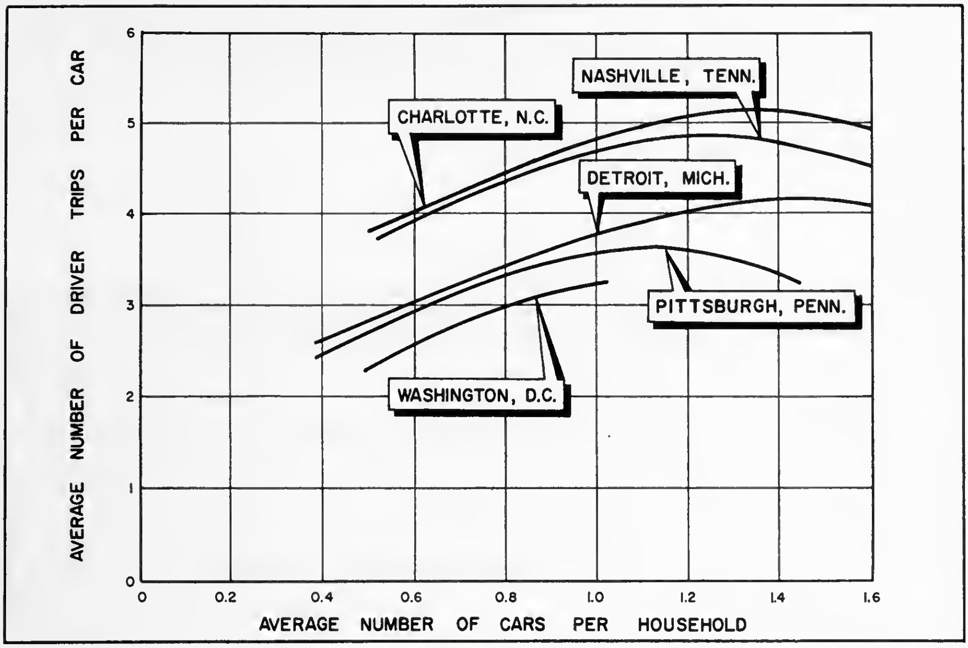

Figure 34
AUTOMOBILE TRIPS RELATED TO CAR OWNERSHIP

higher proportion of daily travel is more easily diverted to other modes of travel. Where car ownership is low, most of the cars are used for travel to and from work, and consequently are unavailable for other trips during most of each day.

Multi-Car Families — The number of driver trips per car in most multi-car families tends to average a little less as successive cars are acquired. As shown in Table 14, three-car families in Chicago averaged 2.86 driver trips per car, compared with 2.99 trips for one-car families; in Nashville, three-car families averaged 3.68 trips whereas one-car families averaged 4.70 trips.

The use of successive cars in multi-car families in Nashville, Chattanooga, and Chicago is depicted in Figure 35. In all three cities, the use of the second and third cars (i. e. average number of trips per car) is generally less than the use made of vehicles owned by one-car families. In Nashville and Chattanooga, with metropolitan area populations slightly under 400,000 residents, the increase in daily auto trips per family attributable to the second and third cars is considerably less than the average auto travel in one-car families. In Chicago, use of the car in one-car families is much less than in smaller cities because of the availability of extensive public transportation facilities and higher land-use densities, and travel by the first and second cars are comparable; use of the second and third cars is less work-oriented than the first car and, therefore, is somewhat less affected by densities and transit.

Table 14

DRIVER TRIPS IN MULTI-CAR FAMILIES[1]

CARS PER FAMILY	*AVERAGE DRIVER TRIPS*	*CITY* Chicago	Nashville
One	Driver Trips	2.99	4.70
	Average Per Car	2.99	4.70
	Average First Car	2.99	4.70
Two	Total Driver Trips	5.92	8.24
	Average Per Car	2.96	4.12
	Average Per Second Car[2]	2.93	3.54
Three	Total Driver Trips	8.57	11.00
	Average Per Car	2.86	3.68
	Average Per Third Car[3]	2.65	2.76

[1]Source: Origin-destination studies in each area.
[2]Assumes first car averages same number of trips as one-car families.
[3]Assumes first and second cars average same number of trips as in two-car families.

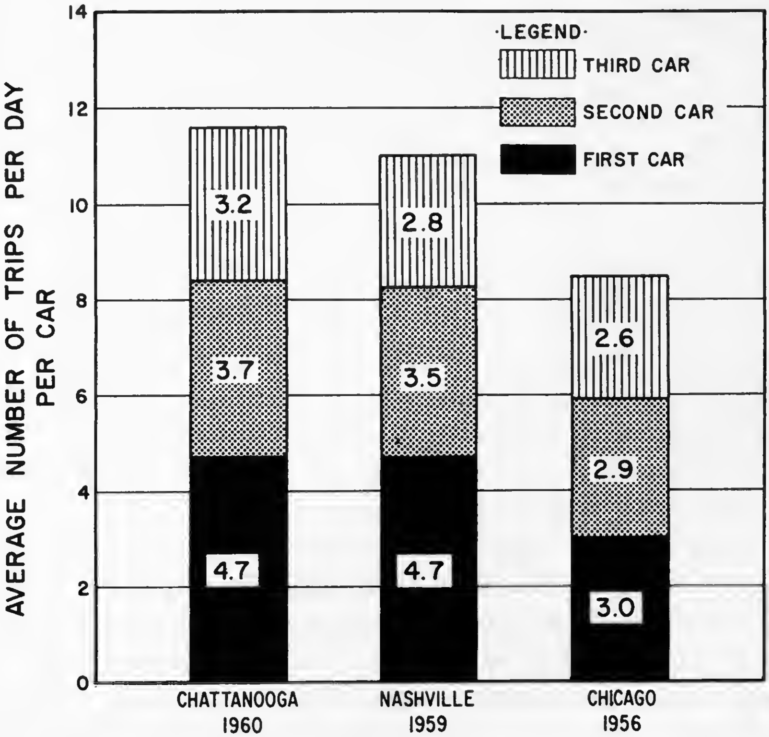

Figure 35
Use of Cars in Multi-Car Families

Land-use densities and public transportation affect car use within each city. Their effects are apparent in Figure 36 which relates use of first, second and third cars to distance from the Chicago central business district. Families living about 15 miles from the Loop make nearly twice as much use of the first car as those who live in or adjacent to it. Use of the second and third cars follows a similar, but less pronounced pattern.

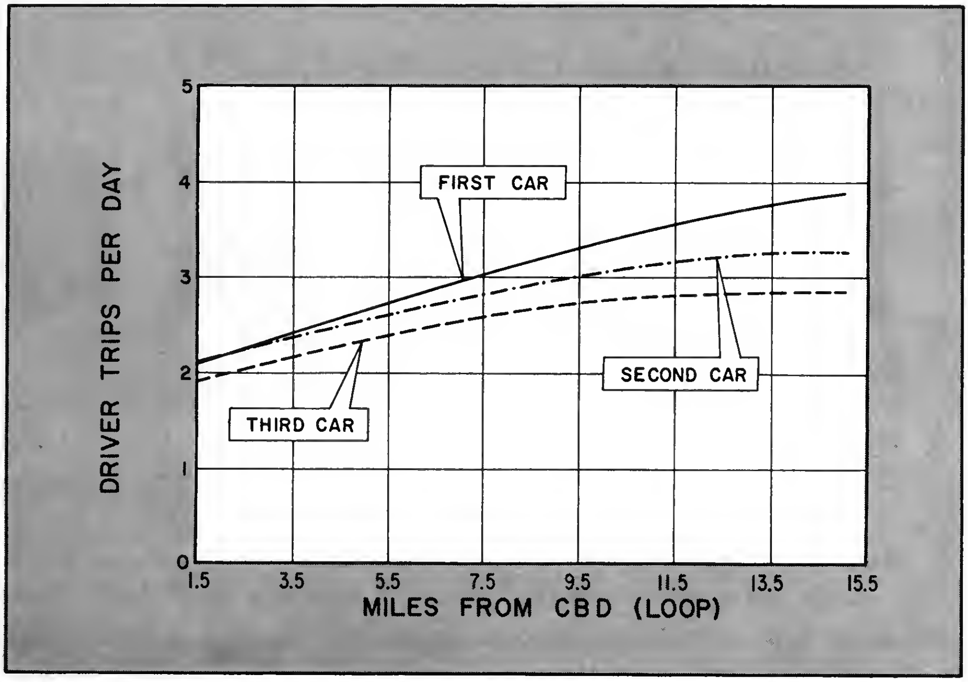

Figure 36
USE OF CARS IN MULTI-CAR FAMILIES RELATED TO PLACE GARAGED
CHICAGO, ILLINOIS — 1956

Income — Effects of family income on both the number and character of trips performed in the Phoenix area is clearly illustrated by Figure 37. Similar relationships have also been found in many of the study cities.

Trip production increases with income: low-income groups in Phoenix produce about 1.6 trips per person daily whereas high-income groups produce about 3.6 trips per day. Work trips are a reasonably stable component of daily travel, but trips for other purposes increase rapidly with rising income levels. The highest economic class produces nearly twice as many non-work trips per person per day as the lowest economic group — the greatest increases are in shopping and business travel.

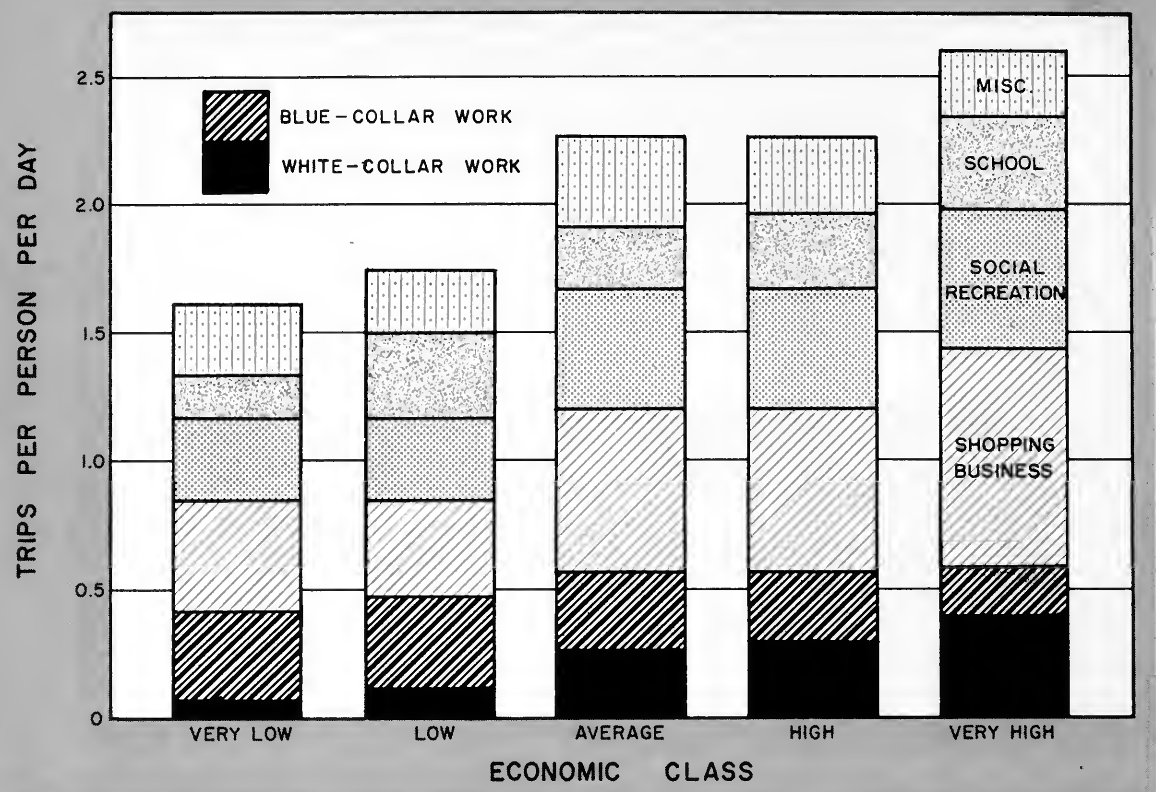

Figure 37
DAILY TRIPS RELATED TO ECONOMIC CLASS AND PURPOSE
PHOENIX, ARIZONA — 1957

Work trips are produced at substantially the same average rate per person in the middle and upper income families, and at somewhat lower rates in low-income brackets. Low-income populations tend to congregate at high density in areas of mixed land use with some job opportunities within walking distance of dwelling places; thus, actual work travel in these zones may probably be greater than indicated.

TRIP PURPOSES

Trip purposes reflect the daily activities of residents within an urban area. The one or more persons who work to support each household make daily trips to their jobs. Shopping for food and other essentials generates travel, and trips to school, church and various social and recreational activities are often made by members of the household as a unit.

Trip purposes in the study cities are shown in Table 15, and graphically summarized in Figure 38. In all cities, trips may be grouped in a few basic categories: about 40 per cent of all trips were reported "to home"; 20 per cent "to work"; 12 per cent "social and recreational"; 18 per cent "business" and "shopping"; 3 per cent, "school", and the remainder (about 7 per cent),

Table 15

TRIPS BY URBAN RESIDENTS ACCORDING TO PURPOSE IN STUDY AREAS[1]

URBAN AREA	YEAR	PER CENT OF TRIPS TO: Home	Work	Business	Shopping	Social-Recreational	School	Other	All Purposes
Chicago	1956	43.5	20.5	12.4	5.5	12.8	1.9	3.4	100.0
Detroit	1953	39.5	23.5	6.9	8.2	12.1	3.0	6.8	100.0
Washington	1955	41.7	23.4	6.6	8.2	7.1	4.4	8.6	100.0
Pittsburgh	1958	43.4	21.0	13.5	8.4	7.9	5.8	0.0	100.0
St. Louis	1957	40.5	20.8	6.0	10.5	12.3	3.0	6.9	100.0
Houston	1953	40.3	18.9	7.1	10.1	10.8	4.9	7.9	100.0
Kansas City	1957	38.4	20.6	6.7	9.9	12.9	2.8	8.7	100.0
Phoenix	1957	37.2	18.2	7.9	11.5	11.2	5.0	9.0	100.0
Nashville	1959	37.6	19.1	6.5	10.5	13.6	3.3	9.4	100.0
Fort Lauderdale	1959	38.6	17.2	11.7	13.8	12.9	0.4	5.4	100.0
Charlotte	1958	36.6	21.9	7.5	9.0	12.8	2.8	9.4	100.0
Reno	1955	38.6	16.9	11.2	10.4	14.3	0.3	8.3	100.0
Average Per Cent		39.6	20.2	8.7	9.7	11.7	3.1	7.0	100.0

[1]Origin-destination studies in each area.

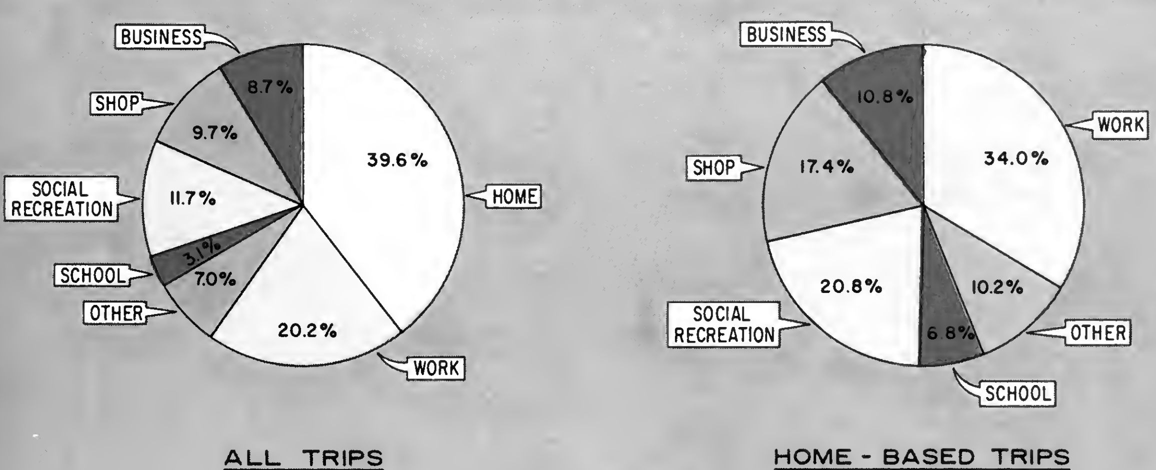

Figure 38
Trip Purposes in Study Cities
(Average Per Cent)

miscellaneous.[6] The non-work trips are spread rather uniformly throughout daylight and evening hours; whereas trips to and from work are concentrated within a few peak hours. In most cities, each of the four peak hours — 7 to 9 in the morning and 4 to 6 in the afternoon — account for seven to 10 per cent of the total daily travel.

Trips "to home" ranged from about 37 per cent in Charlotte and Phoenix to about 43 per cent in Pittsburgh and Chicago. The highest proportions were in large transit-oriented cities, since nearly all transit trips begin or end at home. "Travel to work" was the dominant non-home purpose in all cities, ranging from 17 per cent in Reno and Fort Lauderdale to about 23 per cent in Washington and Detroit. The relatively low proportions of work trips in Reno and Fort Lauderdale reflect the special character of these areas; Reno is a tourist center, and many retired people live in Fort Lauderdale.

Home Based Trips — More than 80 per cent of the trips made by urban dwellers begin or end at places of residence.[7] As shown in Table 16, home-based travel in the study cities ranged from 86 to 92 per cent of all "linked" trips.[8] Nearly all transit trips, about 94 to 99 per cent, were found to begin or end at home; between 87 and 95 per cent of all auto passenger trips were home-based.

"Home-based" trips are distributed according to purpose category in Table 16 and Figure 38. About 34 per cent of all trips are for work; 21 per cent are social-recreational; 17 per cent, shopping; 11 per cent, business and seven per cent, school. The remaining 10 per cent comprise miscellaneous trip purposes.

Work Trips — Work travel was the most important category in all communities, accounting for more than one fourth of all home-based trips in resort areas such as Phoenix, Reno and Fort Lauderdale, and up to 40 per cent or more in cities of over a million inhabitants, as Detroit and Washington.

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[6]In the 1945-1949 period, trip purposes in urban areas were: "home" about 43 per cent, "work" 23 per cent, "business" and "shopping" 14 per cent, "social-recreatoinal" 12 per cent, "school" 2 per cent, and the remainder "miscellaneous".

[7]See tables A-15 through A-20, Appendix C, for additional breakdowns of home-based trips by purpose category. About three fourths of all trips are "home-based". However, when trips are "linked" to eliminate minor travel interruptions, as changes in the mode of travel in the course of a trip, the proportion of home-based trips is even greater; these comparisons are detailed in Table A-15, Appendix C.

[8]The definition of "home-based travel" is somewhat agglomerated in smaller cities because many persons go home for lunch at noon. In the origin-destination surveys, these trips were reported as destined to or from an "eat-meal" category which did not identify "home" as the actual place of terminus. However, the auto-driver category is the only classification where "eat-meal" trips (part of the personal business category) seriously affects the proportion of home-based travel, (see Appendix C). In Phoenix, Charlotte, and Reno, for example, "eat-meal" trips that were not otherwise identified with a home terminus, accounted for 20 to 29 per cent of all non-home-based driver trips, whereas in larger cities, the proportion was much smaller.

Table 16

HOME-BASED TRIPS BY URBAN RESIDENTS IN STUDY AREAS ACCORDING TO PURPOSE[1]

URBAN AREA	HOME-BASED TRIPS AS PER CENT OF ALL LINKED TRIPS	PER CENT OF HOME-BASED TRIPS TO AND FROM: Work	Business	Shopping	Social-Recreational	School	Other	All Purposes	TOTAL HOME-BASED TRIPS PER DWELLING UNIT
Chicago[2]	86.8	37.5	9.7	18.9	22.8	4.0	7.1	100.0	5.17
Detroit	87.0	41.6	8.6	13.9	20.1	6.3	9.5	100.0	4.67
Washington	91.6	43.1	9.6	14.2	12.5	9.4	11.2	100.0	4.23
Pittsburgh[2]	87.0	37.7	21.6	14.9	13.8	12.0	----[3]	100.0	4.21
St. Louis	91.3	37.5	8.1	17.3	21.5	6.4	9.2	100.0	4.90
Houston	91.0	33.1	8.9	17.3	18.6	10.8	11.3	100.0	5.51
Kansas City	88.2	33.4	8.8	17.2	22.7	6.0	11.9	100.0	5.14
Phoenix	85.3	25.2	10.2	19.7	20.0	11.6	13.3	100.0	4.76
Nashville	85.5	30.3	8.5	16.9	23.9	7.4	13.0	100.0	5.48
Ft. Lauderdale	86.5	27.9	15.3	24.0	22.9	0.9	9.0	100.0	2.82
Charlotte	83.9	32.2	8.0	15.6	23.8	6.6	13.8	100.0	5.56
Reno	86.5	29.2	12.7	18.1	26.3	0.5	13.2	100.0	4.88
Avg. Per Cent	87.6	34.0	10.8	17.4	20.8	6.8	10.2	100.0	4.78[4]

[1]Source: Origin-destination studies in each area.
[2]Chicago and Pittsburgh data are for "linked" trips — see Table A-15, Appendix C.
[3]All trips in Pittsburgh have been identified with one of the listed purposes.
[4]Unweighted average.

Social-Recreational Trips — Social and recreational trips were second in importance in all cities except heavily transit-oriented Washington and Pittsburgh; they ranged from 14 per cent of all home-based trips in Pittsburgh to over 26 per cent in Reno.

Shopping and Business Trips — Travel for shopping and personal business ranged from 24 per cent in Charlotte to over 35 per cent in Pittsburgh and Fort Lauderdale.[9]

[9]In Pittsburgh, business and shopping trips amount to more than a third of the home-based travel, mainly because of the unusually low production of social trips. In Fort Lauderdale, although nearly 40 per cent of the home-based trips were made for shopping and business purposes; work and school travel were less than average in this community because of the large percentage of elderly, retired residents.

School Trips — Trips for school purposes were highly variable, depending on the season when interviews were made and the proportion of school-age children in the population. They ranged from less than one per cent in Reno and Fort Lauderdale to more than 10 per cent in Houston, Phoenix and Pittsburgh.[10]

Trips Per Household — There is a relatively stable pattern of trip generation on a per household basis, with approximately 4.8 home-based trips per household per day. Trip production varied within 15 per cent of this average except in Fort Lauderdale where the trips generated for all purposes was low because of small family size, curtailed activity of retired couples, and few school-age children.

Trips produced by the various purpose categories are graphically summarized in Figure 39.

Work trips averaged about 1.6 trips per dwelling unit per day and had an average occupancy of about 1.2 persons per car with about 0.9 driver trips per car; they ranged between 1.5 and 2.0 trips per household per day in most communities.

Business and shopping trips averaged 1.3 trips per dwelling unit and had an average occupancy of 1.4 people per car with approximately 0.7 driver trips per car.

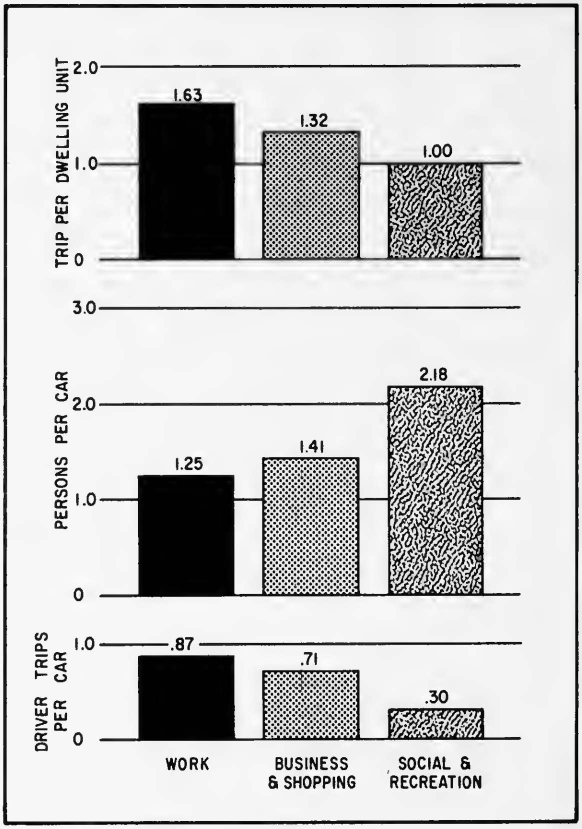

Figure 39
TRIP GENERATION BY PURPOSE, STUDY CITIES
(AVERAGE PER CENT)

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[10]Miscellaneous trips consisted of trips to "change-of-mode" points of trips to "serve passenger" (mostly by auto drivers). In Pittsburgh, these trips were all reclassified to specified purposes by linking the two parts of trips for "change of mode" or by identifying the "serve passenger" trips with the passenger's purpose. This accounts for the high percentage of "school" trips in Pittsburgh, since many of the "serve-passenger" trips represent the transport of school children by their parents.

About one social trip per dwelling unit was made daily with an average occupancy of 2.2 people per car and about 0.3 driver trips per car; social and recreational travel per household varied widely, from about 0.5 trips per day in Washington, to 1.3 trips per day in Charlotte, Nashville, and Reno.

Planning Implications — Non-work trips for shopping, business, social and recreational and other purposes have been shown to increase in frequency as income and car ownership levels rise. Since automobile ownership in urban areas will probably continue to increase at a greater rate than population between now and 1980, non-work trips will represent a larger share of all travel as the ratio of cars to population increases.

Most non-work trips are made during midday and evening hours, rather than at peak hours. Thus, peak-hour travel will become a smaller proportion of 24-hour travel. The implication is that new highways built to accommodate peak-hour travel will receive relatively more over-all use in future years than they do at present.

CHARACTERISTICS OF WORK TRAVEL

Work travel is the most important and most stable component of a community's daily travel. Trips to and from work increase in general proportion to population and labor force, and do not increase significantly as income and car ownership rise.

The direct correspondence between work trips and labor force is apparent from Table 17. The number of home-based trips per resident employee

TABLE 17

HOME-BASED TRIPS PER EMPLOYED RESIDENT IN STUDY AREAS[1]

URBAN AREA	EMPLOYED RESIDENT LABOR FORCE	HOME-BASED WORK TRIPS (LINKED)	TRIPS PER LABOR FORCE	WALK TRIPS TO WORK	WALK TRIPS PER LABOR FORCE	TOTAL TRIPS PER LABOR FORCE
Chicago[2]	2,260,000	3,233,000	1.43			
Detroit[2]	1,200,000	1,738,305	1.45	128,360	0.10	1.55
Washington	710,442	1,030,439	1.45			
St. Louis	590,678	836,504	1.42	51,700	0.09	1.51
Kansas City	379,075	570,375	1.50			
Phoenix	122,764	211,747	1.73			
Fort Lauderdale	47,510	77,140	1.62			
Charlotte	79,131	127,945	1.62			

[1]Source: Origin-destination studies in each area.

[2]Population in employed labor force at same percentage of all population employed at time of 1950 census.

lies within a small range – from 1.4 in Chicago to 1.7 in Phoenix. In most cities, there are about 1.5 trips per employed person. The smaller average number of trips to work in auto and transit by workers in large cities may be compensated for by more trips on foot in high-density areas. For example, pedestrians traveling to work, reported in Detroit and St. Louis, add substantially to the average trips per worker in those cities.

Income and Travel Mode – Family income and car ownership are indicative of the mode of transportation that will be chosen for specific kinds of travel by workers. The number of workers who occupy each car is directly related to the ratio of persons to cars owned which is, in turn, determined by economic status. As shown in Table 18, there is a close correlation between economic levels, cars owned, and the number of workers who ride to work in each car. The cars owned per worker increases from about 0.3 in the extreme low-income categories (under $2,000) to over 1.0 in the high-income groups (over $7,000), whereas the average occupancy decreases from 1.7 to 1.2. More than three times as many passengers are carried in cars owned by low-income workers than in cars owned by medium or high-income workers.

TABLE 18

CHARACTERISTICS OF WORK TRIPS RELATED TO FAMILY INCOME

St. Louis, Missouri – 1957[1]

AVERAGE INCOME	*CARS OWNED PER WORKER*	*AVERAGE OCCUPANCY (People Per Car)*	*PASSENGERS PER CAR*
Less than $2,000	0.34	1.67	0.67
$2,000 – $3,000	0.43	1.40	0.40
$3,000 – $4,000	0.54	1.38	0.38
$4,000 – $5,000	0.65	1.32	0.32
$5,000 – $6,000	0.85	1.30	0.30
$6,000 – $7,000	0.99	1.18	0.18
$7,000 – $9,000	1.23	1.17	0.17
Over $9,000	1.40	1.13	0.13

[1]Source: St. Louis Metropolitan Area Transportation Study, 1957.

The interrelations between travel mode, income, and use of car for work are portrayed in Figure 40. More than half of the low-income workers (residents of high-density apartment districts near the central city) travel regularly to and from work in private cars and about three fourths of the cars owned by the low-income populations are used primarily for work trips. Relatively low car ownership is compensated for by higher car occupancies. Even in the lowest income brackets, more persons rode to work in cars than used public

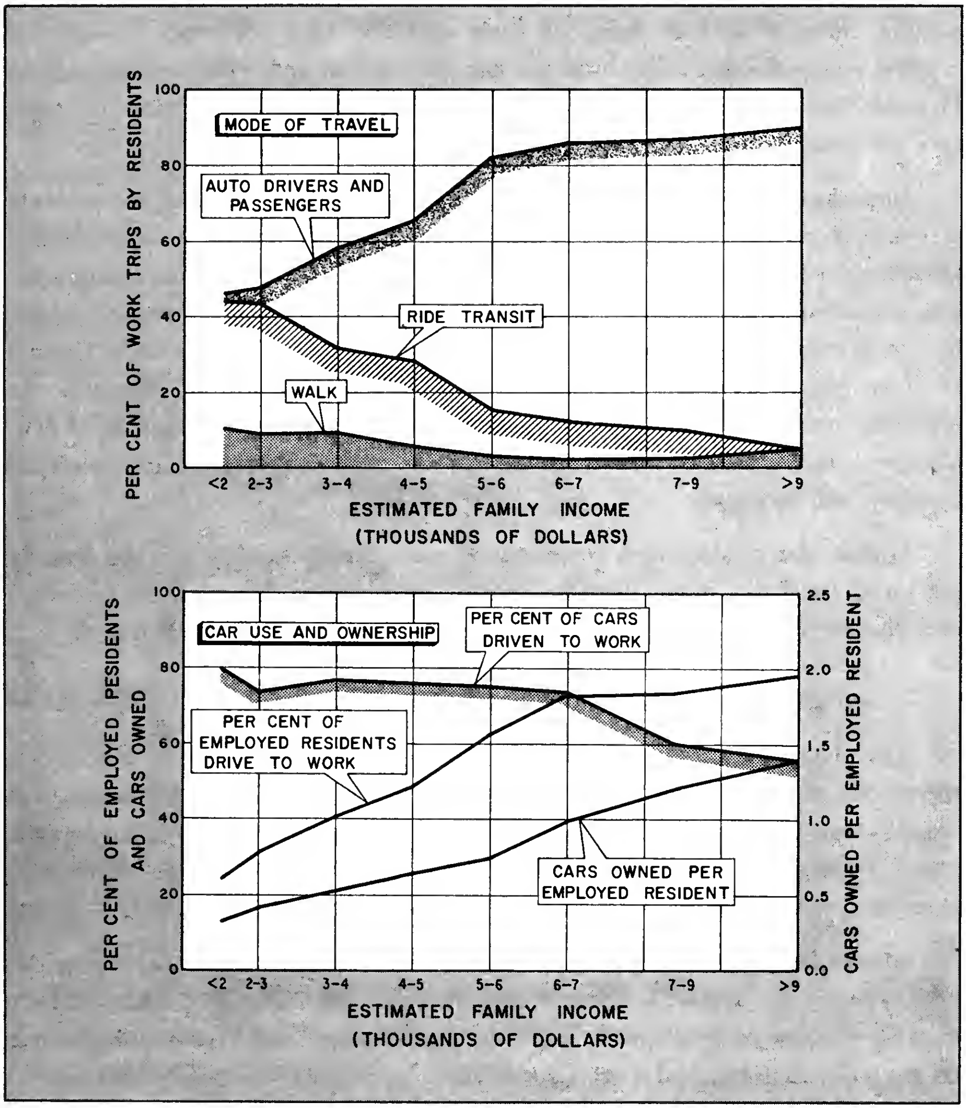

Figure 40

Car Ownership and Income Related to Work Travel

St. Louis, Missouri — 1957

transit — about 90 per cent of the high-income workers rode in cars compared to slightly over 50 per cent of low-income workers. Thus, transit riding to work decreased consistently as income levels increased.

Ten per cent of the lowest-income workers walked to work, whereas a very low proportion of the medium and high-income groups made work trips on foot.

The proportion of cars driven to work decreases as the number of cars owned per resident increases. In families that average less than one car per worker, three fourths or more of their cars are used for work travel. In families where there is more than one car per worker, and where car ownership exceeds the number of residents employed, a smaller proportion of their cars are used for work.

Importance of Car — The car is an essential mode of travel for workers at every economic level, even in the largest cities. It provides an economic advantage which enables the worker to extend his employment commuting area. The car expands the labor market in which workers, especially those from low-income families, can compete for jobs; workers can become increasingly flexible in their places of work and residence. Thus, car ownership becomes an economic necessity rather than a prestige symbol. As decentralization of employment opportunities continue, the automobile's importance in providing mobility will increase.

Unless the quality and coverage of mass transportation can be greatly improved (and this is not likely), there is little chance that workers who own cars can be attracted back to transit except for centrally oriented travel.

CHANGING TRAVEL MODES

The average citizen continues to increase his preference for automobile travel. In the immediate post-war period, about two thirds of all urban trips were by car; today, more than 85 per cent of all trips are by car in all but the very largest cities. In St. Louis, for example, about 85 per cent of all trips were made by car in 1957 in contrast to less than one third in 1945.

Modes Related to Purpose — Travel modes of various purpose categories within the study cities are summarized in Table 19. The proportion of total trips by car ranges from about 75 per cent in Chicago and Washington to over 98 per cent in Reno and Fort Lauderdale.

Work trips are the most "transit-oriented" of all purpose categories, ranging from 67 per cent by car in Chicago to 97 per cent in Fort Lauderdale and Reno. The average number of work trips per day by auto drivers tends to decrease

TABLE 19

COMPARATIVE USE OF AUTOMOBILE FOR VARIOUS TRIP PURPOSES[1]

	PER CENT OF TRIPS BY AUTOMOBILE			
URBAN AREA	*Work Trips*	*Social Trips*	*Business and Shopping Trips*	*All Trips*
Chicago	67.4	86.5	81.5	75.7
Detroit	78.8	93.4	88.7	83.3
Washington	69.7	88.3	82.9	75.7
Pittsburgh	76.8	93.0	89.0	79.7
St. Louis	79.9	92.6	89.5	84.4
Houston	82.5	95.6	93.2	87.1
Kansas City	92.6	96.8	94.6	90.1
Phoenix	96.2	99.0	98.0	93.6
Nashville	89.5	97.3	96.0	92.3
Fort Lauderdale	96.5	99.0	99.3	98.6
Charlotte	89.5	97.5	95.8	92.7
Reno	97.3	98.7	98.4	98.5

[1]Source: Origin-destination studies in each area.

as cities become larger in general accord with the availability of transit (or the unavailability of cars).[11]

Between 82 and 99 per cent of all business and shopping trips are by car. The amount of business and shopping travel in a community appears to increase almost directly with an increase in car ownership. The quality of transit service seems to have little bearing either on the average shopping trip rate per car or mode of travel.

Social-recreational travel is related even more strongly to car ownership than business-shopping travel, ranging from 87 per cent by car in Chicago to 99 per cent in Fort Lauderdale.

[11]Small cities with high car ownership average well over one driver trip to work per car. On the other hand, large cities with relatively low car ownership and a well-established public transit system average as little as 0.75 driver work trips per car.

Travel to typical office buildings in Houston, Texas, clearly illustrates the present-day dominance of automobile travel.[12] About 92 per cent of the workers and visitors traveled to downtown buildings by automobile, whereas 97 per cent traveled to outlying office buildings by automobile.

Similarly, travel to regional shopping centers is predominately by car, even in the largest metropolitan areas. For example, the Cross-County Shopping Center in Yonkers, New York, attracted more than 40,000 persons on a peak pre-Christmas Saturday, of which 93 per cent came by car; the 20,000 cars that entered the center averaged 1.8 persons per car, children excluded. At Garden State Plaza, Paramus, New Jersey, 24,000 cars entered the center on a typical peak pre-Christmas day, bringing over 95 per cent of all shoppers.

Effects of Car Ownership — The effects of car ownership on the use of transit in St. Louis, Kansas City, and Philadelphia are illustrated in Figure 41. The proportion of all trips made by transit in each zone in the St. Louis study area is plotted against the average number of cars owned per dwelling place, and a trend line drawn. Similar trend lines are shown for the other cities.

Transit use in St. Louis decreases as auto ownership increases. Where ownership is very low, transit accounts for up to half of all travel by zone residents; however, its use decreases rapidly as car ownership builds up to 1.5 cars per household, at which point there is negligible transit use.

The curves for Kansas City, Philadephia and St. Louis show similar patterns. However, city size and population density, as reflected in the quality of transit service, also relate to transit use. Transit in Philadelphia accommodates a larger proportion of trips at all car ownership levels than in St. Louis or Kansas City, and is more extensively developed. Similarly, St. Louis transit has a more extensive system than Kansas City. Thus, transit service tends to be more frequent and more extensive in larger cities, thereby diverting more travel from automobiles at every level of car ownership.

Correlated Analysis — The preceding analysis of specific cities has shown that the use of public transportation is related to car ownership, family income, and population density. Accordingly, a correlated analysis of these factors as related to transit usage in the study cities is shown in Table 20 and in Figure 42.

The clusters of points on the scatter diagrams show remarkably consistent relationships between the use of public transportation, urbanized area popula-

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[12]See Table A-21, Appendix C.

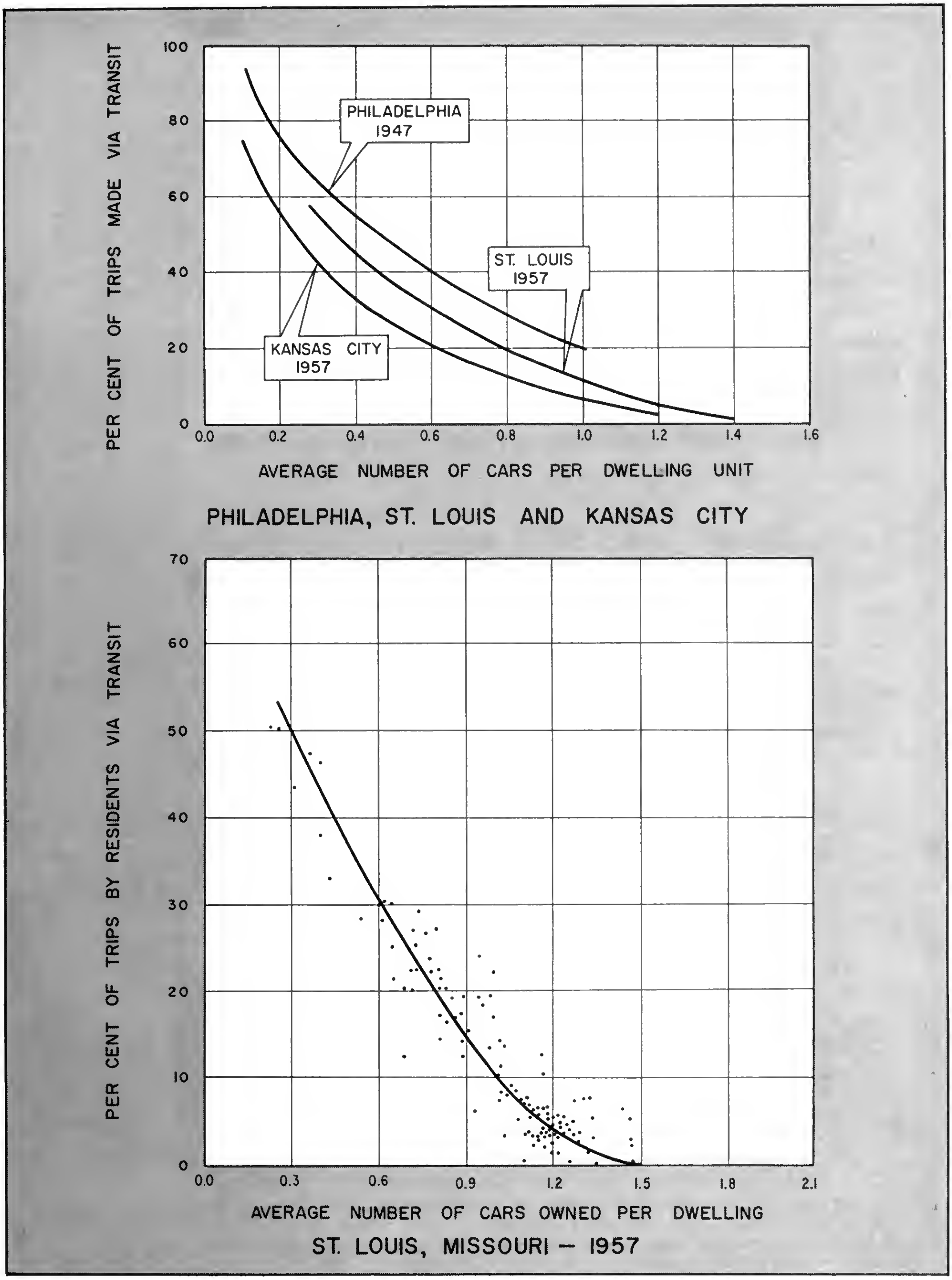

Figure 41
Transit Usage Related to Car Ownership

TABLE 20

TRANSIT USAGE IN STUDY AREAS[1]

	COLUMN								
	1	2	3	4	5	6	7	8	9
CITY	*1950 Urbanized Area Population Density*	*People Per Passenger Car (Study Area)*	*Dwelling Unit Per Car (Study Area)*	*Product [Cols. 1×2]*	*√ Col. 4*	*Product [Cols. 1×3]*	*√ Col. 6*	*Per Cent of Internal Person Trips By Transit*	*Per Cent of CBD Person Trips By Transit*
Chicago	7,713	3.85	1.25	29,695	172	9,641	98	24.3	71.0
Washington	7,216	3.75	1.23	27,060	164	8,875	94	24.3	43.1
Pittsburgh	6,045	3.75	1.15	22,669	151	6,952	83	20.3	51.0
Detroit	6,734	3.51	1.06	23,636	154	7,138	84	16.7	43.2
St. Louis	6,146	3.48	1.11	21,388	146	6,822	83	15.6	46.8
Kansas City	4,687	3.26	1.05	15,280	124	4,921	70	9.9	30.4
Houston	2,594[2]	3.43	1.06	8,897	94	2,750	52	12.9[4]	26.0
Phoenix	3,921	2.87	0.95	11,253	106	3,725	61	6.4	10.7
Nashville	4,821	3.35	1.02	16,150	127	4,917	70	7.7	20.3
Charlotte	4,085	3.28	0.95	13,399	116	3,881	62	7.3	13.9
Reno	2,000[3]	2.43	0.88	4,860	70	1,760	42	1.5	NA[5]

[1]Sources: U. S. Department of Commerce, Bureau of Census; origin-destination studies in each area.

[2]Houston about doubled its city limits prior to the 1950 census, thus the area *actually* urbanized at the time of the study had a much higher density.

[3]Estimated.

[4]Reported as six per cent 1959-60.

[5]NA — Not Available.

tion density and car ownership. The best correlations are obtained when transit usage is directly related to the combined effects of households per car and population density — using both parameters tends to adjust for the changing time periods within a given urban area.[13]

The following indications are apparent:

Transit usage increases rapidly as urbanized density increases.

Transit usage increases rapidly as the number of people per car or households per car increases, and it decreases as car ownership increases.

These relationships may be plotted as a series of "S" shaped (ogive) curves with the steepest points where 50 per cent transit usage is expected.[14]

[13]These findings are corroborated by the relationships of intrazone transit usage found during the *Chicago Area Transportation Study,* 1956. This study showed that knowledge of both car ownership and residential density provide an accurate understanding of transit usage. A coefficient correlation (r) between percentage of trip origins by mass transportation, net residential density and car ownership of .86 was found. (A perfect correlation is 1.0.) It was indicated that the data provide a statistically significant basis for making estimates of mass transportation users.

[14]When the data are plotted on normal probability paper, they cluster about a straight line. This means, therefore, that the data may be approximated by a normal distribution.

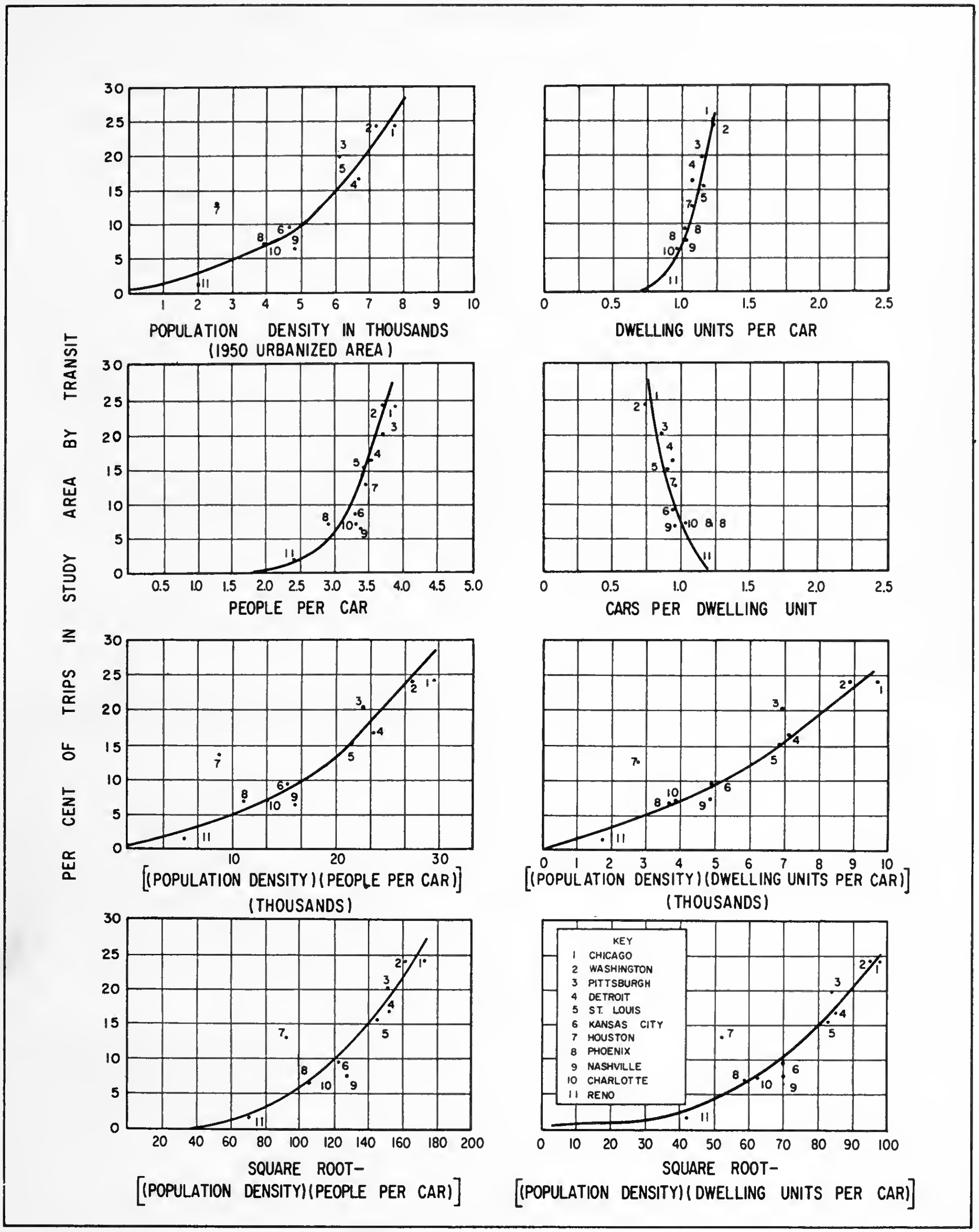

Figure 42
Transit Use Relationships in Study Cities

Similarly consistent relationships between the proportion of transit trips to or from the central business district, car ownership, and population density are shown in Figure 43. The proportion of CBD trips by transit also increases as the population density and/or households per car increase. The increases are, however, at a much steeper rate than for all transit trips within an urban area and show the specialized use of transit in serving the central business district, particularly in the large, high-density urban areas.

The proportion of CBD trips by transit is two to three times as great as the proportion of all trips by transit within an urban area. In Chicago, about 70 per cent of all CBD trips are made by transit, whereas only about 25 per cent of all trips in the area are made by this mode. In Phoenix, (with a low population density and high auto ownership) about 11 per cent of CBD trips are made by transit compared with only seven per cent of all trips within the area.[15]

It is apparent that high land density provides an environment favorable to mass transportation; good service can be provided and patronage can be attracted, whereas in low-density areas, the reverse is true.

[15]"Transit Use" curves, showing relationship between the proportion of transit trips and the product of urbanized area population density and households per car, are described in Chapter IV.

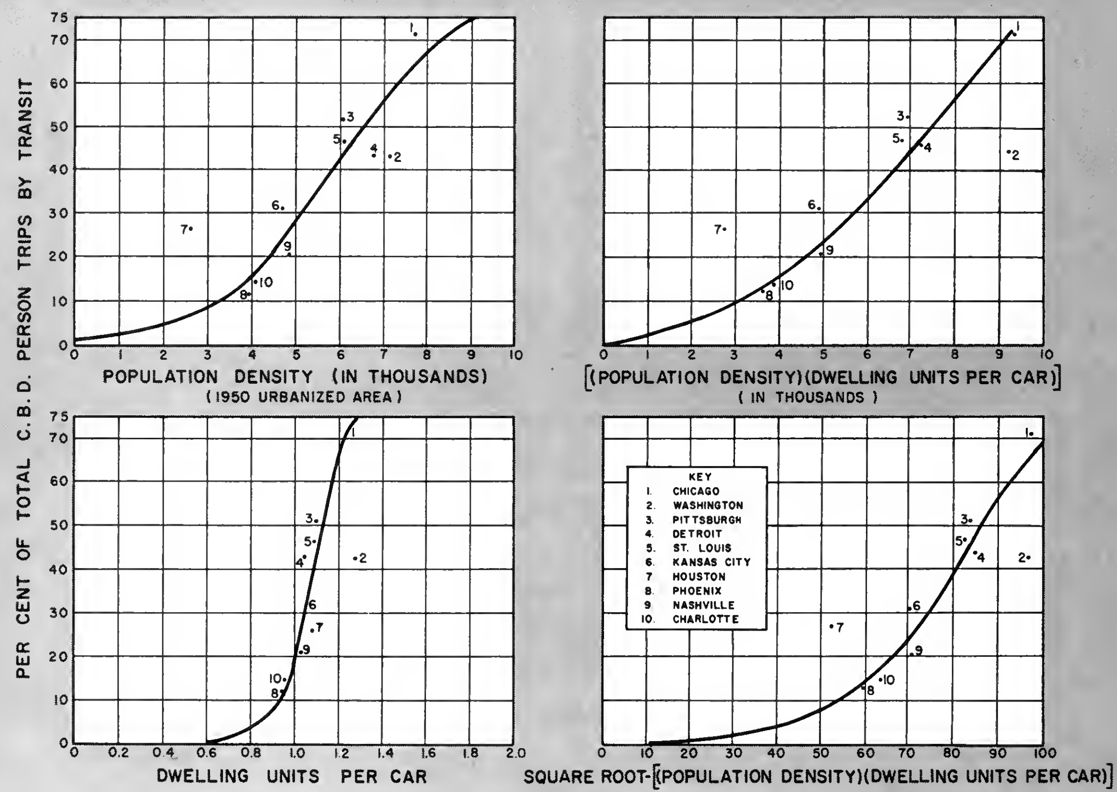

Figure 43
Central Business District Transit Use Relationships in Study Cities

When a family does not own an automobile, mass transportation is almost essential, whereas a family with one car is less likely to use mass transportation; hence, multi-car families will make even fewer trips by transit.

CENTRAL BUSINESS DISTRICT

The central business district is the focal point of the entire metropolitan area. Its role and traffic generation vary with its size, age, and intensity of development. These factors also influence its roadway, transit, and parking requirements.

Generation of Travel – Traffic generation characteristics of the central business districts in the study cities are shown in Table 21. The proportion

TABLE 21

TRAVEL TO OR FROM CENTRAL BUSINESS DISTRICTS IN STUDY AREAS[1]

URBAN AREA	*PER CENT OF TOTAL AREA TRIPS BY EACH MODE TO OR FROM CBD*			*Trips Per Capita to or from CBD*
	Transit Trips	*Auto Trips*	*All Person Trips*	
Chicago	27.2	3.5	9.2	0.18
Detroit	25.1	6.6	9.8	0.17
Washington	59.7	25.3	34.8	0.56
Pittsburgh	16.3	4.0	6.5	0.10
St. Louis	33.8	6.6	10.6	0.20
Houston	36.5	16.3	19.0	0.40
Kansas City	40.3	8.7	11.4	0.24
Phoenix	72.5	14.8	15.4	0.33
Nashville	50.5	13.9	16.3	0.36
Charlotte	46.5	21.7	23.5	0.52

[1]Source: Origin-destination studies in each area.

of total urban area trips having downtown origins *or* destinations varies from seven per cent in Pittsburgh to 35 per cent in Washington.[16] In most larger cities, the downtown attracts about 10 per cent of all travel; in the smaller cities, up to 25 per cent of all trips are to or from the downtown area. *Thus, the vast majority of person trips within an urban area have origins and destinations elsewhere than downtown.*

A high proportion of all travel in public transit vehicles is focused on the CBD, but a relatively small proportion of trips made in cars is generated in the CBD.

Transit — The proportion of total urban area transit trips to or from the CBD ranges from about 16 per cent in Pittsburgh to more than 70 per cent in Phoenix. In Kansas City, Charlotte, and Nashville, about 40 to 50 per cent of all transit trips are generated in the CBD. In larger cities, as Detroit and Chicago, about 25 per cent of all transit trips are to or from the CBD.

Auto Trips — In almost every city, less than 20 per cent of all trips by car are generated in the central business district. The remaining 80 per cent have origins and destinations throughout the urban area. The proportion of car trips generated in the downtown area in the study cities ranges from about four per cent in Chicago to 25 per cent in Washington.

In St. Louis, for example, the seven per cent of the auto riders who travel to and from the central area each day deliver more than half of all persons going to and from the central city; the remaining 93 per cent of the auto trips are dispersed throughout the remainder of the area. In Kansas City, about 10 per cent of the auto riders travel to and from the CBD and account for more than 70 per cent of all downtown trips.

Downtown's relative attraction of travel decreases as the size of urban area increases. As cities get larger, a smaller proportion of the total urban area travel is to or from the central business district.

As shown in Figure 44, more than 25 per cent of the total urban area auto trips are to or from downtown in areas under 150,000 population. This percentage decreases to less than five per cent in areas exceeding two million.

The proportion of total person trips also declines as the size of the area increases, but at a slower rate — from more than 28 per cent in areas under

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[16]The delineation of the central business district is not totally uniform from city to city. The most notable exception is Washington, where the entire "Zero Sector" is defined as the CBD — this oversized area generates a disproportionately high amount of the city's total trips.

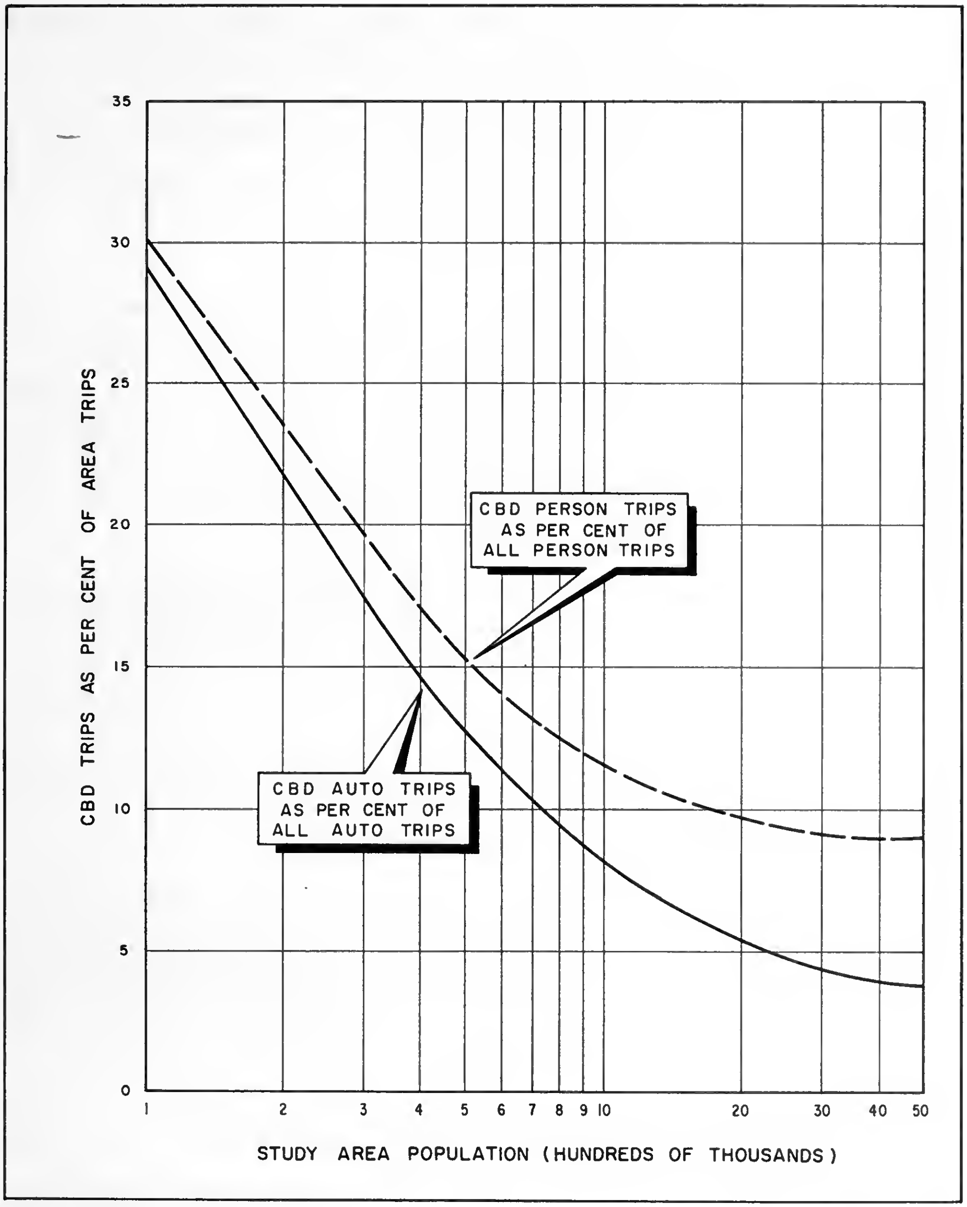

Figure 44
Trips to or from Central Business District Related to City Size

150,000 population to about 10 per cent in areas over two million. The difference between the two curves in Figure 44 illustrates the increasing use and importance of mass transportation in serving central business districts in larger cities.

Each successive increase in metropolitan area population will, therefore, result in a decrease in the proportion of CBD-generated trips largely as a result of new urban growth taking place in suburbia. As distance from downtown increases, travel to the center is more difficult and requires more time; the downtown must increasingly compete with outlying subcenters which are often more accessible. *Since freeways will reduce driving time, they should stimulate travel to downtown.*

Impedances to travel have a "gravity" or "interactance" effect on trip generation — the greater the impedances, the lesser the travel. The relative per capita attraction of downtown Houston and Charlotte, shown in Figure 45, confirms this trend. In both cities, the number of person trips per thousand residents decreases as the distance from downtown increases. Transit trips follow a similar pattern, but decrease more rapidly in both cities. These relationships are consistent with those found in other studies.

In most communities, the central business district is not attracting new visitors in proportion to over-all urban growth. This is because cities are experiencing rapid growth in their low-density suburbs. These suburbs are distant from downtown and have the smallest per capita CBD trip potentials.

People Entering Downtown — The number of people entering the central business districts of typical urban areas and their modes of travel as measured by "cordon counts" are summarized in Table 22.[17]

In most cities, there are less than 400,000 entrants daily. Exceptions are New York City with 3.3 million; Chicago, Philadelphia, and Boston, each with about a million, and Los Angeles with 700,000.[18] Typical maximum accumulations of people totaled 286,000 in Chicago and 158,000 in Los Angeles.

Except for cities with rapid transit systems, automobiles carry more than half of the people who enter downtown. In central Los Angeles, the largest city in the country without a rapid transit system, about three of every four persons entering the CBD are in automobiles. In smaller, auto-oriented cities, virtually all downtown travel is by car.

Through Versus CBD Traffic — Much of the traffic crossing central business district cordons represents "through" traffic with origins and destinations in other

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[17]The number entering includes both CBD and through traffic. Thus, the position of downtown as well as intensity of demand affects cordon values.

[18]In Los Angeles, there is a high proportion of through traffic on the freeways which converge and interchange in the downtown area.

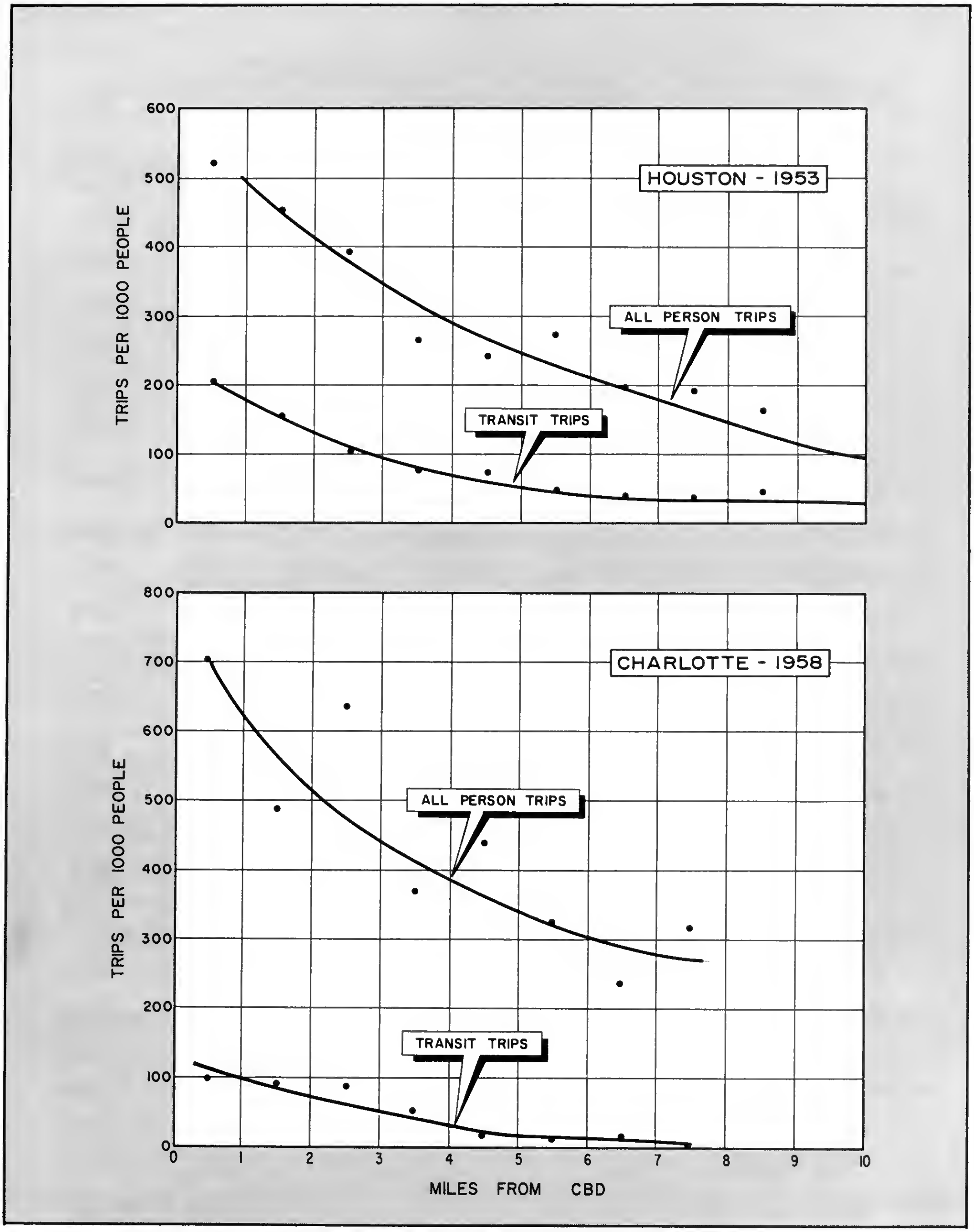

Figure 45
Central Business District Trip Attraction

TABLE 22

PEOPLE ENTERING CENTRAL BUSINESS DISTRICTS
TYPICAL WEEKDAY[1]

CITY	DATE OF COUNT	1950 URBANIZED AREA POPULATION	PEOPLE ENTERING DOWNTOWN Number	Per Cent By Auto	Per Cent By Transit
New York, N. Y.	1956	12,296,117	3,316,000	22.2	77.8
Chicago, Ill.	1960	4,920,816	864,733	40.6	59.4
Los Angeles, Calif.	1960	3,996,946	678,977	75.2	24.8
Philadelphia, Pa.	1955	2,922,470	1,018,000	46.3	52.7
Boston, Mass.	1954	2,233,448	1,263,350	40.8	58.2
San Francisco, Calif.	1954	2,022,078	400,000	51.0	49.0
St. Louis, Mo.	1957	1,400,058	323,500	61.6	28.4
Cleveland, Ohio	1954	1,383,599	370,000	46.0	54.0
Toronto, Ont.	1955	1,253,000	380,026	42.4	57.6
Baltimore, Md.	1955	1,161,852	385,431	69.0	31.0
Milwaukee, Wis.	1958	829,495	262,000	67.6	32.4
Kansas City, Mo.	1957	698,350	203,689	72.0	28.0
New Orleans, La.	1956	659,768	413,443	59.9	40.1
Seattle, Wash.	1954	621,509	185,050	65.3	34.7
Providence, R. I.	1957	583,346	308,778	79.6	20.4

[1]Source: Compiled from cordon count data for each city.

areas. As shown in Table 23, between half and three fourths of all vehicles entering downtown have destinations elsewhere. In New Orleans, for example, 92,000 vehicles enter the central business district daily between 8:00 A. M. and 6:00 P. M., of which 72,000 or 78 per cent, pass through downtown.[19] In Kansas City, 51 per cent of all vehicles entering the central business district pass through; in St. Louis, 62 per cent; in Nashville, 75 per cent.

This non-CBD traffic would largely be divertible to a circumferential freeway around the central business district. Thus, a CBD freeway loop could substantially reduce volumes on streets within the central area.

[19]Wilbur Smith and Associates, *Parking Study, Central Business District, New Orleans, Louisiana,* 1960.

Table 23

WEEKDAY TRAFFIC PASSING THROUGH AND DESTINED FOR TYPICAL CENTRAL BUSINESS DISTRICTS[1]

CITY	*PER CENT OF TOTAL VEHICLES ENTERING CBD*	
	Vehicles Passing Through	*Vehicles Having Destinations in CBD*
St. Louis, Mo.	62	38
Kansas City, Mo.	51	49
Charlotte, N. C.	66	34
New Orleans, La.	78	22
Philadelphia, Pa.	67	33
Nashville, Tenn.	75	25
Bureau of Public Roads (67 Cities)	55	45

[1]Sources: Compiled from origin-destination studies in each area, from data compiled by Bureau of Public Roads, published in Schmidt, R. E., and Campbell, M. Earl, *Highway Traffic Estimation*, Eno Foundation for Highway Traffic Control, Saugatuck, Conn., 1956, and from Wilbur Smith and Associates, *Parking Study, Central Business District*, New Orleans, Louisiana, 1960. Data are for 24-hour periods except New Orleans, which are for 10 years, 8:00 A. M. to 6:00 P. M.

Trends – The shift to automobile transportation is apparent from a review of prewar cordon count data. For example, 35 per cent of all people entering downtown Los Angeles in 1924 came by car; in 1940, 56 per cent, and in 1960, 75 per cent. About 30 per cent of all people entering downtown San Francisco came by car in 1926, compared to 51 per cent in 1954.

The number of persons entering downtown New York City, Chicago, and Milwaukee over the last several decades are depicted in Figure 46. In all three cities, the proportion entering by car has increased, while the total number of entrants has either stabilized or declined.[20]

The number of people entering the Chicago Loop declined from about 925,000 in 1929 to 776,000 in 1935, then remained relatively constant at about 800,000 until 1946-1948 when a peak of over 970,000 was reached. Since 1954, the number of entrants has been about 860,000 (1960–864,733). The proportion

[20]Based on cordon counts received from respective cities. Also see Tables A-22 and A-23, Appendix C.

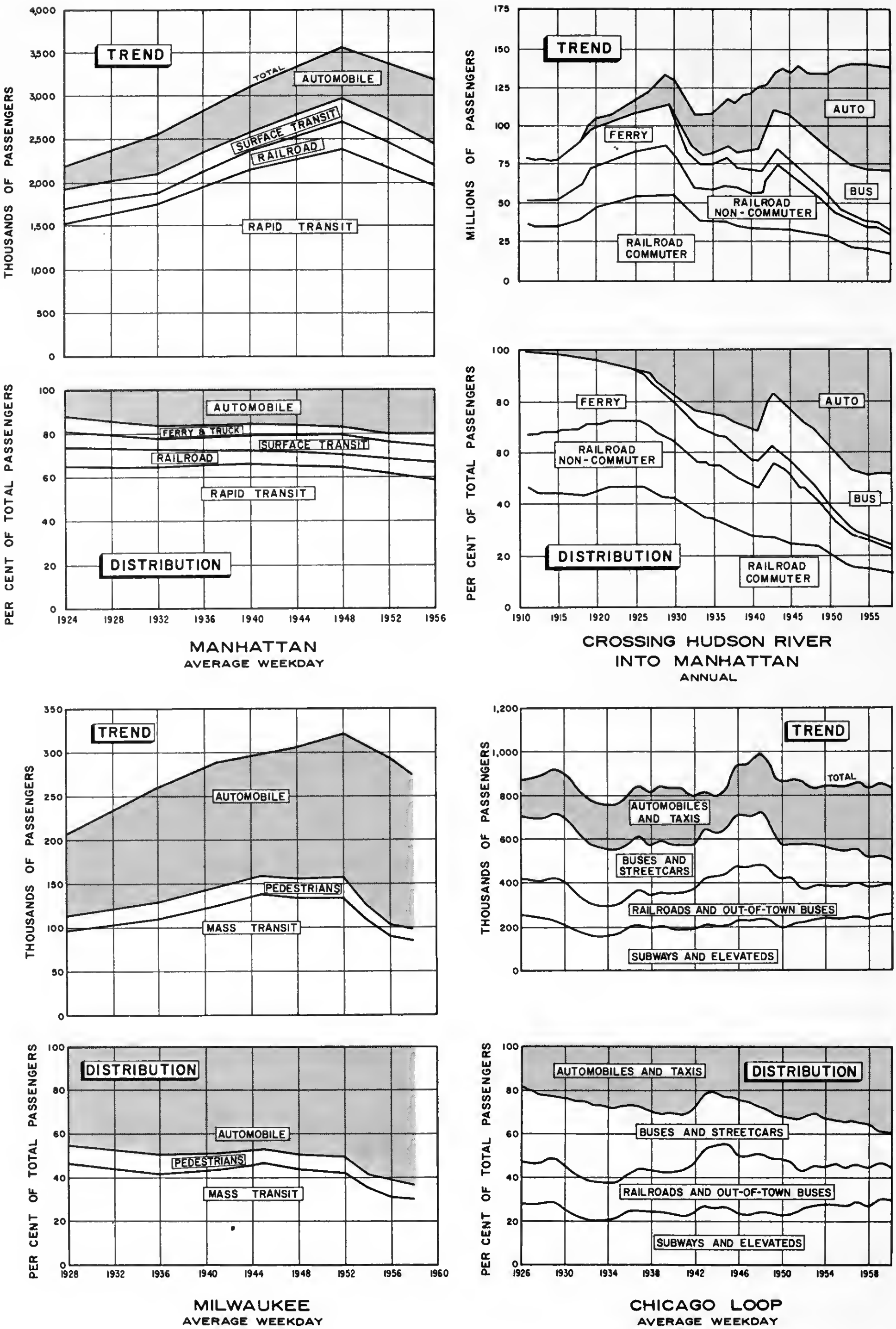

Figure 46
PEOPLE ENTERING TYPICAL CENTRAL BUSINESS DISTRICTS

arriving by automobile increased from about 20 per cent in the 1926-1930 period, to about 40 per cent in recent years with surface transit declining from about 35 per cent in 1926 to about 15 per cent in 1960. The proportion of rapid transit and rail commuters has remained about the same.

The number of people entering downtown Milwaukee increased from about 220,000 in 1926 to a peak of 320,000 in 1952, and then decreased to about 260,000 in 1958; the proportion entering by automobile has increased from about 40 per cent in 1926 to more than 60 per cent in 1958.

The number of people entering Manhattan south of 61st Street daily increased from 2.3 million in 1924 to 3.7 million in 1948, and then decreased slightly to 3.3 million in 1956; the proportion arriving by automobile doubled, increasing from 11 per cent in 1924 to 22 per cent in 1956.

The number of annual trans-Hudson passengers entering Manhattan has continually increased, from about 75 million in 1910 to about 140 million in the 1955-1958 period. The proportion traveling by rail and ferry has declined to about 15 per cent while the proportion traveling by bus and automobile has increased to about 50 per cent.

In the 10-year interval, 1948-1958, there was an over-all increase of 10.2 million trans-Hudson passenger movements — a 3.8 per cent increase; auto passenger movements expanded by 55.7 million, but railroad passenger movements decreased by 55.4 million. The shift to autos has resulted from wide dispersion of new employment and recreation places in northern New Jersey and New York, many of which are served only by car, and from substantial increases in weekend travel by residents of both states. The reduction in trans-Hudson passenger movements has occurred entirely in travel to and from the Manhattan CBD, both during peak and off-peak hours.

Per Capita Trends — Trends in the number of people entering the New York, Chicago, San Francisco and Milwaukee central business districts per thousand metropolitan area residents, are shown in Figure 47. The number of persons entering the central business district is gradually declining when expressed on a per capita basis. For example, the number of people entering Manhattan per thousand metropolitan area residents decreased from 269 in 1940 to 234 in 1960; in Chicago, the comparable figures are 168 and 140; in Milwaukee, 370 and 288; in San Francisco, 235 and 160.

TRIP LENGTH

The trips that people make generally reflect the purpose for which they are made. Most originate or end at home and are made to the place of employ-

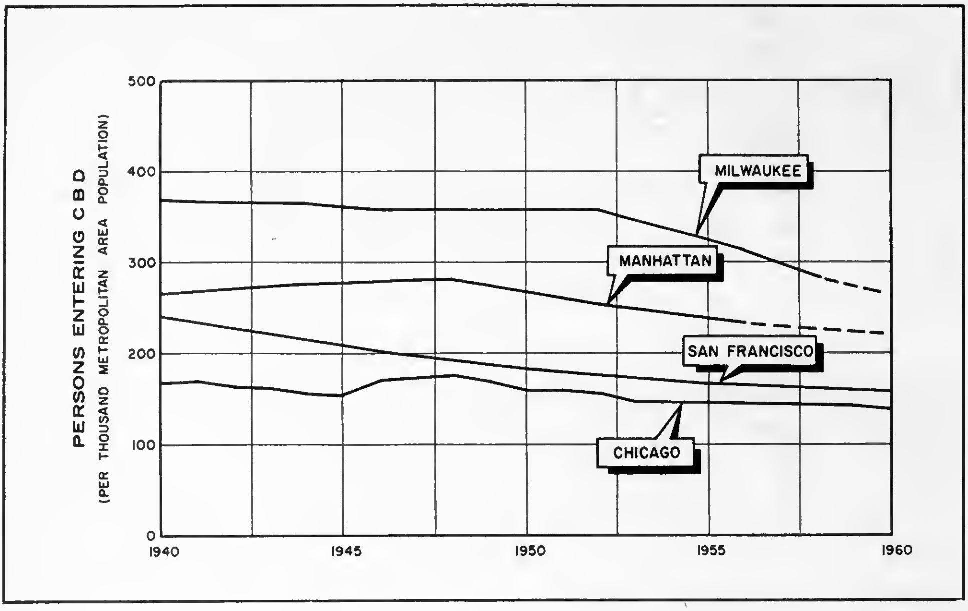

Figure 47
TRENDS IN PER CAPITA VISITATION TO TYPICAL CENTRAL BUSINESS DISTRICTS

ment, for shopping, etc. Trips tend, therefore, to be as short as possible to meet the traveler's needs. Most urban trips are short, averaging less than three miles in length in small cities like Reno, and increasing gradually as the urban area grows larger, to about five miles in length, as in the Chicago metropolitan area. Even in many cities of more than a million population, one third or more of all trips are less than two miles long.

The "travel friction" created by trip length is illustrated in Figure 48 for home-based trips generated by people who reside within a two to six-mile band from the St. Louis central business district (Ring II). The relative rates of travel (trips per unit of time by a constant number of persons to generators of equal size) at different distances in minutes of off-peak auto driving time are shown for work, social-recreational and business-shopping trips. The rates of attraction for all three trip classes diminish as driving time increases. Business-shopping trips are the shortest and decrease the fastest as driving times increase. Social trips, in turn, are more strongly influenced by trip length than work travel, as shown by the steeper slope of the social-recreation line.

These relationships are directly influenced by the competitive scramble for jobs at the highest available rates of pay; by retailers deploying shopping

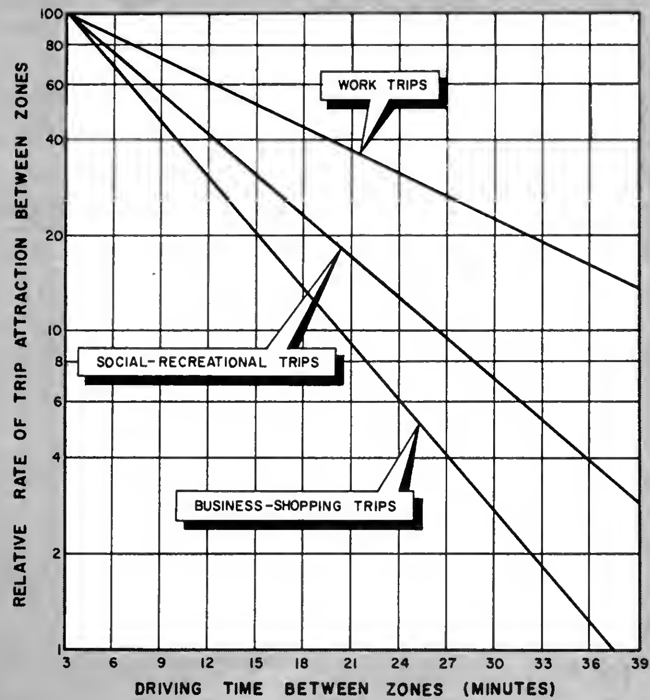

Figure 48
TRIP PURPOSE RELATED TO TRIP ATTRACTION
AND TIME-DISTANCE BETWEEN ZONES
ST. LOUIS, MISSOURI — 1957

centers in strategic patterns to intercept and attract the customer; and by persons of similar likes and economic status spreading into the new suburbs around the entire periphery of the growing city.

The low-density development taking place in the suburbs of all cities is tending to increase average trip length and decrease the proportion of short trips. As the new growth occurs and the average diameter of the urbanized area increases, the opportunities for longer trips increase at a faster rate than opportunities for short trips. Also, new express highways are encouraging the production of longer trips by stimulating the urbanization of undeveloped areas close to the new routes and by reducing the amount of time required to travel between sections of the community.

The relative lengths of various kinds of trips in St. Louis and Kansas City are depicted in Figure 49. (All trips are home-based except the miscellaneous category shown for Kansas City.) Work trips are longer on the average than trips for other purposes. Land zoning tends to segregate the residential and industrial uses and most work trips must, therefore, extend beyond the residential neighborhoods where they are generated.

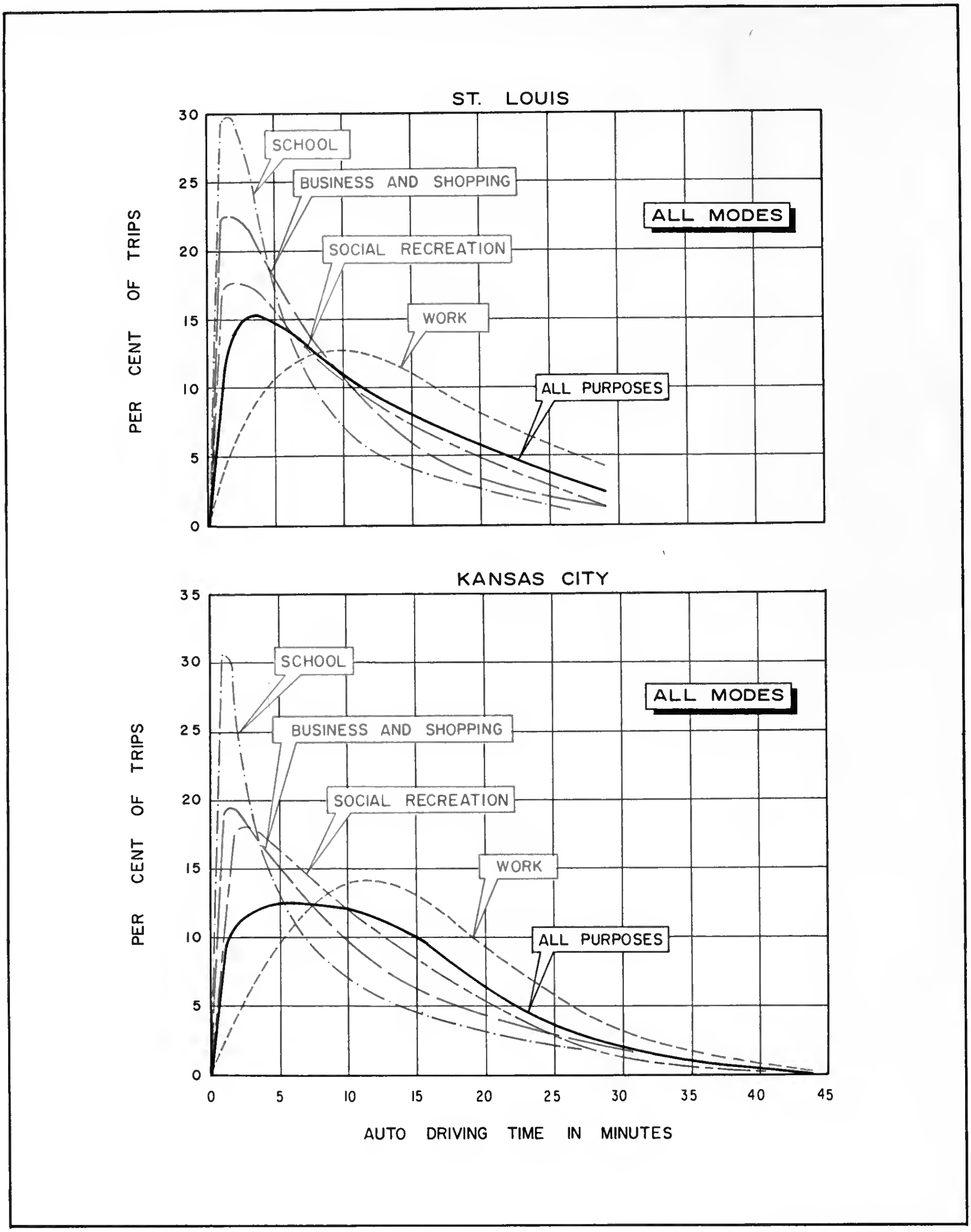

Figure 49
Trip Lengths of Various Trip Purposes
St. Louis and Kansas City, Missouri
1957

Business and shopping trips are of medium length because land zoning allows for islands of retail stores within the residential community to meet residents' daily needs. School trips are shortest since most neighborhoods have their own public schools. Miscellaneous trips are nearly as short as school trips, since they have neither end at home and usually occur entirely within the central part of the community.

Length of Work Trips – The similarity of trip-length distribution of work travel in Kansas City, St. Louis, and New York City is clearly shown in Figure 50. (All trip lengths have been measured in minutes of travel time rather

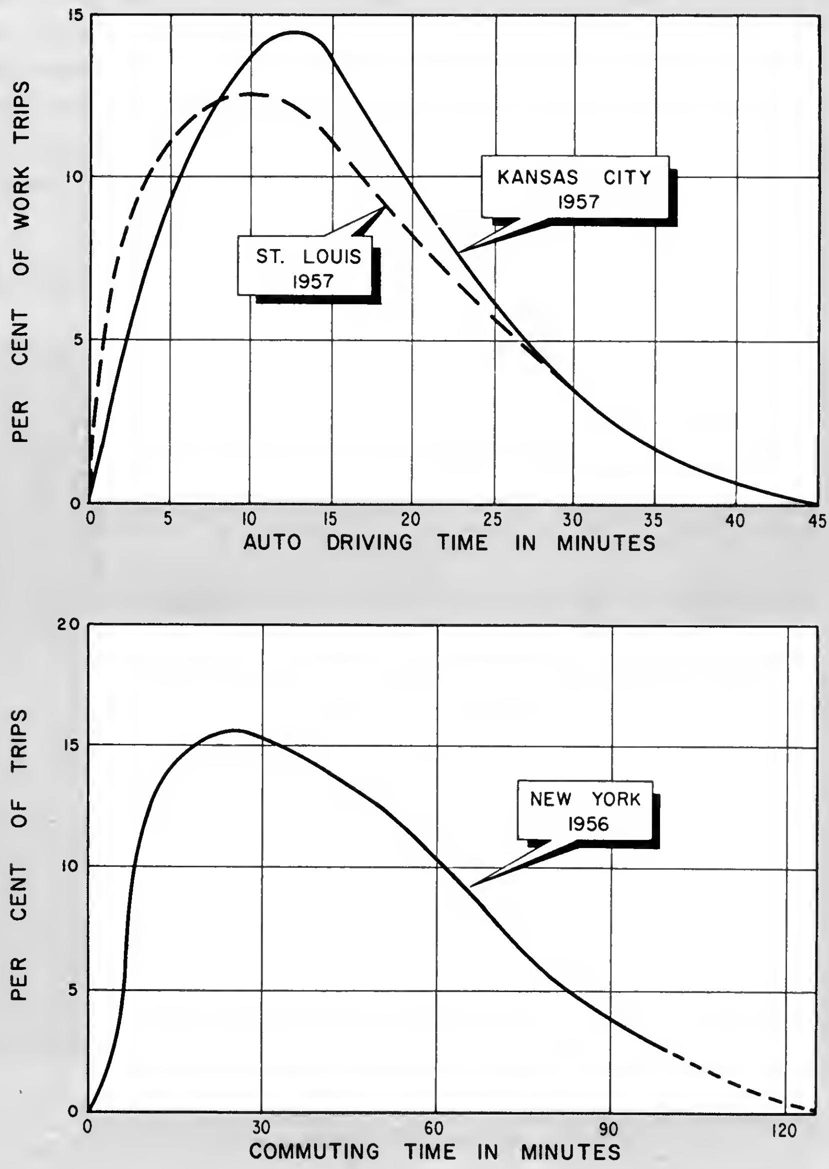

Figure 50
Travel Time to Work

than miles of distance.) The modal driving times in St. Louis and Kansas City are about 10 to 15 minutes; those in New York, over 30 minutes. Except for the difference in trip times, the shape and vertical amplitude of the distribution curves in New York and Missouri are markedly alike.

The journey to work does not necessarily increase in length as the metropolitan area expands. As cities evolve, there is pressure to minimize travel distances by reorientation of land uses as suburban areas tend to become self-sufficient.

This process has developed even in older cities such as Philadelphia, where a recent study of work travel showed that about 70 per cent of the employed persons living outside the City of Philadelphia find employment in areas outside the city limits; practically all get to work by automobile in an average time of 17 minutes.[21] The 30 per cent who travel into the city to work average 40 minutes per trip. About 92 per cent of the employed workers who live in Philadelphia work within the city; they average about 28 minutes travel time to work.

[21]Source: Mitchell, Robert B., Chairman, Department of Land and City Planning, University of Pennsylvania, July, 1960.

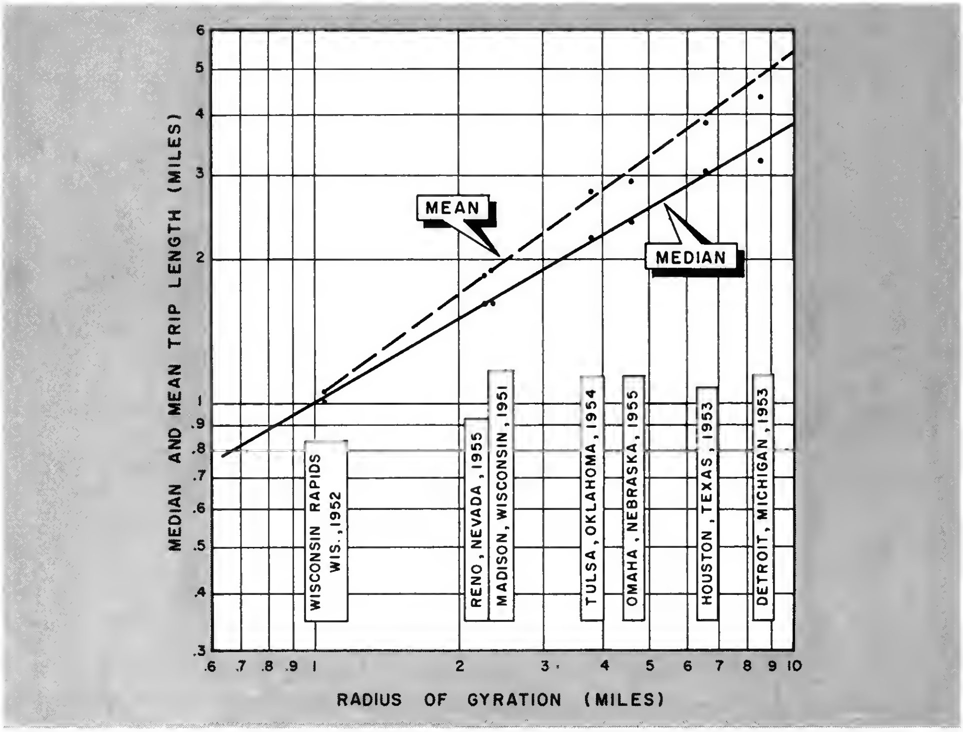

Figure 51
Auto Trip Length Related to
Population Distribution

Relation to City Size — Trip lengths in urban areas are related to the distribution and concentration of population within the area. Internal trip lengths can be correlated with the average distribution or dispersion of population in the urban community, as illustrated by Figure 51.[22] There is a straight-line relationship between trip lengths and the radius of gyration (second moment) of the population about the central business district. (When the centroid of the population and downtown have coincident locations, the radius of gyration is equivalent to the standard deviation of the population.)

It is apparent that the area occupied by a city is more significant than its density in determining average length of trips. For example, the St. Louis and Kansas City studies both encompassed about the same area, although the St. Louis population was about 50 per cent greater than Kansas City. Automobile trips averaged about the same length in each purpose category in the two cities.

The interrelationships between trip length and urban size afford a basis for anticipating future urban travel. These additional analyses are set forth in Chapters V and VI.

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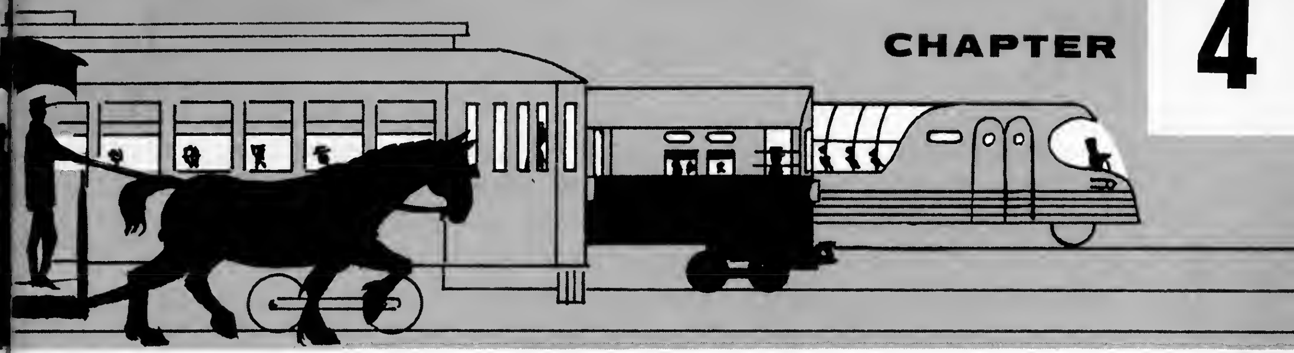
[22]Herla, Marc H., *Characteristics of Automobile Trip Length in Urban Areas,* unpublished thesis, Bureau of Highway Traffic, Yale University, May, 1957.

CHAPTER 4



PUBLIC TRANSPORTATION in THE OVER-ALL PLAN

SUMMARY

TRANSIT is an integral part of an urban area's total transportation system. Although it does not serve the majority of trips in urban areas, it is valuable in serving those particular movements or trip linkages that are concentrated in space and time, especially in the large, high-density urban complexes.

Because of urban population dispersion and increased use of automobiles, transit no longer enjoys a dominant position in urban transportation. Service is more extended, patronage is decreasing and peak hours are becoming even more concentrated. All transit riding in 1959 was almost 30 per cent less nationwide than 1940 levels.

Rapid transit riding has declined about 20 per cent since 1940, although it has stabilized in recent years because of its faster speeds and its location along many high-density travel corridors.

The consistent and predictive relationship between the amount of transit usage, urbanized area population density, and the number of households per car explains why transit riding is decreasing. Basically, the lower the population density and the number of households per car, the less the transit usage.

Freeways can help transit by providing facilities for some transit travel and by reducing surface street volumes which, in turn, give greater freedom to local transit movements.

Rapid transit, with its high peak-hour passenger capacities, is a desirable element in the total urban transportation system wherever there are sufficient concentrations of people to warrant such facilities.

The cited capacity of rail rapid transit — 40,000 persons per track per hour — has been fully realized only in New York City, and at high-load ratios; maximum one-way, peak-hour loads per track reported in other cities range from about 10,000 persons in Cleveland to 30,000 in Chicago and Toronto.

Bus rapid transit can accommodate about 22,000 persons per hour, assuming uninterrupted freeway operation and adequate delivery areas in downtown; where buses can stop along freeways, about 6,000 to 7,000 persons per hour can be accommodated in specially designed bus-ways or bus lanes, although higher capacities can be achieved when turn-outs or passing lanes are provided in the freeway design.

The need for rapid transit is contingent upon the future size and intensity of development within the central business district, on population density and concentrations along selected corridors of travel, and on resulting peak-hour capacity requirements. In general, extensive rapid transit systems in American metropolitan areas will be limited to urban complexes with two million or more people by 1980, although some form of rapid transit also may be desirable in certain areas containing from one to two million people.

Rapid transit assists freeways in providing radial CBD-oriented peak-hour capacity. It is also valuable in helping maintain existing land-use densities in certain areas, in serving established central business districts, by reducing downtown parking demands, and in providing reserve capacity for future or unanticipated growths.

Just as freeways do not obviate the need for transit, neither can rapid transit be regarded as a substitute for needed new freeways. Rapid transit does not diminish the basic needs for area-wide urban freeway systems, since most of these needs exist independently of transit. Furthermore, freeways are needed to serve off-peak and weekend periods when there is comparatively little demand or justification for rapid transit.

Most rapid transit proposals are limited in coverage and scope, when compared to complete urban freeway systems.

Comparisons of the economic feasibility of alternate rapid transit proposals usually will indicate that transit routes should be integrated with freeway construction, and that flexible, rubber-tired vehicles should be used.

Future rapid transit in most cities will be provided by express buses operating on freeways either within specially reserved and designed peak-hour transit lanes, or along special median bus lanes. Such freeway bus operations will usually involve lower capital costs, provide greater coverage, be better adapted to low or medium density areas, and permit routes and services to adapt to changing land-use and population patterns.

Cities with extensive rail transit systems will find it advantageous to retain and improve these facilities. Similarly, where existing railroad tracks or rights-of-way can be incorporated into transit systems, it may be economical to consider rail transit. These situations will, for the most part, be few in number and limited to the largest cities.

In the future, over-all transit riding will continue to decrease but at a slower rate as car ownership approaches saturation levels.

The form and density of development in many urban areas demand the continuance of transit. An efficient carrier in terms of street requirements, transit should be encouraged to maintain its service, particularly into and out of the central business district. At best, it will continue at present levels, providing transportation primarily for people who do not own or drive cars. Its role and function, however, will be different from its earlier status. No longer the dominant travel mode, except in special cases, it will serve as an important adjunct to private vehicular transportation.

TRANSIT has been important in the growth, development and concentration of urbanized areas, and is an integral part of the city's total transportation system.

Public transportation, or transit, is the movement of large groups of people in vehicles operating on specified routes and schedules; it includes buses, streetcars, and rapid transit. *Rapid transit* generally refers to facilities operating over exclusive or private rights-of-way, often grade-separated from public roads to permit higher speeds; it includes subways, elevated railroads, suburban railroads, monorails, and express buses on freeways.

In this chapter, present and future roles of transit in the urban area are analyzed. Special consideration is given to the potentials of rapid transit, particularly as they relate to urban freeway requirements.

TRANSIT ORIGINS

Transit had its origin in the omnibus and horsecar of the pre-Civil War 19th Century, and its heyday in the half century thereafter. The electric streetcar appeared in the 1890's and soon became instrumental in altering over-all city development; it helped create mass origins and destinations in American cities and was, in turn, sustained by them; the central cities were consolidated, land values increased, and residential suburbs linked to downtown by transit lines radiating throughout the urban area. Around the turn of the century, it was firmly believed that electric railways would remain indefinitely as the basic means of urban travel despite the appearance of the automobile.[1]

Although buses appeared as early as 1905, widespread motor bus service did not begin until 1920, and trolley bus operation about 1928.[2]

The country's first elevated railroad was completed in New York City in 1876; others began operating in Chicago in 1892; Brooklyn, about 1900; Boston, 1901; and Philadelphia, 1905. First electrification was in Chicago in 1895. Boston's Tremont Street Subway, opened in the fall of 1897, was the nation's first subway; others opened in New York City in 1904; Philadelphia, 1908; Chicago, 1943; Toronto, 1954; and Cleveland, 1955. The first extensive rapid

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[1]Bauer, John, and Costello, Peter, *Transit Modernization and Street Traffic Control,* Public Administration Service, Chicago, 1950, p. 46. Consolidation and electrification usually involved heavy bonded indebtedness and high capitalization, often at a basic five-cent fare to cover fixed charges. By May, 1919, 62 companies operating 5,192 miles of track were in receivership; 60 companies had dismantled and scrapped 534 miles of line, and 38 companies had about 257 miles of track.

[2]American Transit Association, *Transit in America.* Much of the statistical information in this chapter has been compiled from the *Transit Fact Books* of the American Transit Association.

transit operation in a freeway median was initiated in 1958 along the Congress Street Expressway in Chicago, replacing the old Garfield Park elevated railway; however, in California, the Pacific Electric Railroad had previously operated in the median strip of the Hollywood Freeway through Cahuenga Pass.

Urban transportation facilities have generally not kept pace with community requirements. This lag can be explained historically by the rapid changes in transportation technology, other new developments, and the successive availability of superior plants and equipment; probably no other utility has been subject to such great change. Just as the horsecar was supplanted by the electric street railway, the trolley was short-lived, and was gradually replaced by the motor bus and automobile.[3]

TRANSIT TRENDS

Trends in public transportation clearly indicate that transit does not enjoy the position it had 30 years ago. Analysis of these trends gives insight into the problems facing transit and its future status within the urban area.

Patronage – As shown in Figure 52, there have been substantial reductions in transit riding in the last 30 years, except for the peaks during World

[3]Hilton, George W. and Due, John F., *The Electric Interurban Railways in America*, Stanford University Press, Stanford, California, 1960.

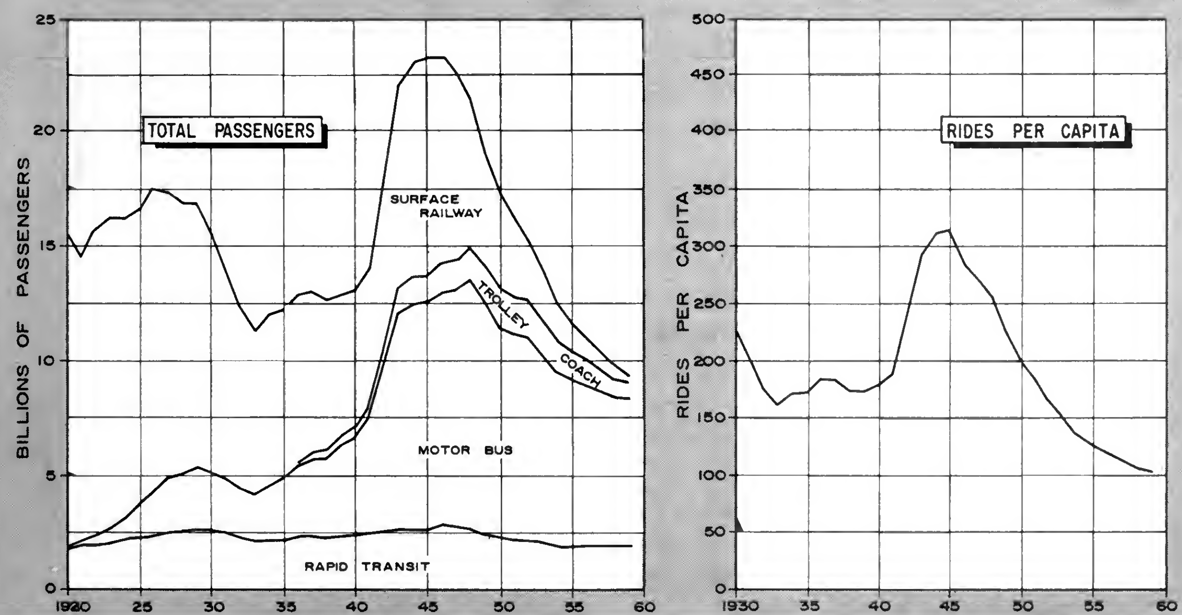

Figure 52
TRENDS IN TRANSIT PATRONAGE

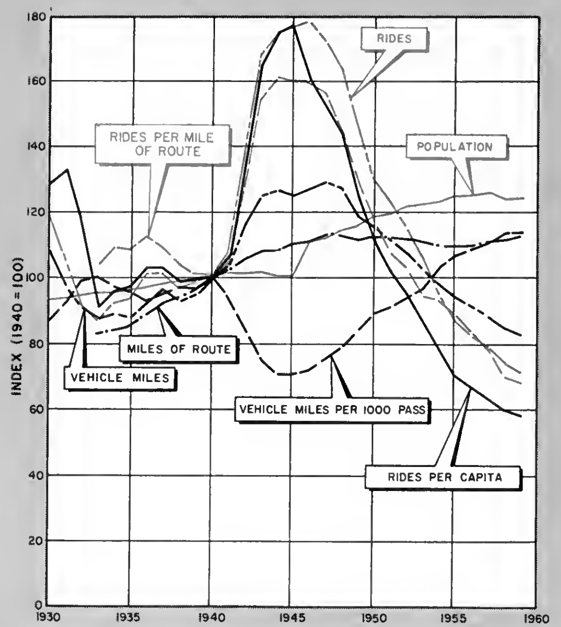

Figure 53
TRANSIT TREND INDICES

War II. Although nearly every city in the country substantially increased its population in this period, transit patronage decreased continually. The 10 billion passengers carried in 1959 represented a 59 per cent decline over the peak year 1946, and about a 45 per cent decline over 1929. The 102 rides per capita in 1959 represented a 60-per-cent reduction over 1929.[4]

Various indices of transit usage, plotted in Figure 53, show how transit riding has declined while relative service per passenger has increased. In 1959, the number of rides per capita was about 60 per cent of 1940 levels whereas vehicle miles per 1,000 passengers increased 14 per cent.[5] The increase in relative service largely reflects route extensions into suburbia.

Rapid Transit – Rapid transit has declined less than surface transit in recent years, although it carries about as many passengers as 40 years ago. Its patronage has reduced about 20 per cent since 1940. Much of this decline can be attributed to reductions in night and weekend riding, since in most cities there have been no appreciable changes in peak-hour riding.[6]

Rapid transit riding has stabilized since 1955 at about 18 billion annual passengers with slight increases reported in New York, Chicago, Cleveland, and Toronto during 1959. Trends in the use of the Cleveland rapid transit, shown in Figure 54, illustrate this stability. Average October weekday riding increased from about 40,700 persons in 1955 to 51,400 in 1957, declined slightly to 51,200 in 1958 and then increased to 59,400 in 1959. The increase in 1959 apparently resulted from the westward extension of the route during the latter part of 1958.

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[4]See Tables A-24 through A-30, Appendix C, for detailed trend information.

[5]In 1959, transit riders in New Orleans, San Antonio, and Denver exceeded 1940 levels; New York, Chicago, Philadelphia and Boston had about two thirds to three fourths of their 1940 patronage; Pittsburgh, Portland (Oregon), Indianapolis, and Akron, about half.

[6]New York City, with its large rapid transit system, significantly influences over-all rapid transit statistics.

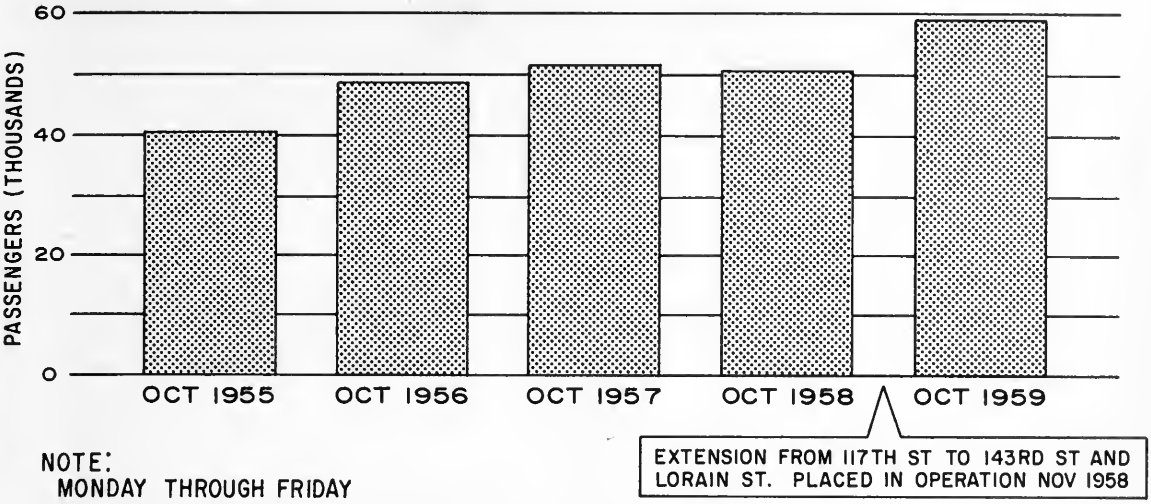

Figure 54
Average Weekday Traffic on
Cleveland Rapid Transit System
Cleveland, Ohio

Rapid transit has maintained its relative stability because it serves a specialized, "captive" central business district-oriented patronage, and because alternate modes of transportation are usually unavailable, economically unfeasible, or inconvenient.

Consumer Expenditures – Consumer expenditures for transportation, shown in Figure 55, depict the changing role of transit. Expressed in constant (1947) dollars, the country in recent years has spent about $25 billion annually for transportation, of which almost $23 billion were spent for automobiles and their operation. Thus, in the free market for transportation, Americans spend about 12 times as much on automobiles as on local transit and rail commuting.[7]

The proportion of the consumer's transportation dollar spent on public transit has decreased from 33 cents in 1909, to 8 cents per dollar in 1954. Thus, the assumption that improved transit will attract automobile users assumes a reversal of prevailing consumer attitudes.[8]

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[7]Bello, Francis, "The City and the Car," in *The Exploding Metropolis,* Editors of Fortune Magazine, 1958, p. 32.

[8]Owen, Wilfred, *The Metropolitan Transportation Problem,* The Brookings Institution, Washington, D. C., 1956, p. 72. Over an extended period, the proportion of total consumption expenditures devoted to public transportation has been declining slightly, remaining between 1 and 1.6 per cent of the total consumer expenditures.

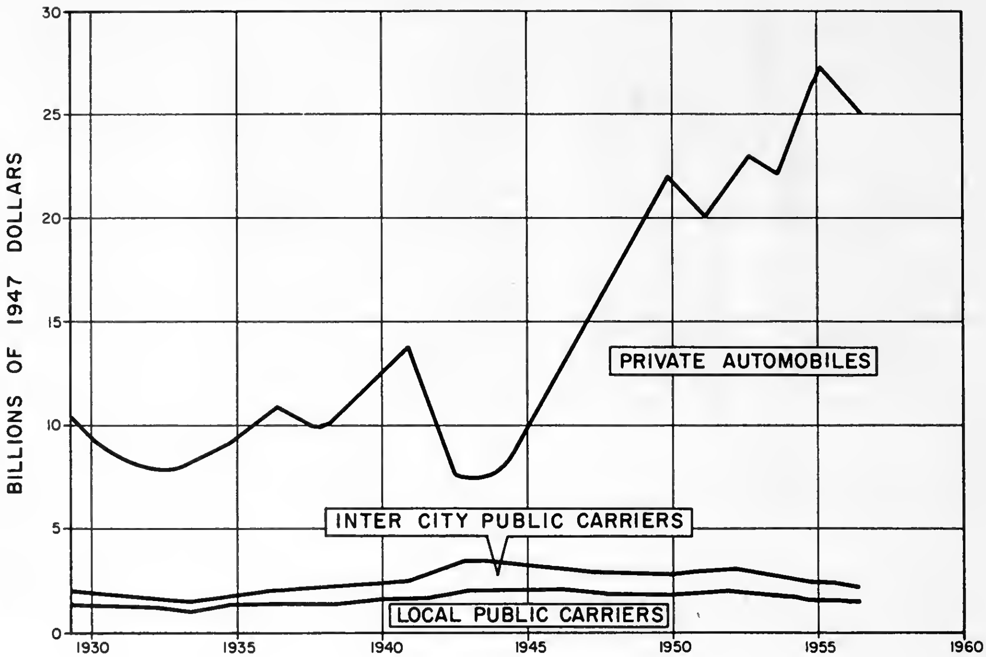

Figure 55
TRENDS IN CONSUMER EXPENDITURES FOR TRANSPORTATION

Transit Revenues — Since the end of World War II, the cost of providing a single seat in a city-type bus (example: Newark, New Jersey), increased from $338 in 1945 to $505 in 1958, and $557 in 1960.[9]

The increase in transit operating costs that has accompanied the decline in patronage since World War II is apparent from the trends in revenues, operating expenses, taxes, and net incomes depicted in Figure 56. In 1959, net transit revenues before taxes totalled $110,320,000; after taxes, net operating income amounted to $25,620,000 — less than two per cent of total operating revenues. By way of comparison, net operating income was about 14 per cent of the total revenue in the 1933-1936, and 1942-1943 periods.

Transit fares have increased to meet rising labor and operating costs, to compensate for extended operations, and to provide needed revenues.[10] Present

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[9]Harper, Herbert, E., "Buses—City, Suburban and Inter-City," *Newark Commerce,* Vol. No. 3, September, 1960.

[10]Source: American Transit Association. The average annual earnings per employee in 1959, $5,229, has doubled since the war years and has more than tripled since 1931.

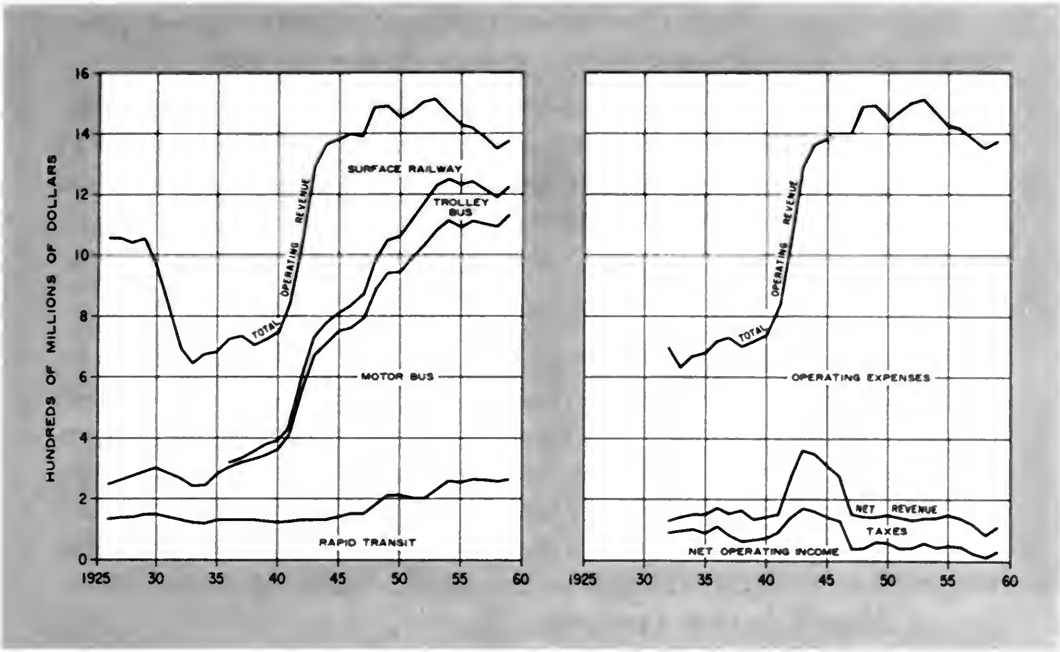

Figure 56
TRENDS IN TRANSIT REVENUE AND INCOME

average fares range from 15 cents per ride to 25 cents and are more than double the wartime rate. Each increase in fares has reduced patronage – usually there is a two-thirds realization of the fares.

Contributing Factors – The continued reduction of transit patronage is a result of many factors – all may be related directly or indirectly to increasing automobile ownership and use.

The automobile has become inextricably interwoven into the new suburban growth pattern as patrons and employees of outlying industrial plants and shopping centers become almost entirely dependent on private automobile transportation. Shopping has rapidly become a "family" habit, with family shopping trips made increasingly by automobile.

Changing recreational habits have reduced the number of transit passengers; television, for example, has been cited as a reason for a 50-per-cent decline in motion picture theater attendance throughout the country since 1945, thereby minimizing transit travel to and from principal theaters.

The five-day work week, and industry's general return to a one-shift operation have considerably diminished transit riding; Saturday is no longer the heaviest transit day of the week.

Physical improvements to streets and highways by local, state and federal agencies often have outpaced changes in transit's physical plant.

Increases in fares, necessary to meet rises in total transit costs, have tended to suppress patronage. The current transit problem is further accentuated by extreme peak-hour concentrations of traffic, and the resulting equipment and labor requirements — most declines in patronage have occurred in off-peak usage.

PRESENT TRANSIT OPERATIONS

There are approximately 1,600 transit companies in the United States, with a total of 150,000 employees and revenues of approximately 1.4 billion dollars.[11] An estimated 15 to 18 million families depend on them for public transportation. However, most companies are finding it increasingly difficult to provide attractive services; in most areas, patronage is diminishing, systems are curtailing their operations, and service is often divorced from other aspects of urban transportation. More than 120 cities are now without transit and in many others, service has been reduced to a minimum.

The principal transit operations are limited to a relatively small number of large cities. Half of all 1959 revenue passengers were in the 10 largest cities; and New York, Boston, Philadelphia, and Chicago accounted for one of every three revenue passengers. Transit operations in New York alone comprised one fifth of all revenues and passengers in the United States.

Basic Facts — The scope and magnitude of present (1959) transit operations in the United States is apparent from Table 24. In 1959 there were approximately 53,000 miles of lines; 94.0 per cent were motor bus; 2.4 per cent trolley coach; 2.9 per cent surface railway; and the remainder (0.7 per cent) subway and elevated. Of 66,000 transit vehicles in use, about 75 per cent were buses, 14 per cent subway and elevated cars, 6.5 per cent trolley coaches, and 4.5 per cent street railway cars. These vehicles aggregated more than 21,589,000 vehicle miles in 1959; 82 per cent by surface transportation, and rapid transit, 18 per cent. They carried 9,557,000 passengers — 81 per cent by surface transportation and 19 per cent by rapid transit.

Surface transit speeds have increased slightly in the last 30 years, averaging 10 to 12 miles per hour today compared with 8 to 11 miles per hour in 1922.

Rides per capita in most cities are below the 1959 national average of 102. The highest number of rides per capita, 181, was found in New Orleans — a low-fare, high-density community.[12]

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[11]American Transit Association, *Transit Fact Book, 1960.*
[12]See Table A-31, Appendix C.

Table 24

SUMMARY OF 1959 TRANSIT OPERATIONS[1]

ITEM		Subway and Elevated	Surface Railway	Trolley Coach	Motor Bus	Total
		TYPE SERVICE				
ROUTE MILES (*Single Track and Round Trip Bus Route*)	*Number*	1,245	2,806	2,491	106,300	112,842
	Per Cent	*1.1*	*2.5*	*2.2*	*94.2*	*100.0*
LINE MILES	*Number*	386	1,514	1,256	49,700	52,856
	Per Cent	*0.7*	*2.9*	*2.4*	*94.0*	*100.0*
PASSENGER VEHICLES OWNED	*Number*	9,000	2,983	4,297	49,500	65,780
	Per Cent	*13.7*	*4.5*	*6.5*	*75.3*	*100.0*
TOTAL VEHICLE MILES OPERATED (*Millions*)	*Number*	388.7	81.3	112.4	1,576.5	2,158.9
	Per Cent	*18.0*	*3.8*	*5.2*	*73.0*	*100.0*
TOTAL PASSENGERS CARRIED (*Millions*)	*Number*	1,828	521	749	6,459	9,557
	Per Cent	*19.1*	*5.4*	*7.8*	*67.7*	*100.0*
PASSENGERS PER MILE OF ROUTE (*Per Year*) (*Millions*)		1.47	0.19	0.30	0.61	0.85
VEHICLE MILES PER PASSENGER (*Per Year*)		.21	.16	.15	.24	.23
OPERATING REVENUE (*Millions*)	*Amount*	$272.2	$93.0	$91.0	$920.2	$1,376.4
	Per Cent	*19.6*	*6.8*	*6.6*	*67.0*	*100.0*

[1]Source: American Transit Association, *Transit Fact Book, 1960.*

Transit systems in New York, Chicago, Los Angeles, and Boston are controlled by authorities, whereas the systems in Detroit and Cleveland are municipally operated. Facilities in Philadelphia, St. Louis, Washington, San Francisco, and Pittsburgh are all privately operated. In Newark and Philadelphia, subways are city-owned and leased to transit companies.

The Importance of Transit — The Peak Hour — Public transportation remains important as a peak-hour carrier of people. It is especially essential in serving peak-hour home-to-work trips to and from the central business district and other high-density corridors of travel. In St. Louis, for example, buses and streetcars comprise three per cent of the outbound peak-hour traffic, yet carry more than 40 per cent of the total peak-hour passengers leaving downtown.[13]

In almost every city, there is heavy peak-hour usage. For example, approximately 54 per cent of the 71,000 persons entering or leaving downtown daily on Canal Street, New Orleans, use transit, whereas in the evening peak hour, 70 per cent depart by transit.

Transit riders accounted for about 26 per cent of the total 24-hour person trips leaving the St. Louis central business district on a typical 1957 weekday. They comprised 42 per cent of the peak-hour trips, and 20 per cent of all trips in the remaining 23 hours.

Transit usage by people leaving the Philadelphia central business district on a typical 1955 weekday was similar.[14] Transit accounted for about 50 per cent of the total 24-hour person trips, 72 per cent of all peak-hour person trips, and 46 per cent of all trips in the remaining 23 hours.

Trans-Hudson travel in the New York metropolitan area registers even higher peak-hour use of public transportation.[15] During the three morning peak hours, 82 per cent of the total inbound trans-Hudson passengers traveled by transit, whereas only 46 per cent traveled by transit during the 21 remaining off-peak hours; on a daily basis, 60 per cent moved by transit.

Present Rapid Transit — Principal rapid transit systems of elevated, subway, and surface subway cars, suburban railroads and freeway express bus operations are found in major American cities; these systems are summarized in Table 25. Rail rapid transit is operated in New York, Chicago, Boston, Philadelphia, and Cleveland and to a very limited extent in Los Angeles; express bus operations are found in almost every area shown in the table. Express buses also operate on freeways in Atlanta, Dallas, Sacramento, Portland, San Antonio, Columbus, San Diego, Richmond, and Cincinnati; perhaps there are similar operations elsewhere.

13Wilbur Smith and Associates, *A Highway Planning Study for the St. Louis Metropolitan Area,* 1959.

14Source: Philadelphia Urban Traffic and Transportation Board. See Table A-32, Appendix C.

15Herring, Frank W., *Trans-Hudson Passenger Travel, 1948-1954, A Pilot Study,* Port of New York Authority.

Table 25

EXISTING RAPID TRANSIT SYSTEMS OF MAJOR METROPOLITAN AREAS[1]

AREA	1950 POPULATION		CONVENTIONAL RAIL		STREET-CAR	EXPRESS BUSES ON FREE-WAYS	SUBURBAN RAILROADS	
	Metropolitan Area	*Central City*	*High Density*	*Low Density*			*Electric*	*Other*
New York-Northeastern New Jersey	12,911,994	7,891,957	X	X	X	X	X	X
Chicago	5,495,364	3,620,962	X	X		X	X	X
Los Angeles	4,367,911	1,970,358		(X)		X		
Philadelphia	3,671,048	2,071,605	X	X	X	X	X	X
Detroit	3,016,197	1,849,568				X		
Boston	2,369,986	801,444	X	X	X			X
San Francisco-Oakland	2,240,767	775,357				X		X
Pittsburgh	2,213,236	676,806				X		(X)
St. Louis	1,719,288	856,796				X		
Cleveland	1,465,511	914,808		X	X	X		
Washington, D. C.	1,464,089	802,178				X	X	

[1]Source: Compiled from information received from American Transit Association. Figures in parentheses (X) denote limited application only.

Rail Systems — General characteristics of the principal rail rapid transit systems are summarized in Table 26.[16] New York City dominates the rapid transit picture with about 58 per cent of the total line miles, 67 per cent of the track miles, and 77 per cent of total annual passengers. It is believed to be the only system providing almost complete area-wide coverage.

The average annual passengers per mile of line ranges from about 1.2 million in Cleveland, to almost 6 million in New York and 11 million in Toronto. Route location, with respect to population concentrations, is obviously an important factor in determining transit usage.

New York City has nine principal lines, Chicago and Boston four, Philadelphia three, Cleveland two, and Toronto one.[17] The systems in New York, Philadelphia, Chicago and Boston include both elevated and subway lines, whereas the Toronto and the Cleveland systems are mainly surface. All systems except Toronto and Boston operate some express service although most multi-track express operations are in New York City. Average speeds generally range from 18 to 26 miles per hour; the Cleveland system, with average over-all speeds

[16]Descriptions of these systems are contained in Appendix B.
[17]See Table A-33, Appendix C.

TABLE 26

RAPID TRANSIT USE — PRINCIPAL RAIL SYSTEMS[1]

LOCATION	*LINE MILES*	*SINGLE TRACK MILES*	*ANNUAL PASSENGERS*	*PASSENGERS PER MILE OF LINE*
New York City	236.70	836.86	1,328,957,962	5,620,000
Chicago	68.23	204.96	113,330,994	1,665,000
Philadelphia	32.23	86.60	73,296,325	2,275,000
Cleveland (CTS)	14.92	33.84	17,822,146	1,190,000
Hudson and Manhattan	8.47	18.04	31,398,369	3,710,000
Boston	25.06	64.32	96,000,000[2]	3,890,000
Sub-Total	385.61	1,244.62	1,658,805,796	*4,300,000*[4]
Toronto	4.60	10.00[3]	50,000,000	10,800,000
Total	390.21	1,254.62[3]	1,708,805,796	*4,370,000*[4]

[1]Source: American Transit Association.
[2]Estimated (Boston subway — surface lines with about 21 miles of grade separated route carry about 54,000,000 passengers annually.)
[3]Estimated.
[4]Average.

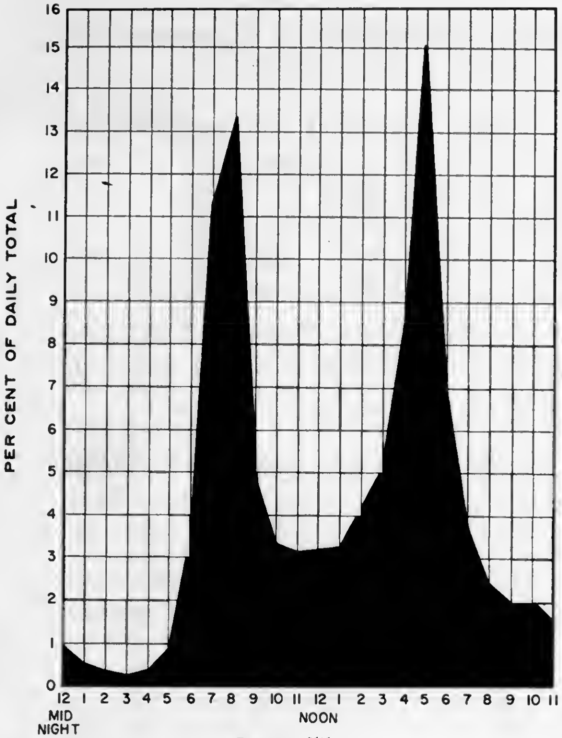

Figure 57
TYPICAL HOURLY VARIATIONS IN RAPID TRANSIT PASSENGERS

of 30 miles per hour is the fastest operation, although comparable speeds are obtained on certain New York and Chicago runs. In recent years, Chicago and New York have slightly reduced route mileage whereas mileage in other cities has increased slightly.

A typical hourly variation pattern for rapid transit traffic, Figure 57, illustrates the high peak-hour usage and value of rapid transit. Each peak hour serves about 15 per cent of the daily traffic; almost half of the day's total transit traffic moves in the four peak hours; about 85 per cent of all riders travel between 7:00 a.m. and 7:00 p.m. As shown in Table 27, the peak-hour use of principal rapid

TABLE 27

DAILY AND PEAK-HOUR RAPID TRANSIT USE IN MAJOR CITIES

Typical Weekday[1]

CITY	*ALL DAY*	*PEAK-HOUR VOLUME AT MAXIMUM LOAD POINT*	*PER CENT*
Rapid Transit			
New York City	4,490,000	672,000	15.0[2]
Chicago	559,000	177,000	19.2
Philadelphia	570,000	94,000	16.5
Boston	616,000	106,000	17.2
Cleveland	80,000[3]	18,000	22.5
Toronto	250,000	30,000	12.0
Commuter Railroads			
New York City	466,000	104,000[4]	22.3[2]
Chicago	234,000	68,000	29.1[2]
Philadelphia	100,000	24,000	24.0

[1]Source: Gottfeld, Gunther, *Rapid in Six Metropolitan Areas,* U. S. Government Printing Office, November, 1959.
[2]Represents per cent of daily total trips in peak hours.
[3]Includes Cleveland Transit and Shaker Heights systems.
[4]Assumed as 50 per cent of 7-10 A. M. volumes.

transit systems ranges from about 12 per cent of the daily total in Toronto to 23 per cent in Cleveland.

The high peaks indicate both the service afforded and the problems inherent in rapid transit operations. Peak hours require about four times as much equipment as can be operated productively at other times.

The capacity of rail rapid transit is often cited as 40,000 people per track per hour. This capacity assumes 10 car trains; 100 persons per car; and 40 trains per track per hour (90 seconds headway). Using the value of 34 trains per track cited by the New York City Transit Authority in system planning, peak-hour capacity is approximately 34,000 persons per track per hour.[18]

It appears that only New York City has consistently realized the 40,000 persons per hour figure on selected lines at high load ratios. Toronto, however, has approached this figure for 15-minute peaks. As shown in Table 28, maximum (one-way) peak-hour loads reported in other cities range from about 10,000 persons per track per hour in Cleveland, to about 30,000 persons per track per hour in Chicago and Toronto.

TABLE 28

REPORTED PEAK-HOUR TRACK LOADS[1]

CITY	*PERSONS PER TRACK PER HOUR*
Toronto	30,000
Chicago	28,000
Philadelphia	20,000
Boston	18,000
Cleveland	10,000

[1]Source: Compiled from Gottfeld, Gunther, ***Rapid Transit in Six Metropolitan Areas***, U. S. Government Printing Office, November, 1959. During Christmas peaks, 40,000 persons per track per hour have been reported in Toronto.

Bus Rapid Transit — Freeways readily adapt to express bus operations by reason of their limited access designs and spacing of interchanges. Rapid transit is provided by buses in an increasing number of cities, particularly as freeway systems evolve. When operating on freeways, express buses can provide speeds approaching those of rail rapid transit.

Characteristics of freeway bus operations in selected cities are shown in Table 29. In almost every city, buses generally do not stop until they enter

[18]See: ***Rapid Transit Construction Program***, Board of Transportation, the City of New York, July 25, 1951.

Table 29

UTILIZATION OF FREEWAYS BY URBAN TRANSIT BUSES IN VARIOUS CITIES[1]

CITY	BUS ROUTE	LENGTH OF ROUTE: Terminal to Terminal	LENGTH OF ROUTE: Part of Route on Freeway: Miles	LENGTH OF ROUTE: Part of Route on Freeway: Per Cent	NUMBER OF STOPS ON FREEWAY	RUSH HOUR INTERVALS IN MINUTES	RUSH HOUR SERVICE — BUS SPEEDS IN MILES PER HOUR: Express: On Freeway	RUSH HOUR SERVICE — BUS SPEEDS IN MILES PER HOUR: Express: Terminal to Terminal	RUSH HOUR SERVICE — BUS SPEEDS IN MILES PER HOUR: Local: Terminal to Terminal
Atlanta	Six Lines	11.5	—	—	0	3	—	17	10.0
Chicago	2 — *Hyde Park*	8.5	5.5	65	0	7	36	23	16.0
	5 — *Jeffery*	14.0	5.5	39	0	3	36	13	10.0
	Outer Drive Express	11.5	6.5	57	0	3	38	13	10.0
	LaSalle Express	7.6	4.0	53	0	2	38	11	9.2
Cleveland	39 — *Memorial Shoreway*	—	8.5	—	0	3	21-24	18-20	—
	55 — *Bulkley Blvd.*	—	5.5	—	0	1-½	13	13	—
Dallas	*Five Lines*	—	1.3-3.7	—	0	5-10	—	—	—
Detroit	33 — *Dearborn*	—	3.8	—	0	NA	32	18-20	14-15.0
	41	—	6.7	—	0	NA	40	18-20	14-15.0
	58 — *Plymouth*	—	4.6	—	0	NA	19	18-20	—
Los Angeles	44 — *Beverly*	11.0	3.1	28	0	NA	27	12	10.0
	83	10.0	3.1	31	0	NA	27	11-14	—
	91	15.0	5.2	35	0	NA	27	15	12.5
	93 — *Express*	—	8.0	—	3	NA	23-30	18-20	—
	93 — *Local*	—	4.4	—	2	NA	23-28	15-17	—
	58	—	15.0	—	0	NA	28	—	—
	5	15.6	6.6	42	3	NA	36	17-21	11.2
	7	—	5.6	—	0	NA	37	—	—
Pittsburgh	*22, 23 and 24*	—	—	—	0	NA	—	16.5-25.4	11.6-15.9
Oakland	*Key System Transbay Lines (L)*	13.69 (L)	—	—	0	2-6	43[2]	20-26	—
San Francisco	*30*	—	3.6	—	0	NA	—	—	—
	Greyhound to:								
	San Rafael	13	—	—	0	8	—	28	—
	San Mateo	11	—	—	0	NA	—	—	—
	Redwood City	17	—	—	0	NA	—	—	—
	San Jose	49	21	—	0	NA	—	32	—

[1]Source: Adapted from compilation by DeLeuw, Cather and Company from data in report, *The Utilization of Freeways by Urban Transit Buses: A Nationwide Survey*, by Wolfgang S. Homburger and Norman Kennedy, The Institute of Transportation and Traffic Engineering, University of California, Berkeley. Additional operation via Schuylkill Expressway since time of survey; express buses also operate in St. Louis, Washington, D. C., New Jersey area of New York City, and other cities.

[2]On Key System's "L" Line as observed by DeLeuw, Cather and Company on April 18, 1958.

NA — Not Available.

surface streets. Therefore, most buses have express speeds on the freeway ranging from about 25 to 40 miles per hour with terminal to terminal average speeds ranging from 15 to 25 miles per hour. Six lines in Atlanta, for example, have terminal to terminal speeds of 17 miles an hour; similar operations are found in Dallas, Pittsburgh, and Chicago. Buses serving distant suburban areas, and traveling extended distances on freeways can achieve high over-all speeds. For example, Greyhound express buses operating between San Francisco and San Jose have an over-all speed of over 30 miles an hour.

The Port of New York Authority's Manhattan bus terminal clearly indicates the capabilities of modern freeway bus operation under certain conditions and basic travel patterns. Interurban buses using the terminal have accommodated between 20,000 and 25,000 passengers one direction in the rush hour on peak weekdays. Four hundred and fifty buses arrive regularly each weekday between 8:00 and 9:00 A. M. at this terminal, utilizing a lane in the Lincoln Tunnel; a similar number depart in the evening peak hours.

Fringe Parking and Rapid Transit — Fringe parking has been provided in many cities, often in conjunction with rapid transit or express bus service and has substantially increased the scope and coverage of the transit lines. Examples of successful fringe parking related to rapid transit are listed in Table 30. In virtually every case, average trip times to the core area via transit are comparable to those via auto. Most of these parking areas, however, serve large high-density central business districts, and are not necessarily typical of experiences in other cities.

TRANSIT USE

The role, usage, and relative importance of public transportation varies among cities of different size, type, location, and economy.[19] Factors that affect transit include the density, composition, and spatial distribution of the population, age, and land-use pattern of the city, dominance and location of the central business district, topography as related to opportunities for area expansion, economic levels within the area, and car ownership. Quality of transit service and fares also influence usage.

Transit travel is, to a large extent, made by people who do not have alternate choices available, and often by people who do not usually own cars or have cars available for other uses. For example, school trips by transit represent a substantial proportion of non-CBD travel in most cities.

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[19]Chapter III contains a detailed analysis of transit use factors and characteristics.

Table 30

FRINGE PARKING AT RAPID TRANSIT STATIONS IN SELECTED CITIES[1]

CITY	SPACES	LOCATION	UTILIZATION
Chicago	1,070	Various rapid transit stations	Immediate public acceptance.
Philadelphia	400	Northern terminus of Broad Street Subway	Plans underway to add 200 spaces.
New York City	1,175 initially 1,300 present	Lincoln Tunnel parking by Port of New York Authority	1,734 parkers — maximum day; 8,440 parkers per week. Cost per driver $1.00 (parking and bus). Cost per passenger 58 cents. Bus service every 4½ minutes, peak; every 12 minutes, off-peak.
Boston	Not available	Along rapid transit lines	In 1958, $93,000 was obtained in rental income for 712,000 annual parkers.
Cleveland	5,662	Along rapid transit lines, at 7 stations	Spaces have been continually enlarged.
St. Louis	1,200	Municipal parking in Forest Park	1,500 people daily — 70% formerly drove 5 miles; 14 minutes from CBD by buses running every five minutes in peak and every 15 minutes in off-peak; 30 cents one-way, 50 cents round trip.

[1]Source: American Transit Association, *At Mid-1959, Transit Faces the Future*, edited by W. S. Rainville, Jr.

For people who have a choice, such factors as cost, convenience, and travel time influence their selection of travel modes. Two thirds of suburban railroad riders in Chicago, for example, are people who can drive, but do not because of long average journeys, concentrated destinations in the Loop, cost, and time involved in driving and parking.[20]

Transit does not serve the majority of trips in any urban area — although the proportion of transit travel increases rapidly as the size and density of the urban area increases. *Transit usage was found to increase as car ownership decreases, and was shown to be consistently related to the inter-effects of car ownership and population density.*

The old, densely populated cities, usually with low-car ownerships and high populations, have the greatest proportions of transit travel. Their physi-

[20]*Chicago Area Transportation Study, Vol. I, Survey Findings*, Dec., 1959, conducted under the sponsorship of State of Illinois, County of Cook, City of Chicago, U. S. Department of Commerce, Bureau of Public Roads.

cal layouts and the intensities of their central business districts usually were crystallized before the advent of the automobile; for example, in Washington and Chicago, with urbanized area population densities exceeding 7,000 people per square mile (1950), about 24 per cent of all trips were made by transit. The large and long established eastern cities — New York, Philadelphia, and Boston — have even higher transit usage.

Cities that evolved in the motor age are less intensely developed and more reliant on automobile transportation. In some cases (as Los Angeles) automobile travel has helped create many focal points, thereby tending to de-emphasize the dominance of the central business district. In spread-out cities, such as rapidly growing Phoenix and Houston, with 1950 urbanized area population densities of 4,000 and 2,600 people per square mile, respectively, only about 10 per cent of all person trips are made by transit.

Transit Use Curves — Knowing the factors and characteristics affecting transit, it is believed possible to derive predictive relationships for the purposes of estimating or evaluating transit potentials in any given area. The transit use curves shown in Figure 58 are an outgrowth of the detailed analyses of transit usage and reflect the composite effects of all pertinent factors.[21]

[21] The "transit use factor" represents the product of urbanized area population density and households per car and is plotted along the "x" axis; the per cent of all trips made by transit, within the CBD and the urban area, are shown along the "y" axis. The per cent of travel by transit ranges from 0 to 100 per cent in an "S" shaped curve.

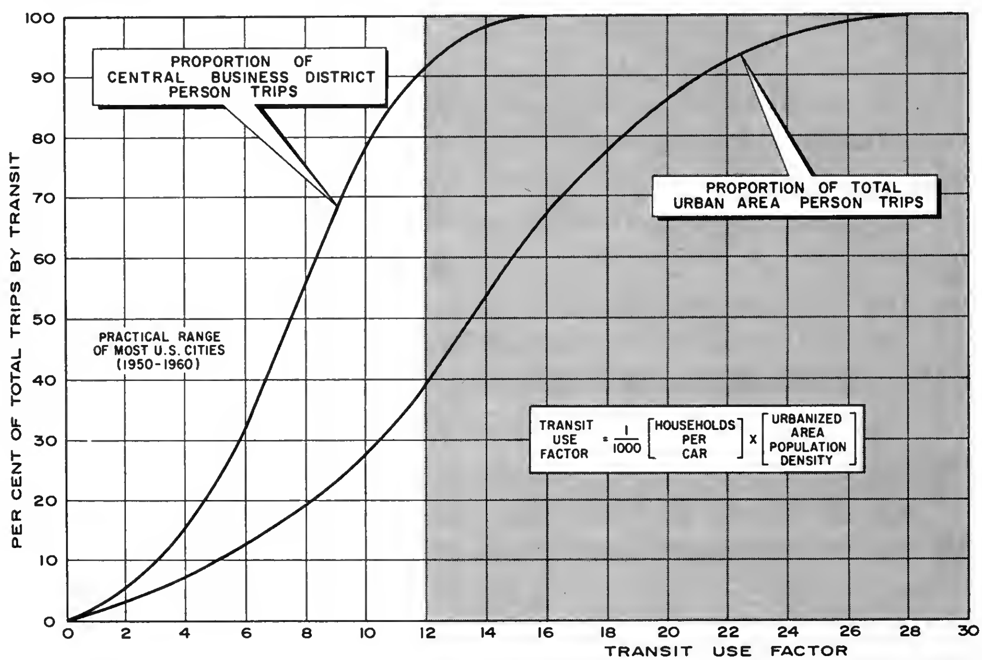

Figure 58
TRANSIT USE CURVES

The curves relate transit usage to car ownership and population density. Transit usage increases as population density and/or the number of households per car increase; the greater the density, and the lower the car ownership, the greater the proportion of transit travel. The curves relate the per cent of total person trips by transit to a "transit use factor," the product of urbanized area population density and households per car. Most present-day American urbanized areas have transit use factors under 12, and the practical range of the curve is generally below 10.

The curves clearly show that transit is more extensively used by people traveling to and from the central business district. The CBD transit use curve builds up more rapidly than the area-wide use curve as the transit use factor increases. For example, residents in an urban area with a transit use factor of 10, typical of the large transit-oriented cities (Chicago, Washington, Philadelphia, and Boston), would make about 27 per cent of their total trips and about 77 per cent of their downtown trips by transit.[22] Residents in an urban area with a transit use factor of 5 (typical of medium-sized cities such as Nashville) would make about nine per cent of their total trips and about 22 per cent of their downtown trips by transit.

In two areas with the same densities, but with different levels of automobile ownership, the area with greater ownership will generate fewer trips by mass transportation. Similarly, where two areas have the same car ownership, the area with the greater population density will have more trips by transit.

A 20 per cent change in the "transit use factor" resulting from a reduction in urban density and/or a decrease in the dwelling units per car, assuming constant levels of fares and no basic changes in service, would tend to reduce the proportion of urban area trips by transit between 25 and 30 per cent in large areas and about 20 to 25 per cent in smaller areas.

The curves afford a rationale for anticipating over-all present and future use of transit within the urban area, assuming no substantial changes in the economy of the area, the quality of service, or the fare structure. They may be used to test, in a very general way, the feasibility of future transit potentials within an urban area and, also, as an approximate guide in long-range planning.

The specific use of transit, in any area or zone, will depend on the specific distribution of origins and destinations around the available or planned transit facilities. Restraints on auto travel, such as in the Chicago Loop or Manhattan, will also influence usage.

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[22]A transit use factor of 10 corresponds to one household per car and an urbanized area population density of 10,000 people per square mile, (e. g. 10,000×1), or to a community with 1.25 households per car and a density of 8,000 people per square mile (e. g. — 1.25×8,000).

Use of Specific Facilities — Within an urban area, the choice of mode of travel on any specific trip depends on relative time, comfort, convenience, out-of-pocket costs, and availability of alternate travel modes.

Hartford, Conn. — A study of car ownership, in relation to transit users, in Hartford, Connecticut, in September, 1960, showed approximately 39 per cent of all bus riders without a car for family use and, therefore, completely dependent upon bus transportation. Forty-nine per cent of all bus riders had one car for family use — presumably these people rode transit whereas other members of the family drove cars; 10 per cent of all bus riders had two cars for family use and two per cent had three or more cars.[23]

Approximately 80 per cent of all riders were traveling between home and work; similarly, 82 per cent of all riders reported daily usage of buses. Bus riding was also influenced by proximity of destinations to bus routes — only 13 per cent of all riders walked more than a quarter of a mile to or from bus stops.

Cook County, Ill. — Results of a transportation usage study conducted in Cook County, Illinois, in 1957 and based on information received from 806 transit riders and 1,304 automobile travelers are summarized in Table 31. One third of all persons indicated "less time" as their reason for choosing their travel mode; "comfort", "car necessary", and "no other means" were cited by about 17, 13 and 13 per cent of the total, respectively.

Twenty-seven per cent of all transit riders used public transportation because of time saved; 15 per cent because no other means was available; 16 per cent because less walking was required; and 13 per cent because of lower cost. Automobile passengers cited less time (36 per cent); greater comfort (24 per cent); car necessary (21 per cent); and, no other means (11 per cent), as the principal reasons for choosing automobile travel.

Diversion Curves — In determining potential use of specific facilities, conventional time or cost-ratio techniques are used.[24] These trip assignment methods apportion travel between a trip's origin and destination by way of alternate routes according to the relative time or cost advantage of one route over another. In the case of freeway assignments with a time-cost ratio of one, a freeway will attract about 40 per cent of the total travel between an origin and destination.

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[23]Wilbur Smith and Associates, *Mass Transportation in the Capitol Region,* Hartford, Conn., 1960. See Table A-34, Appendix C.

[24]Circular Memorandum to Division Engineers from E. H. Holmes, Deputy Commissioner, subject: *Guide for Forecasting Traffic on Interstate System,* Bureau of Public Roads, Washington, D. C., Oct. 15, 1956.

TABLE 31

REASONS FOR CHOICE OF TRAVEL MODE
COOK COUNTY TRANSPORTATION USAGE STUDY[1]

	MASS TRANSIT				AUTOMOBILE				TOTALS	
REASON	*Central Business District*	*Out-lying*	*Total*	*Per Cent*	*Central Business District*	*Out-lying*	*Total*	*Per Cent*	*Grand Total*	*Per Cent*
Less Time	127	92	219	27.2	38	428	466	35.7	685	32.4
Comfort	34	15	49	6.1	37	281	318	24.4	367	17.4
Car Necessary	0	0	0	0.0	41	222	263	20.2	263	12.5
No Other Means	2	120	122	15.1	8	140	148	11.3	270	12.8
Less Walking	34	95	129	16.0	5	35	40	3.1	169	8.0
Less Cost	58	44	102	12.7	0	9	9	0.7	111	5.3
All Other	59	126	185	22.9	4	56	60	4.6	245	11.6
	314	492	806	100.0	133	1,171	1,304	100.0	2,110	100.0

[1]Source: Cook County Highway Department, Traffic Engineering Division, *Transportation Usage Study, 1957.*

Transit assignment curves, as depicted in Figure 59 for Washington and Chicago, have generally been used to assign traffic to proposed transit systems and thereby determine their potentials. These curves are applicable primarily to the assignment of trips to rapid transit by diversion from local transit, local streets, and the freeway system; they are consistent except that the Washington diversion curve is slightly more conservative.

When travel times were equal by transit and by auto, about 40 per cent of the trips were made by transit. However, on an "equal-cost" basis, less than 10 per cent of all trips were potential to transit.

Diversion To Rapid Transit – Rapid transit can attract patrons from automobile transportation, especially where roadways are congested and parking costs are significant.[25]

In San Francisco, where freeway congestion is severe in rush hours, motorists who now ride freeway buses account for seven per cent of the total transit passengers. In Toronto, 13 per cent of the passengers boarding the subway at the Eglington terminus formerly traveled by auto. In Chicago, about 13 per cent of transit riders on the Congress Street rapid transit route formerly traveled by car – most via the expressway. In Cleveland, about 17 per cent of all rapid transit riders were diverted from driving with the greatest diversions by motorists having direct highway access to transit stations.

Examples of Transit-Oriented Trips – Illustrative examples of transit-oriented trips (that would generally be favored by diversion curves) include the following: in New York City between Lower and Midtown Manhattan, and between Morningside Heights and Midtown Manhattan; in Chicago between Uptown Chicago, Logan Square, Oak Park, and the Loop; in Philadelphia between City Hall, West Market Street, and North Broad Street; in Boston between downtown Boston and central Cambridge; in Cleveland between Terminal Square (downtown) and Shaker Heights; in Toronto between downtown and points along Yonge Street; in Washington, D. C., along Pennsylvania Avenue and 14th Street in and adjacent to central Washington; in San Francisco along Market Street in the downtown area; in Los Angeles along Wilshire Boulevard; and in Miami Beach along Collins Avenue.

Most of these situations involve central business district-oriented trips in high-density areas; often, both trip termini lie along a rapid transit route; transit service is usually frequent and comparatively rapid, parking in core

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[25]Studies of commuters' attitudes, based on questionnaire surveys in Washington, Los Angeles, San Francisco, and South New Jersey, have indicated that about one third of all auto drivers would ride improved rapid transit, but that another third would not be potential riders because of their dependence on, and conditioning to, auto transportation. The proportion of auto drivers diverted to existing rapid transit facilities, as shown by experiences in several cities, has been less.

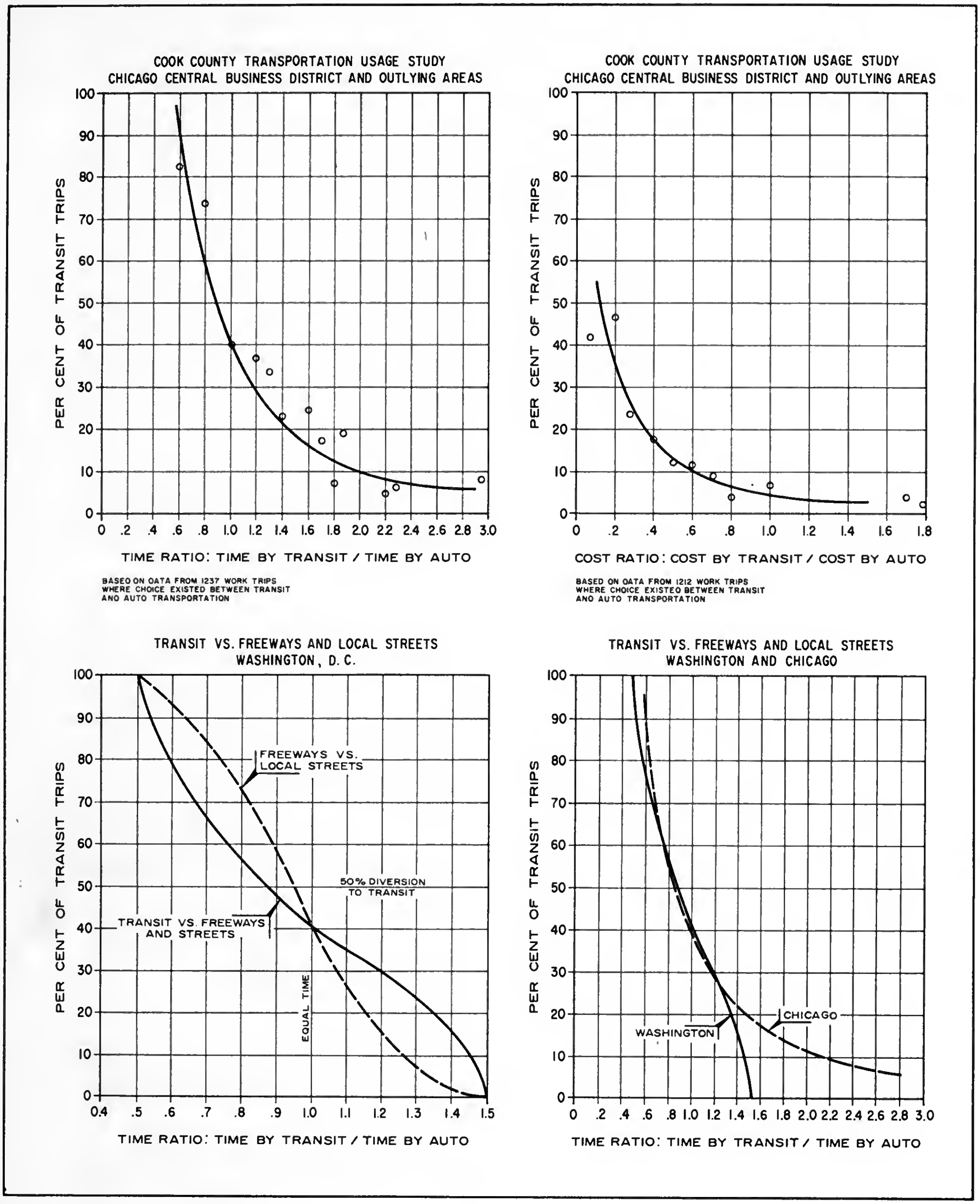

Figure 59
TYPICAL TRANSIT DIVERSION CURVES

areas is difficult and costly; and, substantially shorter walking distances are required of transit users. These situations, however, are not typical and are largely limited to the specific cities listed.

One of the most successful transit operations in the country is the free bus service in Colonial Williamsburg, Virginia. Since its inception in 1951, bus loadings have increased more rapidly than visitation.[26] Since 1953, the number of annual visitors has increased 34 per cent; the number of bus riders, 195 per cent; and the average rides per visitor, 120 per cent. Williamsburg is transit-oriented insofar as the concentration of origins and destinations is concerned. It shows how transportation may be related to land use to minimize vehicular travel and make full use of public transit. It appears unique in its success.

FUTURE RAPID TRANSIT

Future rapid transit will include extension and modernization of existing service, construction of several new systems, limited construction of new facilities to augment freeways, and extensive freeway bus operations.

Trends – Trends in rapid transit planning and operations are toward consolidation, simplification, and modernization of existing rail systems in the large cities and extension of freeway bus operations. Extensions of existing rail systems are being generally limited to high-density areas, as in Toronto, or integration with freeway construction, as in Chicago and Philadelphia. Throughout the country express bus operations are being more extensively developed.

Route Location – Most rail rapid transit facilities recently built, or in advanced planning, traverse railroad rights-of-way or freeway median islands. Chicago has curtailed suburban extensions whereas Philadelphia and Boston are planning suburban extensions.

Station Spacing – Most existing rapid transit lines have stations approximately a half mile apart, while new lines usually have stations planned at one to two-mile intervals.

Speeds – Speeds are being increased by spacing stations farther apart (Cleveland), alternate stop operations (Chicago), and extended zones of express service (New York).[27]

Load Factors – To provide greater comfort, the number of standees should be minimized, especially on buses.

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[26]Wilbur Smith and Associates, *Traffic and Parking, Colonial Williamsburg, 1960,* and *A Plan of Bus Operations, Colonial Williamsburg,* March, 1956.

[27]In New York City, certain express tracks in Manhattan have inadequate capacity, requiring trains to operate on local tracks. In Chicago, the same situation existed until local service was virtually eliminated to provide additional express capacity.

Shuttle Operations – Rapid transit is being used increasingly as a "shuttle" between the central business district and outlying stations where fringe parking is provided.

Equipment – Modern PCC-type cars are being put into service on many rail rapid transit lines; however, it has been estimated that about 275 new cars per year will be required to modernize existing equipment over the next 10 years.[28]

Prototypes of a 70-mile-per-hour car were placed in experimental operation in Chicago in May, 1960. Illustrative gains in speeds through use of this equipment, shown in Table 32, permit savings of 20 seconds per mile and over-all increases of 15 to 20 per cent. In Cleveland, for example, the average speed would approach 36 miles per hour. Similar improvements in motor bus performance can be anticipated in future years.

[28]Transit Research Corporation, *TRC News Letter, Volume 1, No. 4,* New York City, October, 1960.

TABLE 32

RAPID TRANSIT TRAVEL TIMES
WITH
HIGH PERFORMANCE CARS[1]

	ROUTE	
ITEM	*Congress Street Rapid Transit Chicago*	*Cleveland Rapid Transit*
Length of Route	9.5 miles	15 miles
Stations	16	14
Present Operations with PCC Cars		
Time	22 minutes	30 minutes
Speed	26 miles per hour	30 miles per hour
Anticipated Operations with High Performance Cars		
Time	18.8 minutes	25 minutes
Speed	30.2 miles per hour	36 miles per hour
Per Cent Change		
Time	—15 per cent	—17 per cent
Speed	+16 per cent	+20 per cent

[1]Source: Calculations based on data received from General Electric Company on *High Performance Rapid Transit Cars,* October, 1955.

Automation — Automation will be used more in both rail and bus rapid transit. Multiple control of train doors was initiated some 40 years ago; automatic operation of junction points through the use of train identifiers was initiated in Chicago about 1953; and in 1955, an experimental multiple-unit electrically propelled car was remotely controlled between Larchmont and Rye, New York, on the New Haven Railroad. A fully automatic passenger train, demonstrated in October, 1960, by the New York City Transit Authority, is scheduled to operate soon in the 42nd Street Shuttle. Automation is also being studied for multiple zone fare collection in San Francisco, and for the operation of freeway buses in Chicago.[29]

Rapid Transit Plans — Rapid transit improvement proposals have included new or extended rail systems in New York, Chicago, Philadelphia, Boston, San Francisco, Oakland, Toronto, Cleveland and Washington. Bus systems have been proposed for Baltimore, St. Louis, and Vancouver, B. C.[30]

New York City is currently constructing a short $58 million link between two of its rapid transit divisions, and is improving operations on all lines. A $400 million bi-state rapid transit loop has recently been proposed between New York and New Jersey.

In Chicago, a two and one-half mile route is being elevated at a cost of $4 million. The Chicago Transit Authority has proposed a 20-year $315 million public-financed program of rail and bus rapid transit extensions and improvements, mainly in freeway median islands.

Philadelphia is planning a $160 million 10-mile subway extension and a six-mile trolley extension to be financed from city revenues. A proposed $89 million extension into New Jersey over existing railroad rights-of-way would serve 24 million passengers annually. The Passenger Service Improvement Corporation has proposed integration of rail-commuter lines.

New Jersey has enacted legislation enabling the state to contract with commuter lines, and has appropriated $6 million for a one-year subsidy.

Toronto is constructing its 10-mile, $200 million Bloor Street Subway, and Cleveland is considering extension of its system and construction of a downtown subway loop.

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[29]Transit Research Corporation, *TRC News Letter, Volume 1, No. 4,* New York City, October, 1960.

[30]Additional details are contained in Appendix B. Data have been compiled from various transit reports and proposals in each city, and from information received from American Transit Association.

Boston is considering a one-mile $21 million subway link to serve its new Prudential Center, and possible extension of rail or bus rapid transit to the South Shore.

In San Francisco, where topography limits all transportation routes, a $1 billion, 100-mile interurban rapid transit system is planned, with 32 miles of additional right-of-way acquisition; a 3.6 mile underwater tube would be financed through surplus Bay Bridge automobile tolls.

In Los Angeles, a proposed $529.7 million 75-mile network of rubber-tired trains would include four radial routes; over 40 per cent of the system would follow existing or former interurban lines.

A recommended all-bus rapid transit system for St. Louis includes 42 miles of grade-separated exclusive bus roadways and 44 route miles of operation over sections of present and proposed expressways. The $175 million system — in many respects a prototype of future urban rapid transit — has six radial routes, one crosstown route, an elevated downtown bus loop, and 9,000 parking spaces at transit stations.

A 15.9 mile, $59 million rail rapid transit plan using railroad rights-of-way wherever possible, has been recommended for Atlanta.

A monorail between downtown New Orleans and the Moisant International Airport was considered infeasible and contrary to the public interest by the city's Department of Public Utilities.

The $2 billion transportation plan for Washington, D. C., includes eight express bus routes totaling 66 miles of one-way route, four rail rapid transit routes totaling 34 miles of double track, (half in freeway medians), 329 miles of freeways and about 50,000 parking spaces.

Comparative Aspects — It is apparent that there is wide variance in the nature and extent of the various rapid transit proposals. As shown in Table 33, they range in size from the 16-mile-Atlanta system to the San Francisco and Washington systems, each about 100 miles long. In Atlanta, Philadelphia, San Francisco and Los Angeles, fixed-rail facilities are proposed; the Washington plan includes both bus and rail rapid transit; and the St. Louis plan calls for an all-bus system.

Estimated annual patronage of the systems range from about 11 million in Atlanta, to over 128 million for the Washington and San Francisco rail systems. By way of comparison, the Chicago rapid transit system carried 113 million passengers and the Philadelphia system 73 million passengers in 1959. It would

TABLE 33

COMPARISON OF PROPOSED RAPID TRANSIT SYSTEMS[1]

ITEM	CITY							
	St. Louis 1980	*San Francisco 1980*	*Los Angeles*	*Philadelphia-New Jersey Ext. (1962)*	*Atlanta 1970*	*Washington, D. C. 1980*		
Type System	All Bus	Rail	Rail	Rail	Rail	Rail	Bus	Total
Miles (Approx.)	42	100	74	28	16	34	66	100
Capital Costs[2]	$175,000,000	$818,630,000	$529,700,000	$89,600,000	$59,000,000	$475,860,000	$88,230,000	$564,090,000
Gross Income[3]	$ 5,277,700	$ 23,552,000	NA	$ 4,538,000	$ 2,370,000	NA	NA	$ 15,140,000
Net Income (Reserve or Deficiency)	–$6,106,200	–$52,248,600	NA	–$1,251,500	–$1,468,009	NA	NA	–$21,554,500
Passengers Per Year[4]	78,060,000	128,040,000	NA	24,390,000	11,250,000	125,400,000	102,600,000	228,000,000
Cost Per Passenger	$0.305	$0.791	NA	$0.347	$0.503	$0.412	$0.230	$0.330
Passenger Miles Per Year[4]	426,629,000	1,638,400,000	NA	121,946,000[5] 187,919,500[6]	56,250,000	975,335,700	608,520,000	228,000,000
Cost Per Passenger Mile	$0.056	$0.062	NA	$0.070[5] $0.046[6]	$0.095	$0.053	$0.039	$0.048

[1]See Tables A-35, A-36, Appendix C, for details and sources.
[2]Capital costs amortized for 30 years at five per cent.
[3]Before payment of capital costs.
[4]Assumes 300 days per year.
[5]Extension only.
[6]From downtown Philadelphia.
NA – Not Available.

appear, therefore, that estimates of patronage for some of the new systems may be somewhat optimistic, particularly in view of the comparative low population densities in their respective urban areas.

Cost-income analyses indicate that anticipated revenues will exceed operating costs. *In all cities net incomes are insufficient to meet amortization of capital costs; in no case can the rapid transit system be developed as a self-liquidating project.*[31]

The total annual operating and capital costs per passenger ranges upward from 23 cents per bus rider in Washington, to about 79 cents in San Francisco. The St. Louis, Washington, and Philadelphia plans involve costs averaging about 30 to 35 cents per passenger. On a passenger mile basis, total costs range upward from about four cents per passenger mile for buses in Washington to about 10 cents in Atlanta. Total costs for most plans range from about five to six cents per passenger mile.

Types – The various kinds of rapid transit equipment, proposed in recent years, include monorail, helicopter, and rubber-tired trains, as well as conventional trains and buses.

Air Facilities – Seven, 12, or 25-passenger helicopters, costing from $150,000 to $500,000 each, exclusive of some necessary accessories and certain special navigational instruments, can attain maximum speeds of 100 to 150 miles per hour, and can operate from heliports in open areas, or on roofs, where there are adequate glide angles. Their use in metropolitan areas will probably increase in the future, but will be limited by high capital costs, landing space requirements, air-ways capacity, passenger capacity requirements, high passenger fares, and weather restrictions.

Conventional Fixed-Rail – Rail rapid transit is usually located in subways through congested areas, whereas in outlying areas it may also be elevated either on-street or off-street, depressed in private rights-of-way or in the center strip of freeways, located adjacent to grade separated railroad facilities (Cleveland), or use parts of abandoned railroad rights-of-way (Boston). Future improvements in "conventional" equipment may substantially enhance its efficiency and attractiveness.

One variation of the supported rapid rail system involves use of pneumatic-tired railway cars which are supported by rails and supplementary flanged

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[31]Based on 30-year debt service at five per cent interest. See Table A-35, Appendix C.

wheels. This equipment is used in parts of the Paris Metro System and was recently recommended for Los Angeles, and can provide a smoother and quieter ride than conventional rail cars.

Special Track Structures — "Monorail" facilities include cars or trains supported from underneath by a single rail, cars suspended from an overhead rail, or cars hung from two closely spaced rails. To date, most monorails have been experimental or amusement park installations, as those at the Dallas Exposition, Disneyland, and that planned for Seattle's "Century 21" Exposition.

A monorail in use as a public transit facility is the Schwebebahn, an 8.3 mile, double-track line completed in 1903 between Vohwinkel and Wuppertal — Oberbarmen, Germany. The scheduled running time on the 18-station route is 32 minutes with an average speed of about 16 miles per hour, maximum speeds are about 25 to 28 miles per hour.[32]

Monorail facilities require continuous elevation of trains, even where ground-level operation is permissible, or where routes traverse subways.

Conveyor Belts — Systems of moving belts or sidewalks, while useful for transporting large numbers of persons short distances are impractical for long-distance travel because of their restricted speed — three to five miles an hour. They would require off-street structures, either overhead or underground, where routes cross existing streets. Where belts intersect, separated grades or a "walking transfer" across the point of intersection would be required. Their use appears limited to special situations.

Buses — Pavement-borne rapid transit includes all rubber-tired vehicles, motor buses, trolley buses, and the experimental automatic-conventional bus now being studied in Chicago.

Comparative Characteristics — Despite the many possible types of rapid transit equipment, conventional fixed-rail and bus operations appear to be the most common. Accordingly, their comparative merits have been summarized in Table 34. While rail transit has certain superior operating advantages and qualities, it is generally more restrictive in scope, limited in coverage, and more expensive to construct. *In most typical metropolitan areas, express bus systems carefully integrated with freeways, can offer advantages in convenience, travel time, and capital costs over rail systems.*

Capital Costs — The cost of a supported rail rapid transit system varies in each city and is dependent on local conditions, type of construction, route location and design. Total capital costs, including equipment, range from about

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[32]Waterbury, Lawrence S., "Mass Transportation by Monorail," *Traffic Quarterly*, Vol. XV, Number 1, January, 1961.

TABLE 34

RAIL AND BUS RAPID TRANSIT CHARACTERISTICS[1]

FACTORS	*RAIL RAPID TRANSIT*	*BUS RAPID TRANSIT*	
		In Freeway	*In Exclusive Lane*
Initial cost in fixed facilities	High on all parts of system	Little or none	Moderate
Cost of rolling stock	About $1200 per rush-hour passenger	About $400 per rush-hour passenger	About $400 per rush-hour passenger
Life of rolling stock	About 40 years	About 10 years	About 10 years
Capacity per track or lane	Up to about 40,000 passengers per hour	6,000-7,000 per hour with stops	Up to about 20,000 passengers per hour
Rush-hour passengers per operating employee	Up to about 400	Up to about 65	Up to about 65
Operating speeds	High, limited only by design of system and station spacing	Variable, depends on conditions of surrounding traffic stream	High, limited only by design of system and station spacing
Safety	High, through reliance on automatic signals, controls	Variable, depends on conditions of surrounding traffic stream and human factors	Somewhat variable
Speed	Superior in congested areas; little advantage in low-density areas	Inferior in congested areas, little difference in low-density areas	May be inferior in congested areas depending on downtown delivery
Route Coverage	Inferior in low-density areas, must rely on feeder service by buses or private autos	Superior in low-density areas; does not require feeder lines	Superior in low-density areas; does not require feeder lines
Vehicle Comfort	Superior, larger vehicles; smoother operations	Inferior, smaller vehicles	May be inferior
Flexibility	Restricted	Full	Full

[1]Source: Adapted from Homburger, Wolfgang S., "Rapid Transit: Present and Future," *Traffic Quarterly*, Vol. XIV, April 1, 1960.

$4 million to $20 million per mile. In special cases (as in Cleveland), lower costs have been reported.[33]

Total capital investment in a bus rapid transit system is less than for a rail system since buses can operate on freeways and need no special rights-of-way, signal systems, or power facilities. Also, existing bus equipment can be used initially and replaced as needed and special shops for car maintenance are not required. Substantial costs will, however, be incurred whenever grade-separated central business district bus-ways are required.

Operating Costs — Operating costs are generally less for rail since two to ten-car trains require only two men, while buses require one man per vehicle.[34] Some of this differential will be offset by fare collection on buses, thereby eliminating station cashiers, and by not requiring yardmen and interlocking plant operators; future operating costs, especially for trains, will be further reduced by greater automation.

Passenger Capacity — Rail rapid transit can carry 35,000 to 40,000 persons per hour when standing space is included and a maximum of 20,000 seated passengers per hour assuming 10-car trains, 50 seats per car, and 90-second headways (as found in New York City); with six or eight car trains, (as in Cleveland or Chicago) capacities are less.

Buses on freeways can provide up to 22,500 seats per hour, assuming use of 400 to 450 fifty-seat buses per hour with no stops and unimpeded use of freeway lanes. About 120 buses per hour with 6,000 seats can be provided where buses stop at stations along freeways; however, if turn-outs or passing lanes are provided at these stations, higher capacities can be achieved.

Downtown-grade-separated distribution facilities for express buses can be provided although capacities will be less than for rail lines.

Speeds — Rail rapid transit currently provides slightly better operating performance, although station frequency is usually the principal factor in determining speeds. Both buses and trains can attain average speeds of 30 miles per hour with nominal station spacing; they can attain somewhat greater speeds by lengthening distances between stations to two or more miles or by instituting express operations. Free running speeds of over 50 miles per hour are difficult to attain because of station spacing, and average speeds exceeding 45 miles per hour are almost entirely limited to main-line railroad service.

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[33]Reported construction costs vary from about $2 million per mile in open areas where land costs are low, cross streets are negligible, and surface or railroad rights-of-way are available, to $5.5 million per mile or more in "open-cut" sections. Elevated structures generally cost about $4 million per mile; subways upwards from $10 or $15 million per mile. Example: the 4.5 mile combination open-cut and subway in Toronto cost $12 million per mile; the Congress Street median transit line in Chicago, about $4 million per mile. The Cleveland Rapid Transit system, constructed mainly on railroad rights-of-way some 30 years ago, cost about $2 million per mile to complete; however, if fully constructed today, it would cost about $5 million per mile.

[34]For example, maintenance and operating expenses in Cleveland approximate 47 cents per vehicle mile for rail rapid transit, compared with 63 cents for surface motor buses.

Flexibility — Motor buses, operating on their own rights-of-way or in freeways, provide the greatest flexibility since they can operate on any paved route and are not restrained by overhead power wires or tracks. This flexibility assures more convenient service, with a minimum of transferring and shorter walking distances. The same bus can provide rapid transit to a wide area via special grade-separated bus-ways and local distribution over city streets. Fixed-rail facilities, however, because of capital costs are limited to "trunkline" operations which necessitates off-line feeder service and transfers. Rail lines generally serve fixed areas of a city. Buses can be introduced progressively as freeways are built and can be effectively operated in areas where demands do not warrant rail service.

FREEWAYS AND RAPID TRANSIT

In planning integrated urban transportation systems, it is desirable to know how freeways compare with rapid transit in terms of cost and service rendered, and how they may complement each other.

Freeways Aid Transit — Freeways are not incompatible with transit. Rather, they can benefit public transportation in several ways. The fact that many plans for new fixed rail transit include considerable mileage of operations adjacent to or within freeways, further points up the need for urban freeway development, and values to transit.

First, freeways provide roadways and/or rights-of-way for transit that could be duplicated only at enormous expense. Second, bus companies operating on freeways report gains in speed even where buses are interspersed with other freeway traffic. Third, freeways relieve local streets of considerable travel, thereby permitting faster and more efficient local transit operations. Although present Interstate standards do not provide any special transit facilities, often they can be used by express buses operating in regular traffic lanes.

Transit on Congress Expressway — The most heralded and notable example of freeway and transit integration is Chicago's 9.5 mile rapid transit line in, and parallel to, the Congress Street Expressway which was financed jointly by city, county and state agencies, with the city's expenditures for fixed equip-

Rapid Transit on Freeways, as Illustrated by the Express Bus Leaving a Turnout on the Hollywood Freeway, California

ment being reimbursed by the Chicago Transit Authority. It replaces the old Garfield Park elevated, whose route it closely follows, and includes about one mile of subway (linking it to an existing subway), 5.5 miles of median strip right-of-way, and 3.0 miles parallel to the expressway. Sufficient right-of-way exists for future addition of one or more tracks when justified along sections of the route.[35]

Scheduled speed is approximately 26 miles per hour, and maximum running speed is 50 miles per hour. Running time on the Congress Street rapid transit route was reduced to 22 minutes from 28 minutes before expressway construction, and from 39 minutes during the interim construction period.

A 12-hour passenger flow map for the Congress Street rapid transit routes is shown in Figure 60 for a typical day in May, 1959. Approximately 76,000 passengers passed the maximum load point (Racine Avenue), of which over 60,000 traveled in the 12 daytime hours; these passengers were divided equally between the two rapid transit routes using the expressway at this location. The corridor increase in mass transportation passengers was 23 per cent between 1959 and 1960, compared with a six per cent increase in over-all metropolitan area passengers.

As shown in Table 35, trains on the two rapid transit routes using the expressway right-of-way carry about 57 per cent of the 17,500 peak-hour passengers and 36 per cent of the 208,700 daily total passengers. When only the Congress Street rapid transit route is compared to the expressway, trains carried 40 per cent of the 12,600 peak-hour passengers and 22 per cent of the 171,200 24-hour passengers.

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[35]Gunlock, V. E., *Chicago's Rail Rapid Transit Line in the Congress Experssway*, presented at the annual convention of the American Society of Civil Engineers, Boston, Mass., Nov., 1960.

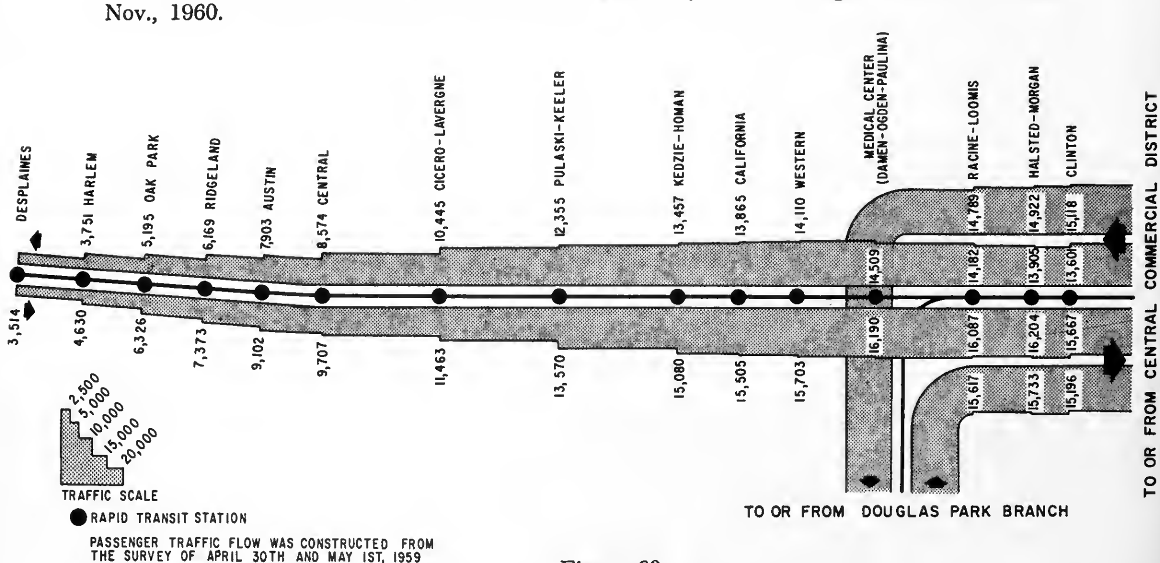

Figure 60
PASSENGER TRAFFIC FLOW
CONGRESS RAPID TRANSIT
CHICAGO, ILLINOIS

TABLE 35

PASSENGER USE OF CONGRESS STREET EXPRESSWAY TYPICAL 1959-1960 WEEKDAY[1]

MODE	PERSONS CARRIED: Peak Hour (Eastbound - AM or Westbound - PM) Number	Peak Hour Per Cent West of Douglas Junction	Peak Hour Per Cent East of Douglas Junction	24 Hours Number	24 Hours Per Cent West of Douglas Junction	24 Hours Per Cent East of Douglas Junction
By Autos in Expressway	7,500	59.5	42.9	133,000	77.6	63.7
By Congress St. Trains	5,100[2]	40.5	29.1	38,231	22.4	18.3
Sub-Total	12,600	100.0	72.0	171,231	100.0	82.0
By Congress-Douglas Trains	4,900[2]		28.0	37,479		18.0
Grand Total	17,500		100.0	208,710		100.0

[1]Source: Chicago Transit Authority; also, Gunlock, V. E., *Chicago's Rail Rapid Transit Line in the Congress Expressway,* presented at the annual convention of the American Society of Civil Engineers, Boston, Mass., Nov., 1960.

[2]These trains travel about two miles on the Congress Street Expressway. Other cited values show the trains' peak-hour load to approach 12,000 people.

Comparative Capacities – Rapid transit is more efficient than the automobile in terms of peak-hour passenger-carrying capacity. It can deliver large numbers of people directly into a concentrated area, and can achieve maximum benefits when *properly* integrated with freeways.

However, specific comparisons of freeway and rail rapid transit capacities usually involve many varying assumptions. Although 40,000 people *can* be moved on one rapid transit track, there are relatively few locations where this actually takes place. At an occupancy of 1.8 persons per car, each freeway lane can carry about 3,200 to 3,600 people per hour; with five people per car, 10,000 persons per lane would be possible. Such comparisons, however, are based on what rail rapid transit and freeways *could* both do, not what *actually* occurs.[36]

A more realistic comparison would relate capacities of rail rapid transit trains with buses operating on freeways. Buses fully utilizing two lanes of an eight-lane freeway (or in a separate reservation parallel to six traffic lanes), would carry approximately 6,000 people per hour in the heavier direction of flow. Cars using the other three lanes could carry up to 10,000 people per hour.[37]

[36]Holmes, E. H., *Urban Transportation Planning and the National Highway Program,* presented at the 1960 annual meeting of the American Association of State Highway Officials, Detroit, Mich., Dec., 1960.

[37]If there are no transit stops on the freeway, higher capacities could be provided by buses.

Thus the effective capacity of an eight-lane freeway may be as great as 16,000 people per hour. Such corridor capacities are adequate for person movements in most urban areas.

The number of daily passengers actually carried by freeways is often comparable to that carried by many rapid transit lines. Almost as many people traverse Los Angeles' famed four-level freeway operation each day as use rapid transit in Chicago.

The decline in traffic as distance from downtown increases is more pronounced on transit lines since they do not usually serve non-CBD oriented travel. The total number of people and the total passenger miles of travel is, therefore, greater than that served by a transit line when both have comparable passenger volumes at maximum load points.

Relief to Freeways – While rapid transit is well adapted to serving downtown, the home end of the trip is often difficult to serve. Therefore, the "supply" of transit, in terms of its capacity, must be matched against demands, and the cost of providing the facilities must be equated to the revenues produced by potential riders. Analyses of proposed rapid transit plans have shown that good rapid transit systems are costly to provide, despite their limited coverage; they do, however, provide valuable capacity in high-density corridors that would otherwise be difficult to obtain.

The proposed comprehensive transit plans are generally limited in coverage and scope, particularly when compared to the proposed freeway systems. They represent, in the aggregate, a relatively small proportion of the total urban transportation needs. They are generally limited to a few routes in large and select cities, and involve average costs of about five to six cents per passenger mile, based on what often appear to be optimum patronage estimates. In several cases, the extent of new rights-of-way could have been reduced by more effective integration with freeways.

Just as freeways do not obviate the need for transit, neither is rapid transit a substitute for freeways. Provision of rapid transit facilities has virtually no effect on *over-all* freeway needs in most urban areas.

To evaluate the impact of rapid transit on freeway requirements, four alternate plans were studied in Washington, D. C. The recommended combined transit and highway plan was found to require about 95 per cent of the freeway route miles, and 87 per cent of the freeway lane miles required by an all-auto plan.[38]

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[38]DeLeuw, Cather and Company, *Civil Engineering Report, Mass Transportation Survey, National Capital Region,* Washington, D. C., Jan., 1959. See Table A-37, Appendix C.

Comparative Travel Times – Comparative travel times via automobile and transit are depicted in Figure 61 for varying conditions.[39] Portal-to-portal trip times are generally shortest via freeways and rapid transit, and longest via arterials and surface transit. In most cities, freeways will consistently provide faster portal-to-portal time, since time lost in walking, waiting and transferring to rapid transit more than offsets time lost in parking and unparking, and since running speeds on freeways and rapid transit are generally comparable, depending on specific route design. Favorable total trip times via rapid transit are conditioned on inability to provide parking near downtown destinations, location of residence near the transit station, and inadequate freeway capacity.

Comparative Costs – The average annual cost of owning a car, (assuming yearly travel of 10,000 miles) is about 10 cents per mile, which for an occupancy of 1.7 people per car corresponds to almost 6 cents per passenger mile. Assuming that user taxes pay for freeway construction, the total cost per passenger ride of freeway travel approximates six cents. Thus, total cost of providing facilities for rapid transit and motorists are about the same (about six cents per passenger). Obviously, the contention that mass transportation is substantially cheaper than automobile travel is subject to question.

When construction costs are expressed in terms of peak-hour capacities, rapid transit is usually less costly than freeways. However, when measured by daily passengers served, freeways often have lower costs per passenger served. The balance toward freeways is even more favorable when weekends and holidays are considered.

Analyses of out-of-pocket costs – those costs that the motorist actually considers – also indicate the relative comparability of the two modes. Once a car has been purchased, only extra or marginal costs can be assigned to a trip. Fuel, oil, and repairs total about 4 cents per vehicle mile. These costs average about 2.3 cents per passenger mile for occupancies of 1.7 persons per car, and 2 cents per passenger mile for an occupancy of two persons per car.

Out-of-pocket auto costs are compared with costs of a 25-cent transit fare in Figure 62. Marginal costs of automobile travel are less than for transit when parking is free or low-cost, when there are several occupants in the car, or when trips are short. However, when parking costs are high, transit is usually more economical. Thus, in many cases it is cheaper to travel by car.

POTENTIALS FOR RAPID TRANSIT

The need for rapid transit will be contingent upon the future size and intensity of development within the central business district, on urban area

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[39]See Table A-38, Appendix C, for detailed assumptions.

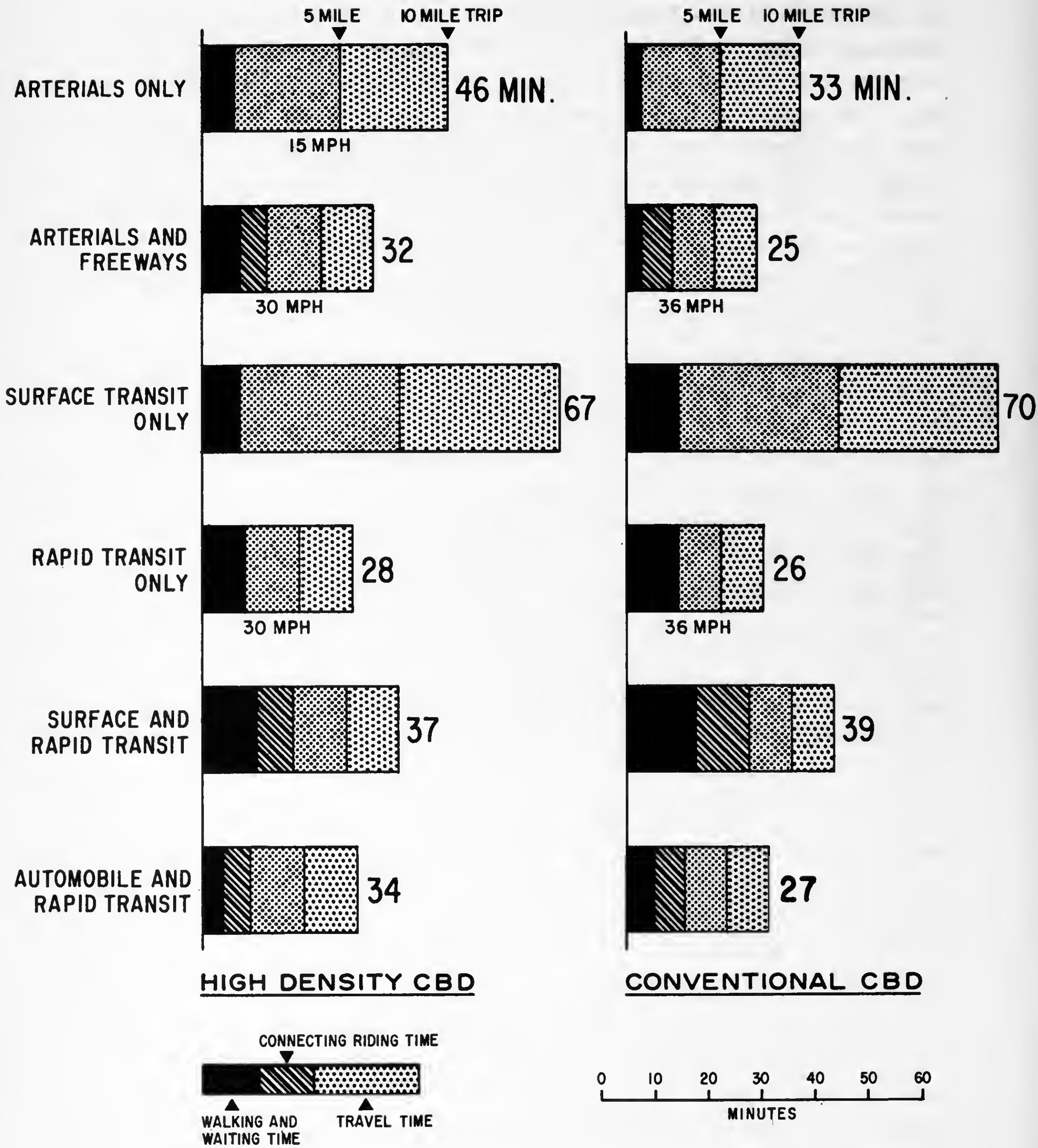

Figure 61
Comparative Travel Times to
Central Business District by Transit and Automobile

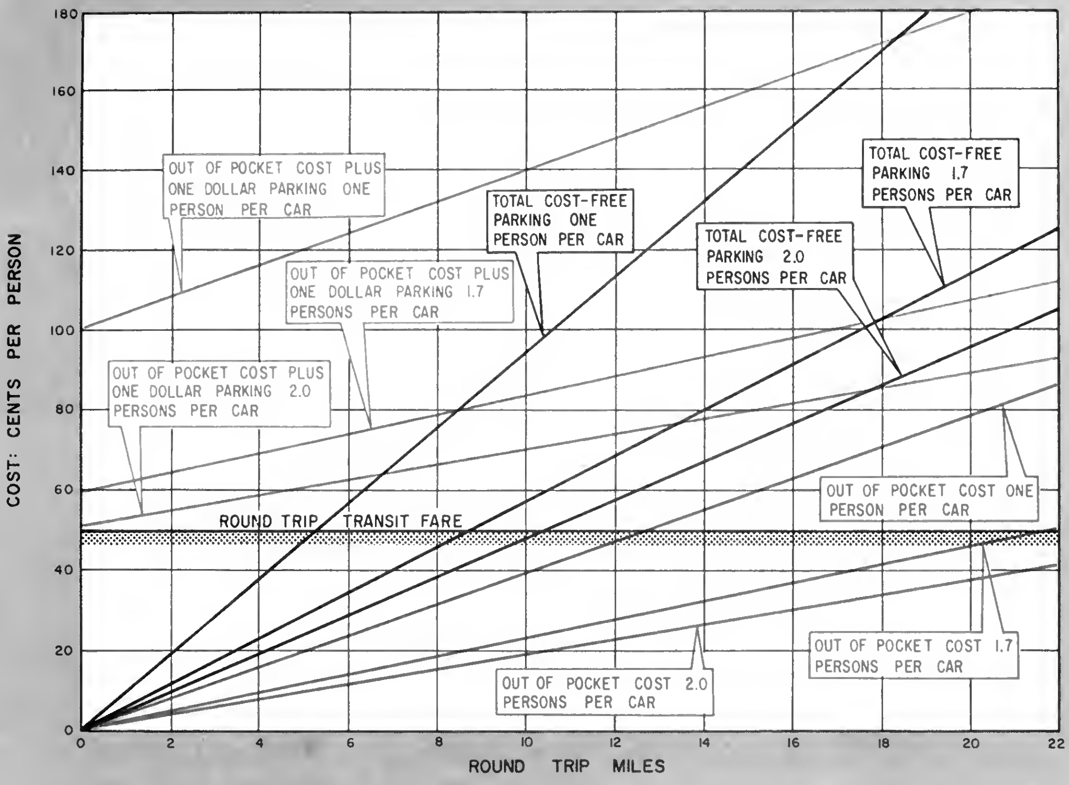

Figure 62
COMPARATIVE ROUND TRIP TRAVEL COSTS
BY TRANSIT AND AUTOMOBILE

population density and distribution, concentrations along selected travel corridors, and on resulting peak-hour capacity requirements.

These conditions necessarily limit extensive rapid transit development to the large, densely-populated urban complexes. As cities become less dense, their highway systems become increasingly adequate in providing necessary transportation.

Thus, extensive rapid transit systems in American metropolitan areas will be limited mainly to urban complexes that will exceed two million people by 1980, although some form of rapid transit may also be desirable in certain areas of one to two million people. The precise determination of rapid transit potentials will, of course, require detailed analyses of each area's future travel requirements.

Criteria — Rapid transit will serve movements in urban areas that are concentrated in time and space and will assist freeways in providing radial CBD-oriented peak-hour capacity — generally beyond that which can be economically provided by freeways. Where traffic assignments show future radial volumes in excess of those that may be carried by an eight-lane freeway, rapid transit on private rights-of-way will probably be desirable. Special facilities may also be desirable where peak-hour directional bus flows exceed 60 vehicles and 3,000 people per hour.

Rapid transit will also be valuable in helping maintain existing land-use densities in certain areas, in serving established central business districts, in reducing downtown parking demands, and in providing reserve capacity for future or unanticipated growths.

Rapid transit will not, however, diminish basic needs for area-wide urban freeway systems; most of these needs are independent of transit. Both existing and proposed rapid transit systems radiate from downtown; thus, while rapid transit may diminish lane requirements on radial routes, it will not likely relieve circumferential travel. The need for circumferential travel facilities, even in large urban areas, will remain unaffected by the provision of most rapid transit facilities.

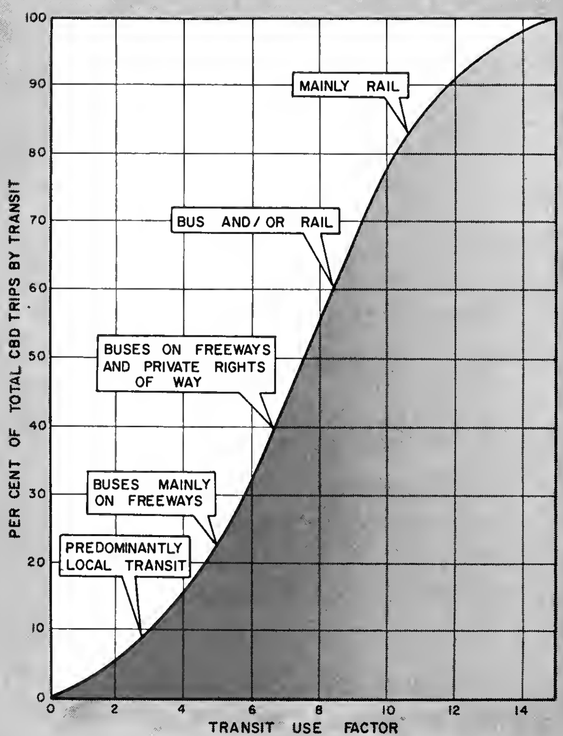

Figure 63
GENERALIZED RAPID TRANSIT POTENTIALS IN URBAN AREAS

The forms and potentials of rapid transit are generally related to the "transit use factor" as shown in Figure 63. There may, however, be specific parts of urban areas where rapid transit is required, or should be retained, even though the curves show a lesser potential on an over-all basis.[40] For example, if the transit use factor in Chicago reduces to half because of greater population spread, it will not diminish the need for retention of existing facilities.

Rail rapid transit, based on these criteria, will be generally limited to areas with use factors exceeding eight or nine; these areas will be relatively few. (The Chicago Transit Authority, for example, considers a net residential density of 35,000 people per square mile necessary for

[40]As previously indicated, a transit use factor of 10 corresponds to one car per household and an urbanized area density of 10,000 people per square mile.

rapid transit to meet operating expenses; such densities are not common in most urban areas.)

Forms — The form of rapid transit will usually be determined by comparing the economic feasibility of alternate transit proposals. Decisions will require skilled engineering and economic study of costs in relation to passenger volumes and over-all regional planning values. Economy usually will indicate that rapid transit routes be integrated with freeway construction, and that, in general, flexible rubber-tired vehicles be used. In some locations, capital costs may be offset by assessment of benefited properties.

Bus — In most cities, future rapid transit will take the form of express bus operations on freeways — either within specially reserved and designed peak-hour transit lanes, or along special median bus lanes. While only a limited number of cities can render rail rapid transit, there are virtually endless possibilities everywhere for express bus operations on new and existing highways.[41] Freeway bus operations are an innovation in rapid transit dictated by demands of urbanization and mobility.

The buses may be best accommodated by a freeway design that incorporates a roadway within the median island. Such a roadway could be used wholly or partially for "unbalanced" traffic operations, and could be gradually devoted to exclusive transit use as volumes require.

Freeway bus operation will usually involve lower capital costs, provide greater coverage, and be better adapted to low or medium density areas. Moreover, buses afford flexibilities that permit routes and services to adapt to changing land use and population patterns. Buses may also readily penetrate high-density areas, even though these areas may be skirted by freeways.

Exclusive bus lanes or rights-of-way could possibly be used by highway traffic during weekends and holiday periods, thus providing additional highway ca-

[41]Anderson, George W., *Downtown From the Public Transit Standpoint*, 40th annual convention, American Retailers Association, Jan., 1958.

Express Bus Operation Within a Freeway Median, as Proposed for Southwest Expressway, Chicago

pacity to serve recreational traffic peaks since few of these trips would be accommodated by public carriers. The special bus-ways would, therefore, serve the dual purpose of accommodating home-to-work and week-end peaks.

As technology improves, electronic operation of buses in freeway rights-of-way, either singly or in trains, may become a reality. Such an operation would combine the advantages of rail and bus transit.

Rail – Cities with extensive rail transit systems will naturally find it advantageous to retain, improve, and, where warranted, extend these facilities. Similarly, where existing railroad tracks or rights-of-way can be incorporated into transit systems, it may be economical to consider rail transit. These situations will, for the most part, be few and will generally involve a limited number of routes in high-density, built-up portions of large cities. Most extensions will be related to freeway construction and/or adaptation of suburban railroad lines or rights-of-way.

Construction of subway and elevated facilities is expensive and fixed-carrying charges are heavy; their justification depends upon huge passenger volumes in select corridors as related to concentrations of demand within the central business district. Such conditions are not common. Future rail lines will, therefore, be limited to areas where traffic cannot be adequately or conveniently served by express buses operating over modern freeway systems.

In cities where the attractiveness and inertia of the central business district will encourage high-density development within select corridors, some new rail rapid transit may be desirable.

It must, of course, be realized that the old, very large cities, such as New York, Chicago, Philadelphia and Boston, are generally unique in terms of function, configuration, concentration and transportation requirements.[42] These areas will continue to be served mainly by rail rapid transit. Investments in existing facilities, coupled with their peak-hour capacities and their relationship to downtown concentrations of people, necessitate their continuance and improvement.

Commuter Railroads – Commuter railroads, like rail rapid transit, are necessarily restricted to the largest cities, but may more advantageously serve many suburban areas where existing networks are available. Modernization should be given the same economic appraisal as other transportation proposals; major capital expenditures will not usually be justified without some type of subsidy. The use of multiple-door control and greater automation on cummuter lines would serve to reduce some of the current peak-hour operating costs.

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[42]For example, the average population density in Manhattan is about 88,000 people per square mile; compared with about 5,000 in Los Angeles, and 50 in the United States.

An extensive proposal for the modernization of cummuter railroads recently suggested that these facilities be used by both freight and passenger trains and that all routes within an area be interconnected to permit better downtown distribution.[43] Since commuters use such facilities only about 20 hours per week, the lines would be available for freight service the remainder of the time. Such a proposal should be carefully evaluated, in light of its applicability to specific situations.

PROSPECTS

By 1920, the auto had wide public acceptance. Although its effects on transit traffic were apparent, there was still little recognition of the threat to transit's stability. Many contended, as in 1960, that riders would revert to transit as soon as they realized how costly it was to use the private automobile. This has not happened; on the contrary, the trends toward private transportation have continued in practically every city.

A renaissance of transit appears unlikely. As shown in Figure 64, the trends are in other directions; declines in the use of surface transit will continue as urban areas continue to disperse, as car ownership increases, and as family incomes rise. Rapid transit patronage may, however, be expected to stabilize and possibly increase in larger urban areas.

Future urban origins and destinations will be scattered over a widening area and relatively few person trips will be divertible from the automoble to improved transit systems. Therefore, suburbia will not usually attain the high levels of transit usage previously developed between the central business district and the "close-in, high-density" portions of the central city.

Public transportation is an efficient carrier of people in terms of street requirements and should, therefore, be encouraged to maintain its service, particularly into and out of the central business district. It will be required, especially in large urban areas, to serve people who do not own or have the use of an automobile, and to provide peak-hour "overflow" capacity along major radial routes. In many smaller areas, taxis or jitneys may gradually supplant transit.

Ultimately, the continued existence of transit may become dependent on some form of subsidy in many areas. This could involve aid for weak lines, and/or outlays for needed capital improvements.

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[43]Berge, Stanley, "How Commuters Can Have Their Trains," *Atlantic Monthly*, May, 1960.

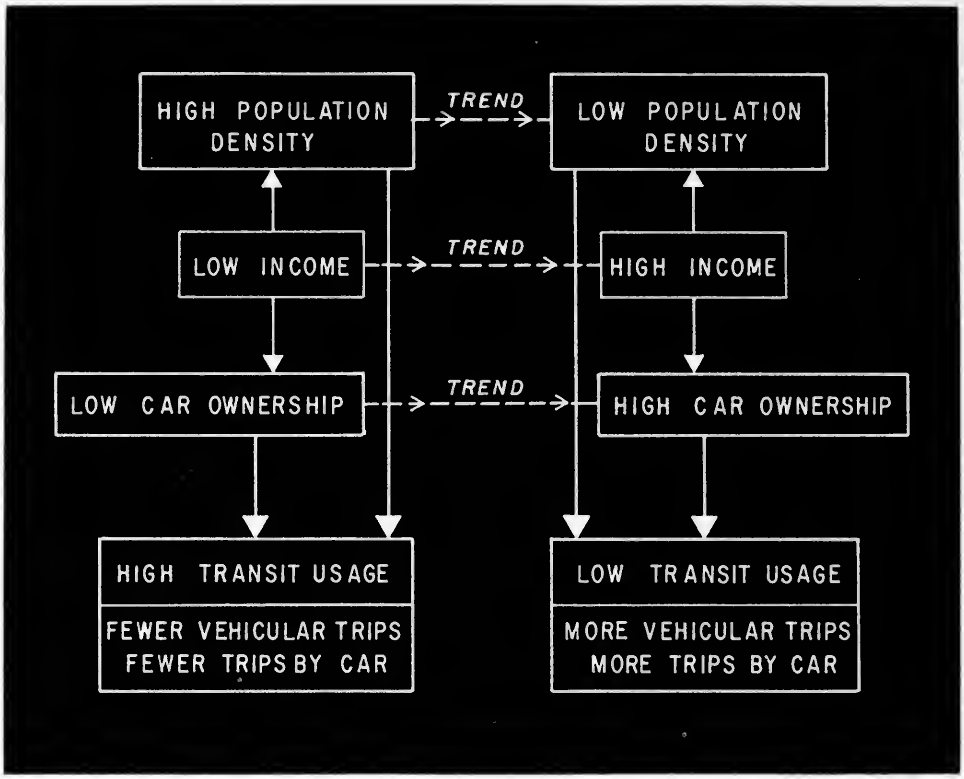
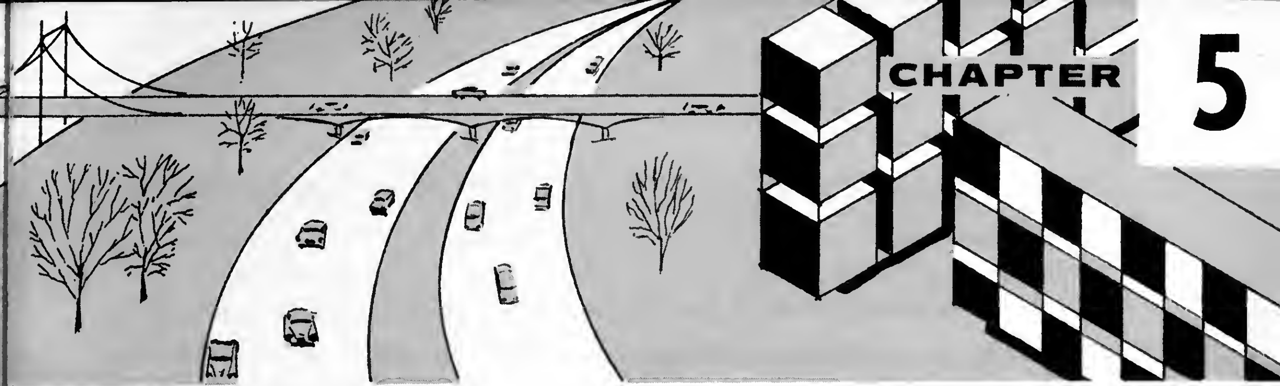


Figure 64
SUMMARY OF URBAN TRAVEL FACTORS

Future rapid transit, while generally limited to large urban complexes, will be a valuable adjunct to freeways in serving concentrated travel movements. Future rapid transit in most urban areas will be provided by express buses operating within freeways, and in some cases, in specially reserved lanes or exclusive rights-of-way. Extensions and improvements of rail rapid transit will be restricted mainly to cities where these facilities exist or where they may be developed economically. Adequate systems of local transportation will serve communities where rapid transit is not warranted, and will also be necessary to help make rapid transit function efficiently.

Transit will remain in future urban areas, but its role and function will be somewhat dissimilar to its earlier status. No longer the dominant travel mode except in special cases, it will serve as an important and special complement to private vehicular transportation.



FREEWAY SYSTEM USE
in
STUDY CITIES

SUMMARY

ALTHOUGH Interstate highways serve the dual functions of connecting urban centers and providing intracity access, a comparative analysis of Interstate freeway systems in various study cities shows that they are often related to intercity linkages rather than to local traffic conditions: their extent varies considerably; there is usually no simple relationship between city size, population and Interstate system mileage.

There is also variation in the amounts of Interstate system mileage currently in operation, and in the degree of augmentation by other freeways. Nashville, for example, has planned a relatively complete network of freeways composed almost entirely of Interstate highways; in Phoenix, a less extensive system of Interstate routes will be supplemented by a projected network of non-Interstate routes; in Houston, many freeways are already in operation.

The number of daily vehicle miles of travel in the study cities, expressed on a per capita basis, is expected to increase over the next 20 years from about 7 at present to more than 10 miles per capita per day by 1980. By 1980, over-all vehicular travel will be increased between 4 and 16 per cent as a result of urban freeway use.

Average trip length in the survey cities is expected to increase from almost 4.5 miles at present to over 5.0 miles by 1980. Trips on freeways are longer than other urban trips; motorists using urban freeways travel about 7 to 9 miles on freeways and about 2 miles on surface

streets, whereas motorists using only arterial streets average about 4 miles.

A completed system of freeways in any metropolitan area can be expected to accommodate a significant part of the vehicular travel performed in that community. The proportion of trips and vehicle-miles of travel assignable to an adequate freeway system increases with city size.

In communities under 100,000 population, freeways may carry up to one fourth of all daily vehicle miles of travel. In metropolitan areas that contain more than a million persons, half or more of all vehicle miles of travel would be accommodated by an adequate freeway system.

The average volume potential per mile of freeway varies from about 25,000 vehicles per day in cities under 100,000 population to about 70,000 cars per day in large cities. Maximum freeway loadings increase at a rapid rate as cities get larger — from about 30,000 cars per day in small cities to more than 200,000 per day in large cities. When cities exceed two million in population, anticipated demands on freeways in the most heavily traveled corridors may exceed the capacities of eight-lane facilities under present concepts of freeway systems.

Freeways are popular! Within the study cities, between 25 and 40 per cent of all local motorists would use the freeway systems daily; in an average week, more than two out of three would use the freeways. It is anticipated that the completed Interstate system will be used daily by nearly 40 per cent of the nation's motorists.

Freeways will serve more travel, be more extensively used and, therefore, become increasingly valuable in large urban areas. Recognition of these facts emphasizes the need for an accelerated program of urban freeway construction over the next 20 years to meet urban traffic requirements.

THE Interstate highway system, although commonly regarded as an inter-city system, will include many important freeway sections within urban limits. The orientation and use of these urban express highways within the communities they serve will vary from city to city, depending on the extent of the system and the size and disposition of urban land uses.

Detailed analyses of the use and impact of proposed freeway systems within the study cities are set forth in this chapter. The findings provide a basis for an over-all evaluation of Interstate highways and other freeways within urban areas, and for projections of future travel.

DESCRIPTION OF FREEWAY SYSTEMS

The relation of the 41,000-mile network of Interstate highways to the study cities is shown in Figure 65.[1] Important "crossroads" cities, as Chicago,

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[1]The study cities are the same as those detailed in Chapter III, with the addition of Hartford, Oakland and Miami. Additional analyses have been made to the extent that data were available.

Figure 65
STUDY CITIES IN RELATION TO INTERSTATE HIGHWAY SYSTEM

St. Louis and Nashville, have as many as eight routes radiating from them. Other cities are not so fortuitous: Miami, located in the southeast extremity of the country, is served by only one route; two Interstate routes enter the Charlotte area but none penetrate the city; Reno, the smallest of the study cities, is traversed by one Interstate highway.

Interstate Systems — Urban Interstate routes and urbanized area limits in each of the study cities have been drawn to the same scale in Figures 66 and 67. The highway configurations vary from city to city as the systems are often related to intercity linkages rather than to local traffic conditions. The drawings clearly show the wide variations of urbanized areas in relation to Interstate routes, ranging from the small Reno-Sparks area upward to the large metropolitan agglomerations of Chicago and Detroit. In most cities, Interstate highways shown on the drawings have determined the general structure of the urban freeway network.

Chicago — The Interstate system in Chicago, largest of the study areas in population and spread, includes eight routes radiating from the Loop toward Milwaukee and Madison, Wisconsin; Moline, Bloomington, and Effingham, Illinois; Indianapolis and South Bend, Indiana; and Benton Harbor, Michigan. A circumferential route traverses the western perimeter of the area.

Detroit — Five radial Interstate routes converge in the Detroit area from Toledo, Ohio, and from Kalamazoo, Lansing, Flint, and Port Huron, Michigan. The network also includes a circumferential freeway around the west and north of the city. The routes provide a relatively complete system of downtown facilities and form a loop around the central business district.

St. Louis — Interstate highways converge in the St. Louis area from Springfield and Kansas City, Missouri; Effingham and Springfield, Illinois; Louisville, Kentucky; and Memphis, Tennessee. Three routes radiate westward from downtown St. Louis, and an "outer belt" route circumscribes the northern and western limits of urbanization.

Houston — Two radial Interstate highway routes intersect in Houston; one connects San Antonio and Baton Rouge, and the other links Dallas and Galveston. In addition, a circumferential route encompasses the north, west and east sides of the Houston area.

Kansas City — The Interstate freeway pattern in the Kansas City area includes a series of routes radiating to Newton and Topeka, Kansas; Council Bluffs and Des Moines, Iowa; and St. Louis, Missouri. The routes converge in downtown Kansas City and form a limited-access loop around the central

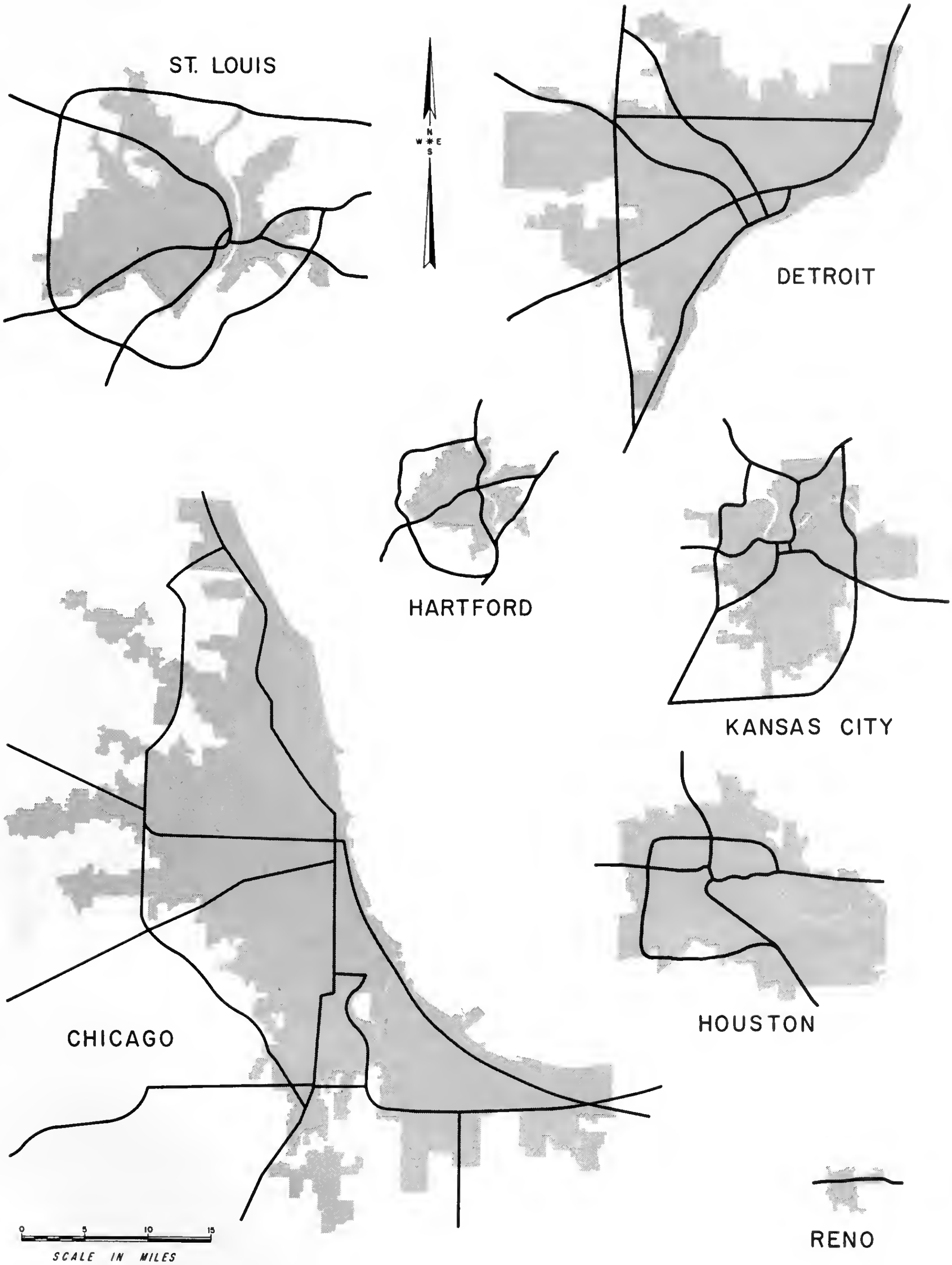

Figure 66
URBAN INTERSTATE SYSTEMS IN STUDY CITIES

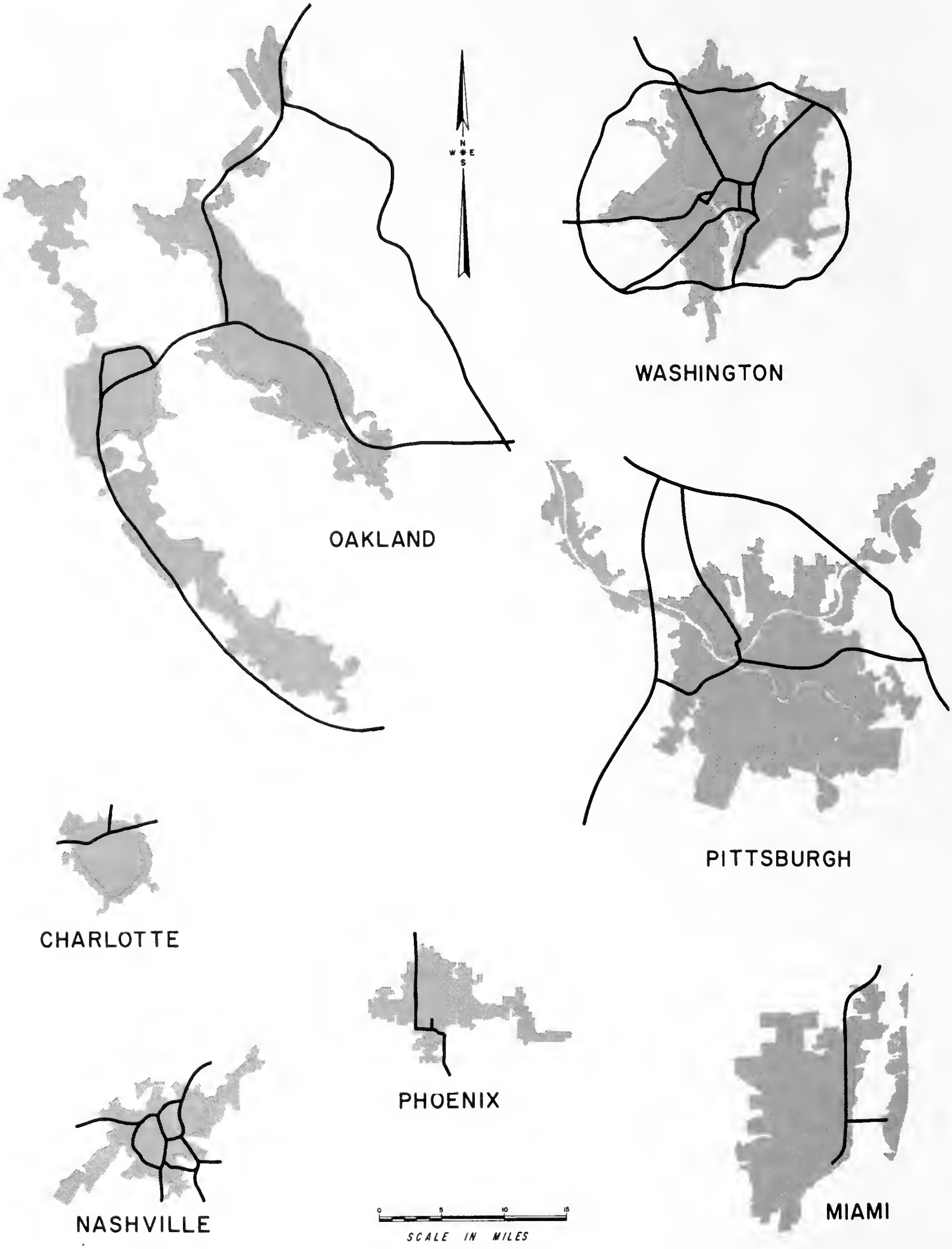

Figure 67
Urban Interstate Systems in Study Cities (Continued)

business district. In addition, two belt routes are provided — one is located along the west side of Kansas City and the other traverses the south and southeast parts of the area.

Hartford — Two radial Interstate routes in Hartford are augmented by a belt around the south and west sections of the urban area. The routes radiate to Springfield and Worcester, Massachusetts, and to Danbury and New Haven, Connecticut.

Oakland — Two Interstate routes in Oakland — one from Sacramento and one from Modesto — converge on the Bay Bridge to enter San Francisco. A belt route extending southerly from San Francisco circumscribes the entire Bay area.

Washington — The nation's capital is the focus for a series of routes radiating to Strasburg and Richmond, Virginia, and to Frederick and Baltimore, Maryland. In the central area of Washington, the routes converge to form the greater portion of an inner loop freeway. In addition, an outer circumferential encompasses the entire area.

Pittsburgh — Although areawise, urbanized Pittsburgh is comparable to Washington, D. C., its Interstate system is much less elaborate. Route locations are restricted by topography, which may account for the less extensive system. Three radials provide access to Harrisburg and Washington, Pennsylvania, and to Youngstown, Ohio. In addition, two routes traverse the perimeter of the urbanized area.

Nashville — Nashville has one of the most complete Interstate systems of any city its size. Interstate highways radiate from downtown Nashville to Louisville and Knoxville, Kentucky; Chattanooga and Memphis, Tennessee; and Birmingham, Alabama. Within the city, the routes form a downtown loop and several legs of an intermediate circumferential freeway.

Phoenix — The Interstate routes serving Phoenix are less extensive than in Nashville; although the urban area is slightly larger in population and is growing rapidly. Interstate routes extend from Phoenix to Tucson, Arizona, and Los Angeles and San Diego, California.

Other Cities — Interstate routes serving Miami, Charlotte and Reno do not comprise "systems" of urban freeways. In Reno, the Interstate highway traverses the city; in Miami, an Interstate highway connects Miami Beach and downtown Miami with points north; in Charlotte, the Interstate routes do not penetrate the city — I-85 traverses the perimeter of the urbanized area and is joined by I-77 which now terminates at their junction.

Relation to City Size — From the individual route descriptions, it is evident that urban Interstate systems have been more influenced by urban area location than by traffic requirements. There is no simple relationship between city size, population, and the amount of Interstate miles allocated to each city.

This is clearly illustrated by Table 36 which compares 1958 Interstate mileage in the study cities with 1950 population and area. The number of people per mile of Interstate route varies from less than 7,000 in Houston and Hartford to more than 20,000 in St. Louis and Pittsburgh. The urbanized area served per mile of Interstate route ranges from about one square mile in Hartford to four in Miami and almost six in Reno.

Table 36

ALLOCATED INTERSTATE MILEAGES IN STUDY AREAS[1]

URBANIZED AREA	AREA (SQ. MILES)	URBANIZED AREA POPULATION 1950	MILES OF URBAN INTER-STATE ROUTE 1958	POPU-LATION PER MILE OF ROUTE	SQ. MILES OF AREA PER MILE OF ROUTE
Oakland-San Francisco	287.3	2,022,078	129.5	15,620	2.2
Pittsburgh	253.6	1,532,953	71.7	21,380	3.5
St. Louis	227.8	1,400,058	61.5	22,770	3.7
Washington	178.4	1,287,333	106.5	12,090	1.7
Houston	270.1	700,508	105.6	6,630	2.6
Kansas City	149.0	698,350	87.9	7,950	1.7
Miami	116.5	458,647	29.0	15,820	4.0
Hartford	52.9	300,788	58.7	5,120	0.9
Nashville	53.7	258,887	26.9	9,620	2.0
Phoenix	55.1	216,038	14.7	14,700	3.8
Charlotte	34.5	140,930	9.5	14,800	3.6
Reno-Sparks	27.0[2]	54,933[2]	4.8	11,440	5.6

[1]Sources: Based on special tabulations of urban Interstate route miles designated in each area as obtained from U. S. Department of Commerce, Bureau of Public Roads.

[2]Reno was not urbanized as of 1950; calculations were, therefore, based on 1955 population and estimated 1955 density for study areas.

Composite Systems — In almost every urban area, the Interstate highway system is supplemented by proposals for other urban express highways or freeways. Again, the extent and status of these routes varies, depending on need, public acceptance and plans for financing. In some cases, "designated" routes have attained official "status"; in other areas, they are still in the "planning" stage.

The nature and status of planned freeway systems in Miami, Nashville, Houston and Phoenix are illustrated in Figures 68 through 71.[2]

Miami — The expressway plan for the metropolitan Miami area, now nearing a million in population, is shown in Figure 68. A highway program costing about $180 million is being financed through a $40 million county bond issue that supplements Interstate and other Federal Aid funds. Although the plan is not as comprehensive as proposals for some cities, it has been accepted, financing arranged, and work initiated.

The Federal Aid Primary route, Palmetto Trail, is entirely completed or under construction. Most sections of the Interstate routes (North-South Expressway and 36th Street Causeway) are completed, under construction, or their rights-of-way are being acquired. Several sections of bond-financed roads, such as the 36th Street Tollway, are under construction or are being designed. The east-west expressway linking downtown Miami with the Tamiami Trail, the Dixie Expressway leading southwest from downtown, and sections of the downtown loop have yet to be acquired or built.

Nashville — The Nashville freeway system, detailed in Figure 69, is largely Interstate and includes a series of radial routes and a downtown distributor loop interconnected by an intermediate circumferential. Long-range plans call for a semi-limited access route around the urban area.

Construction is now underway on about five miles of Interstate 40 to the southwest of downtown and on one mile of Interstate 65 over the Cumberland River. Right-of-way is being acquired and/or construction programmed for three routes; preliminary route locations have been completed for the remainder of the Interstate system.

Houston — The Houston freeway plan, shown in Figure 70, includes gridiron, radial and circumferential routes. Nine routes radiating outward from downtown Houston are linked by a downtown distributor route and by an intermediate belt freeway. The Gulf Freeway, Eastex Freeway, and sections

[2]The approximate status of each planned freeway system as shown in Figures 68 through 71 is based on information received from the Florida, Tennessee, Texas, and Arizona state highway departments.

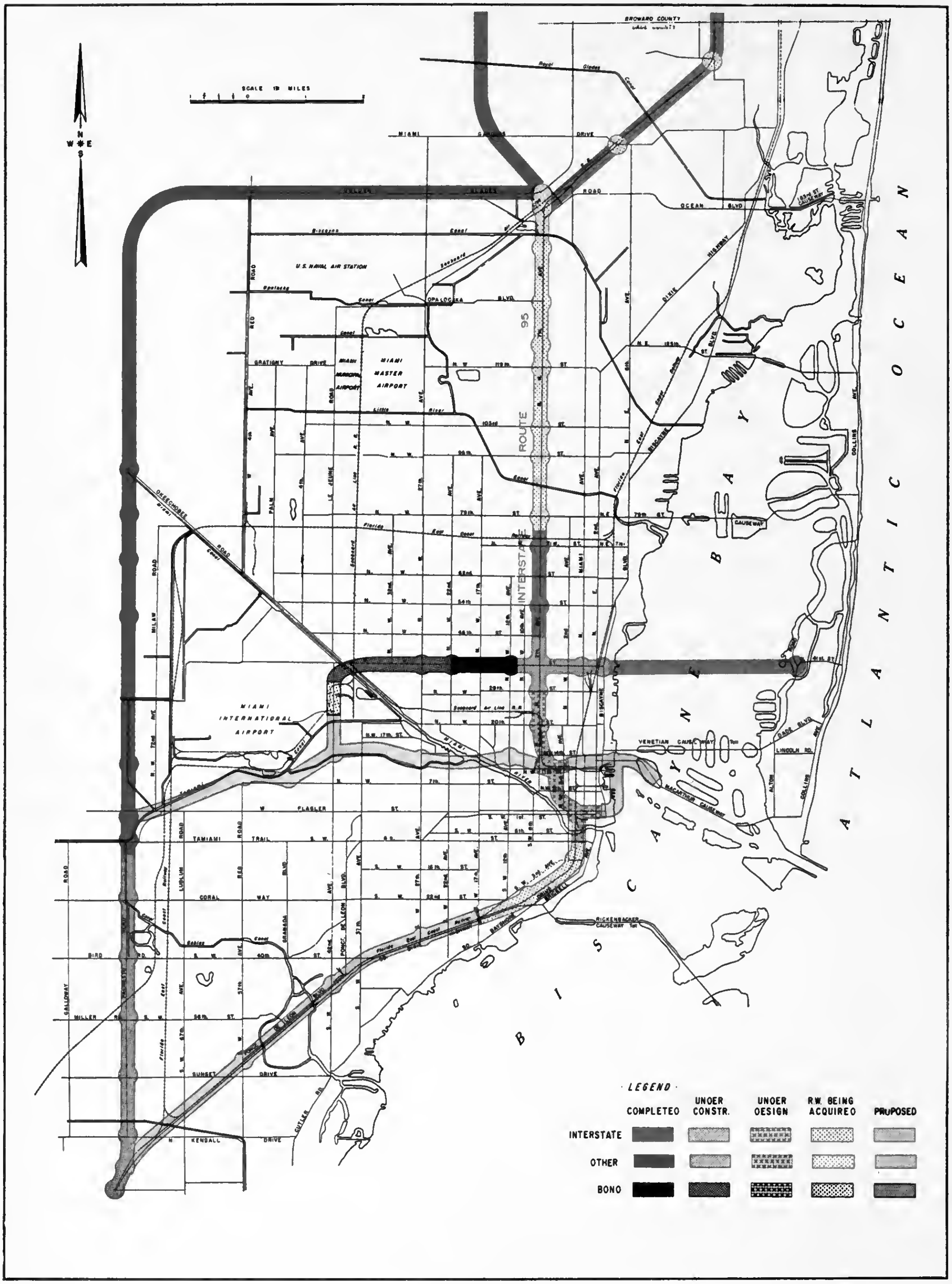

Figure 68
PROPOSED MIAMI EXPRESSWAY SYSTEM
MIAMI, FLORIDA

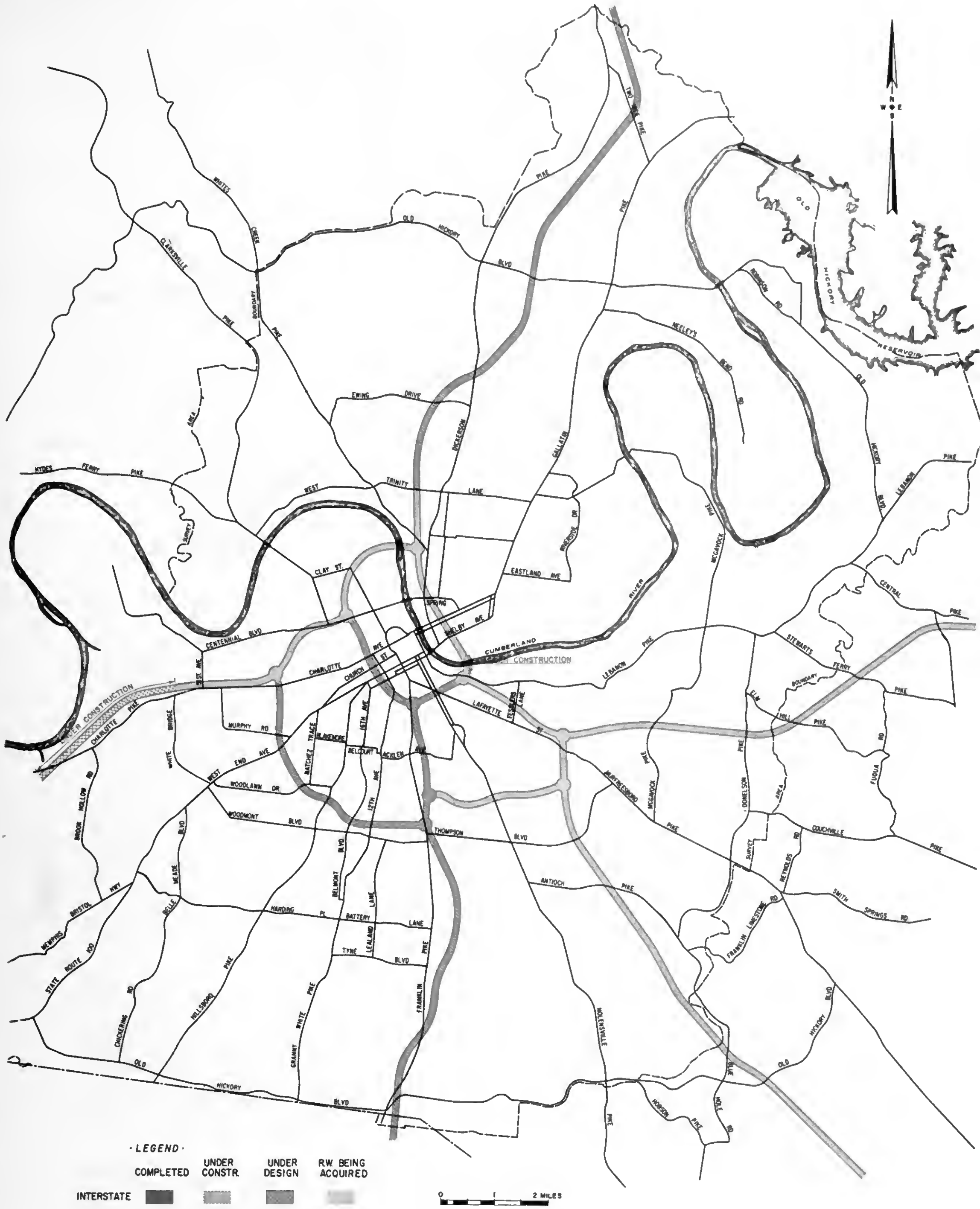

Figure 69
PROPOSED NASHVILLE FREEWAY SYSTEM
NASHVILLE, TENNESSEE

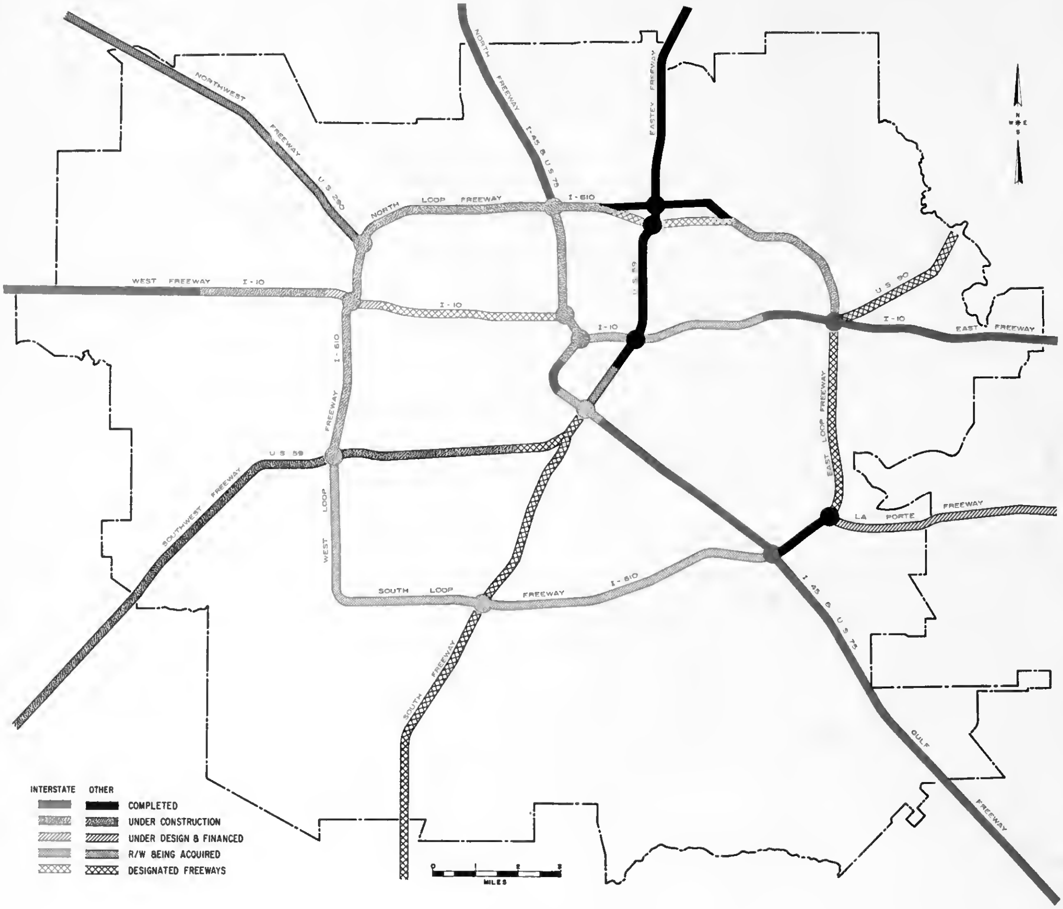

Figure 70
PROPOSED HOUSTON FREEWAY SYSTEM
HOUSTON, TEXAS

of the North and East Freeways and the Downtown Loop are currently in operation.

The Southwest Freeway (U. S. Route 59), and sections of the West and North Loop Freeway (I-610) and the North Freeway (I-45) are currently under construction. At present, the La Porte Freeway is being financed for construction and right-of-way is being acquired for sections of the South Freeway and the South Loop Freeway.

Phoenix — The recommended major street and highway plan for the rapidly expanding Phoenix urban area, shown in Figure 71, has been designed to meet 1980 needs for more than 1,250,000 people. It provides 141 miles of freeways and expressways in the urban area at an estimated cost of $126,500,000, and arterial street extensions and improvements costing an additional $122 million.

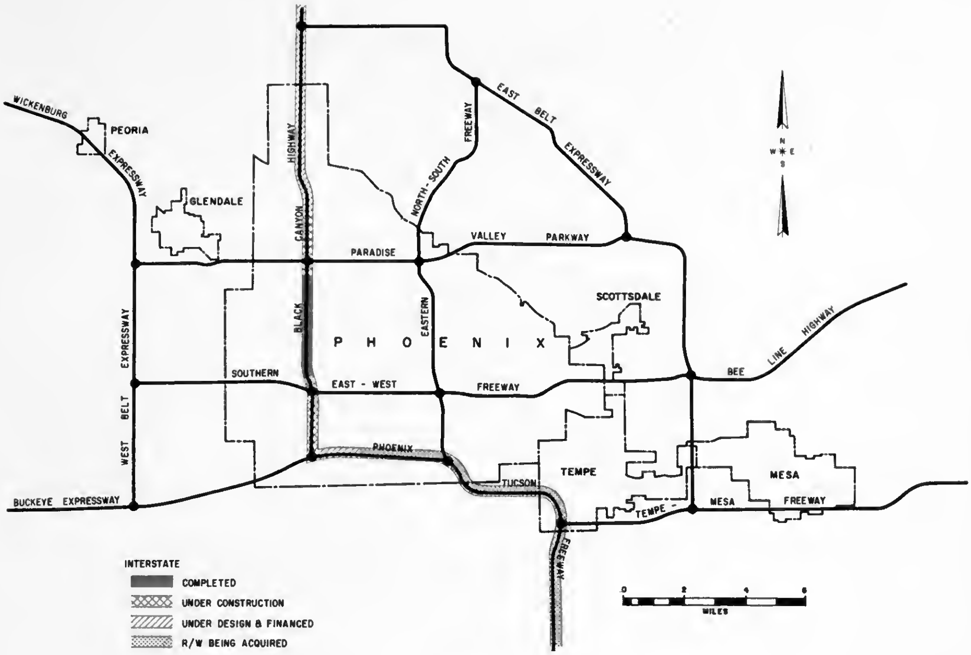

Figure 71
PROPOSED PHOENIX FREEWAY SYSTEM
PHOENIX, ARIZONA

The plan calls for an extensive gridiron network of freeway routes and is attuned to the decentralized character of the area. A distributor loop around the central business district serves as a focus for the system.

Within the Phoenix area, three miles of freeway have been completed, seven miles are under construction, eight miles are being designed, and right-of-way acquisition is underway on 14 miles. These projects are located along the Black Canyon Highway, the Phoenix-Tucson Freeway, and the Tempe-Mesa Freeway (on the eastern extremity of the urban area).

FREEWAY USE

The magnitudes of travel within each study city were determined from detailed analyses of present and anticipated travel patterns based on the origin-destination surveys.[3] Proportions of total urban area travel on the Interstate and other components of freeway systems in each city were also measured, where such information was available.[4]

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[3]The origin-destination studies and freeway assignments in each of the study cities formed the bases for subsequent analyses. These studies are listed in Chapter III. Highway planning studies for Dade County, Florida, and Alameda County, California, were also analyzed.

[4]Various methods were employed to derive the data cited herein, depending on the availability of information. Freeway travel was measured directly from traffic flow charts; in some cases, it was possible to determine total travel by sampling trip data from origin-destination and assignment tables.

Total Urban Travel — Daily vehicle miles of travel in the study cities at the time of the origin-destination surveys are summarized in Table 37. In the aggregate, there were 16.5 million people and approximately 114 million vehicle miles of daily travel in 13 study areas. Expressed in terms of

TABLE 37

SUMMARY OF EXISTING TRAVEL IN STUDY CITIES[1]

CITY	*PRESENT SURVEY AREA POPULATION*	*TOTAL DAILY VEHICLE MILES OF TRAVEL*	*TOTAL DAILY TRAVEL EXPRESSED AS VEHICLE MILES PER CAPITA*
Detroit	2,968,875	25,104,800[3]	8.5
Washington	1,568,522	8,650,000[3]	5.5
St. Louis	1,275,454	8,469,561[3]	6.7
Oakland	910,100	8,250,000[3]	9.1
Kansas City	857,550	6,549,230[3]	7.8
Phoenix	397,395	3,600,000	9.1
Miami	400,000[2]	3,049,000	7.6
Charlotte	202,262	1,400,000	6.9
Reno	54,933	436,570	8.0
Subtotal	8,635,091	65,509,161	7.6
Chicago	5,169,663	30,700,000	5.9
Pittsburgh	1,472,099	10,026,000	6.8
Houston	878,629	5,310,758[3]	6.1
Nashville	357,585	2,688,588[3]	7.5
TOTAL	16,513,067	114,234,507	6.9

[1]Source: Origin-destination studies in each area.

[2]Assumed as 80 per cent of Dade County's 1950 population to compensate for sections of Dade County not included in the origin-destination studies.

[3]Vehicle miles of travel *with* proposed freeway system. Travel on existing streets without freeways is generally about five per cent less.

urban area residents, daily vehicular travel corresponds to nearly seven miles per capita.[5]

In most cities, the average was considerably more, ranging from six miles per capita in Washington to nine miles per capita in Phoenix. Most larger cities generally developed fewer vehicle miles per capita (generally six to seven) because of more extensive transit use.

Anticipated 1980 population travel in a select group of nine study cities is summarized in Table 38. Population in the city totaled 14.2 million and there were approximately 148 million vehicle miles of daily travel. Expressed in terms of 1980 survey area population, daily vehicular travel averaged approximately 10.4 vehicle miles per capita. Travel ranged from about nine vehicle miles per capita per day in Charlotte and Washington to 14 in Oakland.

[5]In several cities, the tabulation assumes that the proposed freeway system was in operation. Without freeways, existing travel would be about five per cent less in these cities.

TABLE 38

SUMMARY OF 1980 TRAVEL IN STUDY CITIES[1]

CITY	*1980 SURVEY AREA POPULATION*	*TOTAL DAILY[2] VEHICLE MILES OF TRAVEL*	*TOTAL DAILY TRAVEL EXPRESSED AS VEHICLE MILES/CAPITA*
Detroit	4,400,000	43,829,600	10.0
Washington	2,720,700	24,000,000	8.8
St. Louis	1,721,360	17,500,723	10.2
Kansas City	1,340,220	16,187,000	12.1
Phoenix	1,250,000	13,600,000	10.9
Miami	1,170,000[3]	13,348,561	11.4
Oakland	1,016,200	14,200,000	14.0
Charlotte	409,735	3,623,523	8.9
Reno	146,000	1,500,000	10.3
TOTAL	14,174,215	147,789,407	10.4

[1]Source: Origin-destination studies in each area.

[2]Anticipated vehicle miles of travel *with* proposed highway systems.

[3]Assumed as 70 per cent of Dade County in 1975, to compensate for sections of Dade County not included in the origin-destination studies.

Freeway Potentials – The proportion of urban travel potential to adequate freeway systems affords insight into the value and use of urban freeways. These comparisons are made in Tables 39 and 40 for existing and future travel, respectively, in the selected study cities.

Existing Travel – Existing travel in the study cities, the number of trips made, average trip length, the proportion of travel assignable to freeways, and the additional travel resulting from freeway routings are summarized in Table 39.

Trip lengths ranged from slightly over three miles in Reno to more than five miles in Chicago, Detroit and Pittsburgh. The proportion of trips assignable to the proposed freeway system ranged from about 23 per cent in Nashville to 54 per cent in Washington.[6] The proportion of travel (vehicle miles) potential to freeway systems ranged from 30 per cent in Nashville to about 50 per cent in Washington and Detroit. Thus, the potentials for freeway use are greater in larger cities.

Motorists go out of their way to use freeways. Based on present levels, additional vehicle miles of travel resulting from increased travel to, from, and upon freeways ranged from about two per cent in Nashville to about nine per cent in Detroit and Oakland.

1980 Travel – A similar analysis for anticipated 1980 travel is shown in Table 40. Trips in the study cities increased in length by about 10 to 15 per cent over present levels – from about 4.5 to 5 miles per trip. This is mainly a result of lower land-use densities, and the greater spread of the urban populace anticipated for 1980.

The proportion of trips assignable to freeway systems ranged from about 30 per cent in Detroit, Reno, Phoenix, Charlotte and Miami to 58 per cent in Oakland. The proportion of trips assigned to urban Interstate highways ranged from 10 per cent in Miami to 26 per cent in Kansas City.

The proportion of travel assignable to freeway systems ranges from about 30 per cent in Miami, Phoenix and Charlotte to over 55 per cent in Washington, St. Louis and Oakland. Thus, an adequate urban freeway network would accommodate up to half of all travel in larger urban areas.

The proportion of total travel on urban Interstate highways ranged upward from about nine per cent in Charlotte and Phoenix to 36 per cent in

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[6]Assignments to comprehensive proposed freeway systems, as shown in the highway planning studies for each city.

TABLE 39

EXISTING TRAVEL IN STUDY CITIES POTENTIAL TO PROPOSED FREEWAY SYSTEMS[1]

	VEHICLE TRIPS					DAILY VEHICLE MILES				Per Cent Increase in Travel Because of Freeways
			Per Cent Assigned to Proposed Freeways[2]				Per Cent Assigned to Proposed Freeways[2]			
CITY	Number of Trips	Trip Length (Miles)	Total	On Interstate	On Other Freeways	Total Vehicle Miles	Total	On Interstate	On Other	
Chicago	6,105,466	5.1	------	------	------	30,700,000	------	------	------	------
Detroit	4,580,056	5.5	33.4	------	------	25,104,800	53.1	------	------	9
Washington	2,000,000	4.3	54.0	------	------	8,650,000	50.0	------	------	3
Pittsburgh	1,700,000	5.9	------	------	------	10,026,000	------[3]	------	------	------
St. Louis	1,816,228	4.7	36.2	14.2	22.0	8,469,561	46.5	18.4	28.1	6
Houston	1,397,219	3.8	42.3	------	------	5,310,758	47.1	------	------	3
Kansas City	1,368,689	4.8	27.3	17.5	9.8	6,549,230	40.0	25.6	14.4	5
Nashville	648,000	4.2	23.3	23.3	------	2,688,588	31.0	31.0	------	2
Miami[4]	851,890	3.6	------	------	------	3,049,000	------	------	------	------
Charlotte	413,637	3.4	------	------	------	1,400,000	------	------	------	------
Phoenix	805,011	4.5	------	------	------	3,600,000	------	------	------	------
Reno	130,847	3.3	------	------	------	436,570	------	------	------	------
Oakland[5]	1,680,000	4.9	47.0	------	------	8,250,000	43.7	------	------	9

[1]Source: Compiled from origin-destination studies in each area, including intrazone and external trips.
[2]Figures are indicated for all conditions where data were available.
[3]Actual use of existing freeways was eight per cent.
[4]1951.
[5]Data are for all of Alameda County.

TABLE 40

ANTICIPATED 1980 TRAVEL IN STUDY CITIES POTENTIAL TO PROPOSED FREEWAY SYSTEMS[1]

CITY	VEHICLE TRIPS					DAILY VEHICLE MILES				Per Cent Increase In Travel Because of Freeways
			Per Cent Assigned to Proposed Freeways[2]				Per Cent Assigned to Proposed Freeways[2]			
	Number of Trips	Trip Length (Miles)	Total	On Interstate	On Other Freeways	Total Vehicle Miles	Total	On Interstate	On Other	
Detroit	7,666,983	5.7	29.0	------	------	43,829,600	48.3	------	------	9
Washington	4,000,000	6.0	53.0	------	------	24,000,000	58.5	------	------	12
St. Louis	2,991,663	5.9	40.9	16.5	24.4	17,500,723	55.5	22.5	30.0	6
Kansas City	2,450,273	6.6	38.2	26.0	12.2	16,187,000	52.8	36.2	16.6	16
Miami	2,721,691	4.9	29.2	10.4	18.8	13,348,561	29.2	13.1	16.1	4
Charlotte	965,085	3.8	30.8	------	------	3,623,523	32.4	8.6	23.8	5[3]
Phoenix	2,526,000	5.4	27.0	------	------	13,600,000	30.8	9.3	21.5	10[3]
Reno	431,400	3.5	30.0	22.2	12.8	1,500,000	35.0	22.2	12.8	7[3]
Oakland	2,730,000	5.2	58.0	------	------	14,200,000	54.0	18.1	35.9	9

[1]Source: Compiled from origin-destination studies in each area, including intrazone and external trips.
[2]Figures are indicated for all conditions where data were available.
[3]Estimated.

Kansas City, averaging about 20 per cent; usage and potentials of Interstate routes varied among urban areas depending on relative system extent. Urban Interstate highways on the average would be likely to accommodate about half of the vehicle miles potential to a system of freeways in the typical community. This proportion, will necessarily vary from city to city, in accord with the specific mileage and configuration of roads in each area.

By 1980, up to 16 per cent more vehicle miles of travel will result from use of urban freeways than if there were no freeway system. In the study cities, this additional travel ranged from four per cent in Miami to sixteen per cent in Kansas City.

Effect of City Size – There is a generally consistent relationship between the proportion of travel on a freeway system and urban area population, regardless of the plan year. Potential use of freeway systems increases as urban areas get larger. As shown in Figure 72, urban freeways would accommodate approximately one fourth of all urban *trips* in cities under 100,000, and slightly over 40 per cent of all *trips* in cities over two million.

Freeways would accommodate about one fourth to one third of all urban vehicle miles of travel in cities under one hundred thousand population and would carry an increasing proportion of travel as urban areas grow larger. Approximately half of all vehicle miles will be assignable to comprehensive systems of freeways in the largest urban areas (over two million population).

A comprehensive plan of freeways in Detroit is designed to accommodate about 48 per cent of that area's travel; in St. Louis, the most extensive plan studied would carry 55 per cent of all urban vehicle miles. The Los Angeles freeway system, when completed, is expected to carry about 52 per cent of all the area's travel; in urban areas, such as Phoenix and Charlotte, an adequate system of freeways would carry about one third of all travel.[7]

System Comparisons – The proposed freeway systems in the study cities vary considerably in extent, in service afforded, and in traffic loadings. Some of the comparative aspects of these systems are shown in Table 41.

Length of the systems varies from 12 miles of route in Reno to over 200 in Washington and Detroit.

The average urban area population per mile of freeway measures the "coverage" of each system and provides a common basis for evaluating various freeway networks. In the study cities, the urban area population per mile of

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[7]California Department of Public Works, *The California Freeway System,* A report to the Joint Interim Committee on Highway Problems of the California Legislature – September, 1958.

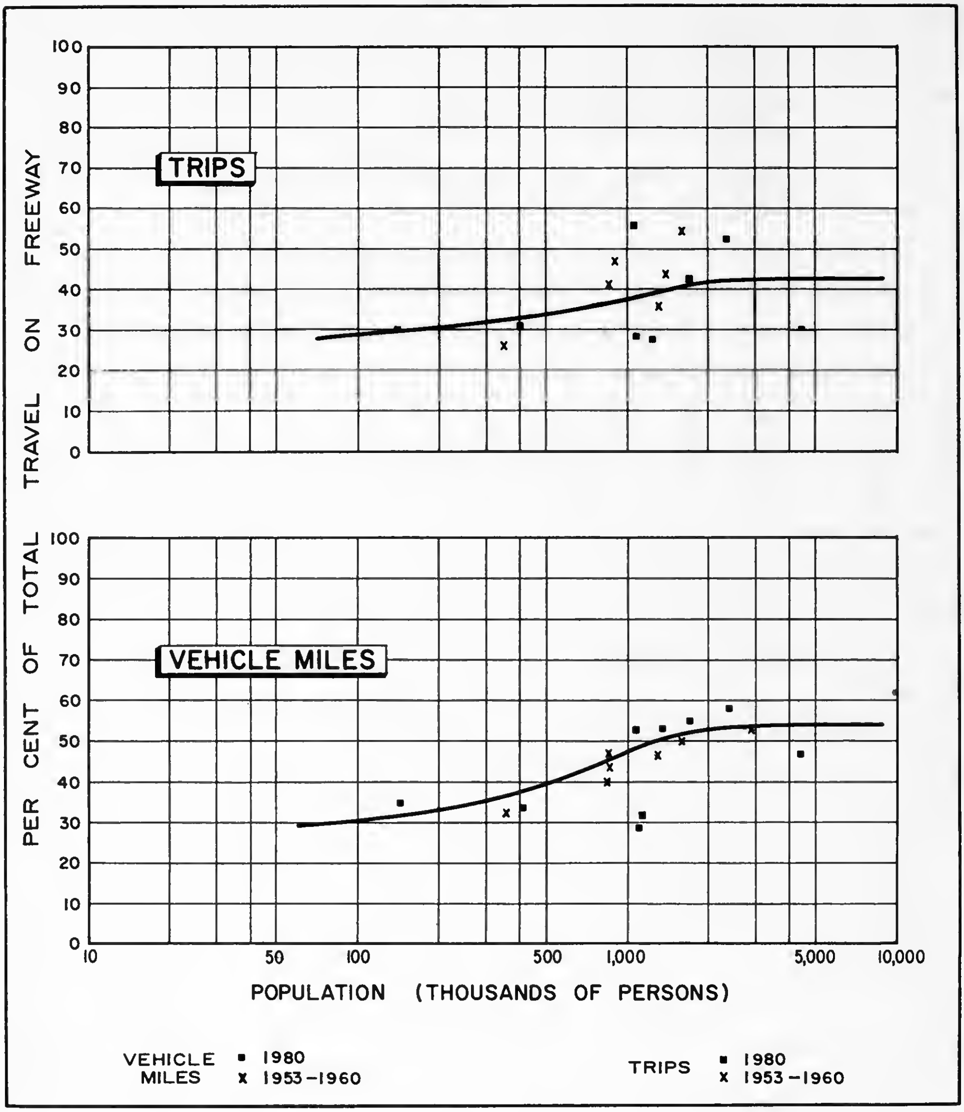

Figure 72
Freeway Travel Related to Urban Area Size

freeway is generally consistent, averaging about 10,000 people per mile of route in most cities. The exceptions are Oakland with its unusual topography, and Miami where freeway needs in future years appear to exceed those provided for in the plan.

The average length of trips on urban freeways ranges from about four miles in Reno to almost ten miles in Detroit.

The average traffic volumes potential to each mile of freeway route (based

TABLE 41

COMPARATIVE FUTURE FREEWAY USAGE IN STUDY CITIES — 1980[1]

CITY	MILES OF PROPOSED FREEWAY (Approximate)	POPULATION PER MILE OF FREEWAY	AVERAGE LENGTH OF TRIP ON FREEWAY	AVERAGE VOLUME PER MILE OF FREEWAY	VOLUME PER MILE ON HIGHEST VOLUME ROUTE	MAXIMUM VOLUME ON SYSTEM (Anticipated Maximum Load Point)
Detroit	350[2]	12,600	9.5	70,000	200,000[3]	240,000[2]
St. Louis	160	10,700	8.0	60,563	119,390	203,966
Washington	270-320	10,300	6.6	60,810	172,000[4]	287,000[4]
Kansas City	153	8,800	9.1	56,111	97,742	208,318
Charlotte	39	10,500	3.9	29,800	36,700	52,646
Miami	63	18,600	4.9	62,202	139,724	188,000
Phoenix	141	8,900	6.2[3]	39,600	50,700	92,000
Reno	12	12,000	4.0[3]	24,590	25,290	39,000
Oakland	134	7,600	9.0[3]	57,600	84,621	107,000

[1]Source: Calculations are based on proposed freeway plans as related to origin-destination studies in each area.

[2]Expressways and connecting routes.

[3]Estimated.

[4]Based on peak-hour assignment expanded.

on traffic assignments) vary from about 25,000 vehicles per day in Reno to about 70,000 in Detroit. The average volume potentials on the most heavily traveled routes are somewhat more variable, ranging from approximately 25,000 vehicles per mile in Reno to 200,000 in Detroit. The "maximum load point" potentials — heaviest assigned volumes on the freeway system — were highly variable and depended on configuration of routes and location of ramps; they ranged from 39,000 vehicles per day in Reno to over 200,000 in St. Louis, Kansas City, Washington and Detroit. It is apparent that changes in the structure of an area's freeway system will have marked effects on maximum system volumes, especially as the size of area increases.

City Size and Volumes — The relation between freeway volume potentials and urban area population is clearly depicted in Figure 73. Again, there is a correlation between city size and freeway traffic. Assignable volumes per mile of freeway increase consistently as cities get larger. Greatest increases are in the volumes along the most heavily traveled freeways and in the "maximum load point" flows.

For example, when cities are under 100,000, potential freeway volumes average about 25,000 vehicles per mile daily, maximum route potentials are slightly higher, and "maximum-load-point" potentials approximate 35,000 cars per day. When cities exceed two million in population, the average potential volume per mile approximates 70,000 vehicles; the potentials along the heaviest route average 140,000 vehicles per mile, and "maximum-load-point" assignments exceed 200,000 per day. By way of comparison, the maximum reported operating volumes on eight-lane freeways are slightly under 200,000 cars per day.

In smaller cities, the average volume per mile on the heaviest traveled freeway is about the same as the average system loading; however, in large cities, it is approximately twice as great. Similarly, the maximum-load-point volumes potential to freeway systems in small cities are about 1.5 times the average flows; in large cities, the ratio is as great as five.

Clearly, the greatest needs for urban freeways are in the larger metropolitan areas. While freeways will benefit travel in all urban areas, they will receive the most use and provide the greatest value in the larger areas.

In most communities under 100,000 population, volumes potential to freeway systems could generally be accommodated on high-type arterials; this is not the case in larger cities, where demands will closely match freeway capacities. As urban areas exceed two million people, volumes potential to certain heavier traveled routes may exceed capacities that can be provided under present concepts of freeway planning.

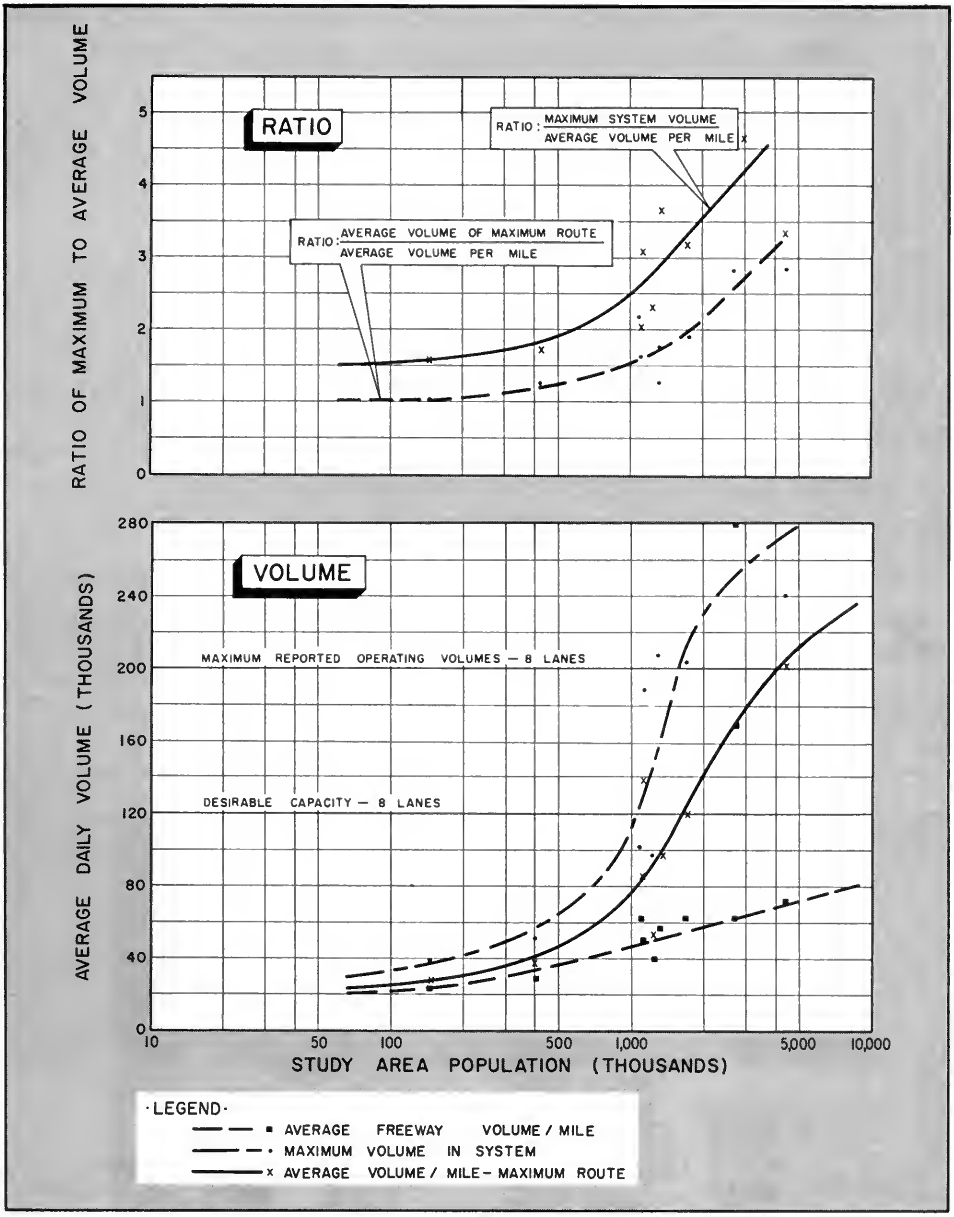

Figure 73
ASSIGNED FREEWAY TRAFFIC VOLUMES
IN RELATION TO URBAN AREA SIZE

Generally, the interrelations between volumes and urban area population seem consistent with the current policy of the Bureau of Public Roads regarding lanes on urban Interstate highways:

"In 1975 the number of lanes in cities exceeding one million population shall not exceed 8; for cities in the population range of 400,000 to 1,000,000, shall not exceed 6; and for cities under 400,000 inhabitants, shall not exceed 4 (population references are to the estimated 1960 population)."[8]

Any relationship between city size and lane requirements (such as shown by Figure 73, or designated by policy) should, of course, be used as a guide only; lane requirements for specific freeways may vary from these generalized criteria, and should be based on actual assignments.

Effect of Freeways on Arterial Travel – Freeways in urban areas serve the essential purpose of relieving arterial and other city streets. Without freeways, it would not be possible to accommodate the rapidly expanding travel in urban areas. Improvements to existing arterials will, at best, provide only modest capacity increases – and at a lower standard of operation.

Freeways will save motorists time and thereby attract traffic from conventional city streets. Trips, however, may be longer.

The effects of freeways on urban travel in St. Louis and Detroit are illustrated in Figure 74. If the proposed freeway systems in these cities

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[8]Source: U. S. Department of Commerce, Bureau of Public Roads, *Instruction Manual for Preparation and Submission of Revised Estimate of Cost of Completing the Interstate System,* Jan., 1960, p. 18.

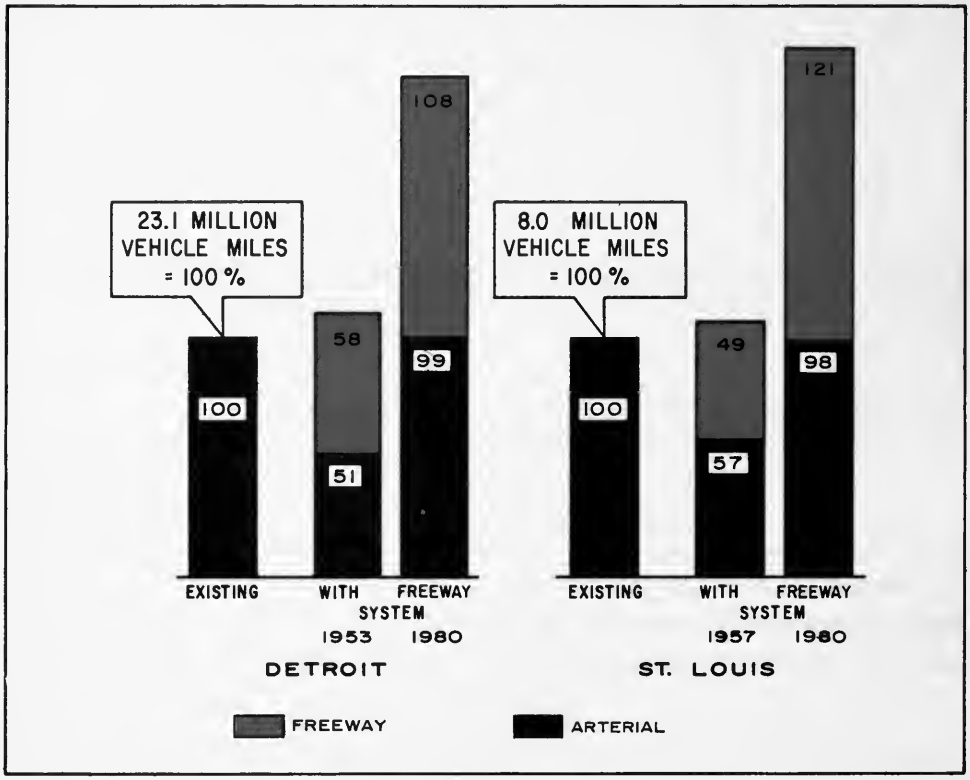

Figure 74
Effect of Freeway Systems on Urban Travel

were in operation today, there would be about six per cent additional travel in St. Louis, and nine per cent more in Detroit. This increase in travel would be more than compensated for by the reductions in arterial volumes. Freeways would reduce arterial street loadings to 51 per cent of their current level in Detroit and 57 per cent in St. Louis.

Travel in both cities is increasing as urbanization continues. Total 1980 travel in each city is expected to more than double present levels. Without freeways, it would be impossible to accommodate the increases. Even with the freeway system, 1980 arterial street traffic will have attained about the same levels as at present. Thus, still more capacity would be necessary after 1980 to serve new growths. The need for a continuing plan of urban freeway construction in both cities is quite apparent.

Freeway Trip Lengths — Freeway trips are longer than other urban trips. As shown in Figure 75, motorists using freeways travel about seven to nine miles on freeways, and about two miles on surface streets. The average length of trips made entirely on surface streets approximates four miles. Freeway users, therefore, travel almost three times as far as other urban drivers.

Different Freeway Users — It has been shown that a completed system of freeways in any metropolitan area will accommodate a substantial portion of the total daily vehicle miles of travel. The average car makes several trips each day, thereby increasing the likelihood that it will use a freeway one or more times during the day; this likelihood is further increased throughout the course of a week.

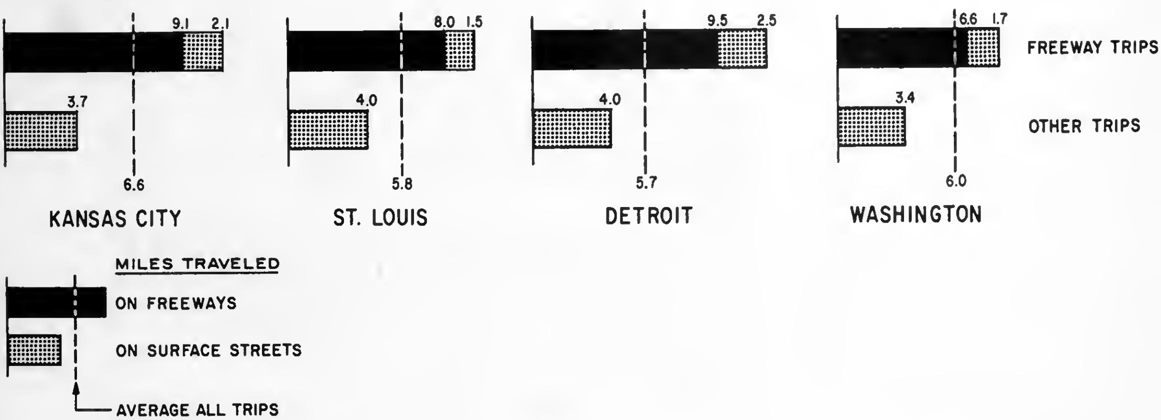

Figure 75
FREEWAY AND ARTERIAL TRIP LENGTHS
1980

The number of *different* cars using freeways is a predictable quantity. Such a relationship was obtained in a recent analysis of auto travel in 13 urban areas.[9] This research found that the combined volume of travel by local vehicles past selected locations on each of the principal arterial streets (including freeways) within a city represented a cross-section of the local cars in traffic. The combined volume of local cars at all locations when expressed as a percentage of local cars registered, contained a predictable number of different cars (also expressed as a percentage of cars registered). The composite data for all 13 cities showed consistent relationships for both one-day and seven-day counting periods, and were confirmed by subsequent findings in Indianapolis, Indiana.

It is reasonable to expect these relationships to apply in all cities. The different local cars in traffic or on the freeway system will, therefore, relate to the total combined one-way volume of local vehicles using a segment of each route as shown by the family of the "freeway use" curves in Figure 76.[10]

If the proportion of local cars passing a series of dispersed freeway locations is known, the curves may be used to calculate the proportion of different local cars contained in the total traffic. (Both total and different or separate local cars are expressed as percentages of local registration.)

Freeway Users in Study Cities — Accordingly, the freeway use curves have been applied to trip volumes assigned to freeway systems in some of the study areas, and the results have been summarized in Table 42. The combined volumes represent one-way volumes at maximum load points along each freeway, since the curves were based on one-direction traffic.

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[9]Smith, Wilbur S., and Wynn, F. Houston, "Different Cars as a Predictable Proportion of All Cars in Traffic," *Proceedings,* Highway Research Board, Vol. 39, 1960. The urban areas studied were San Francisco-Oakland, California; Minneapolis-St. Paul, Minnesota; Houston, Texas; Norfolk-Portsmouth, Virginia; Spokane, Washington; Greenville, South Carolina; Waterloo, Iowa; Lima, Ohio; Reno, Nevada; Pocatello, Idaho; Gulfport, Miss.; Austin, Minnesota; and North Platte, Nebraska.

[10]Curves adapted from the report, *The Wilbur Smith Study of Outdoor Advertising,* Outdoor Advertising Association of America, Chicago, 1960. In developing the freeway use curves, an "exponential" model was used, representing a decreasing rate of increase in y (degree of use) as x (total volume) increases.

The curves were calculated to be:
one-day freeway-use, $\log(100\text{-}y) = 1.99207 - .00311x$
seven day freeway-use, $\log(100\text{-}y) = 1.97855 - .01318x$

where:
- x is the number of *total* local cars passing at a series of locations, expressed as per cent of local car registration,
- y is the number of *different* local cars expressed as per cent of local car registrations.

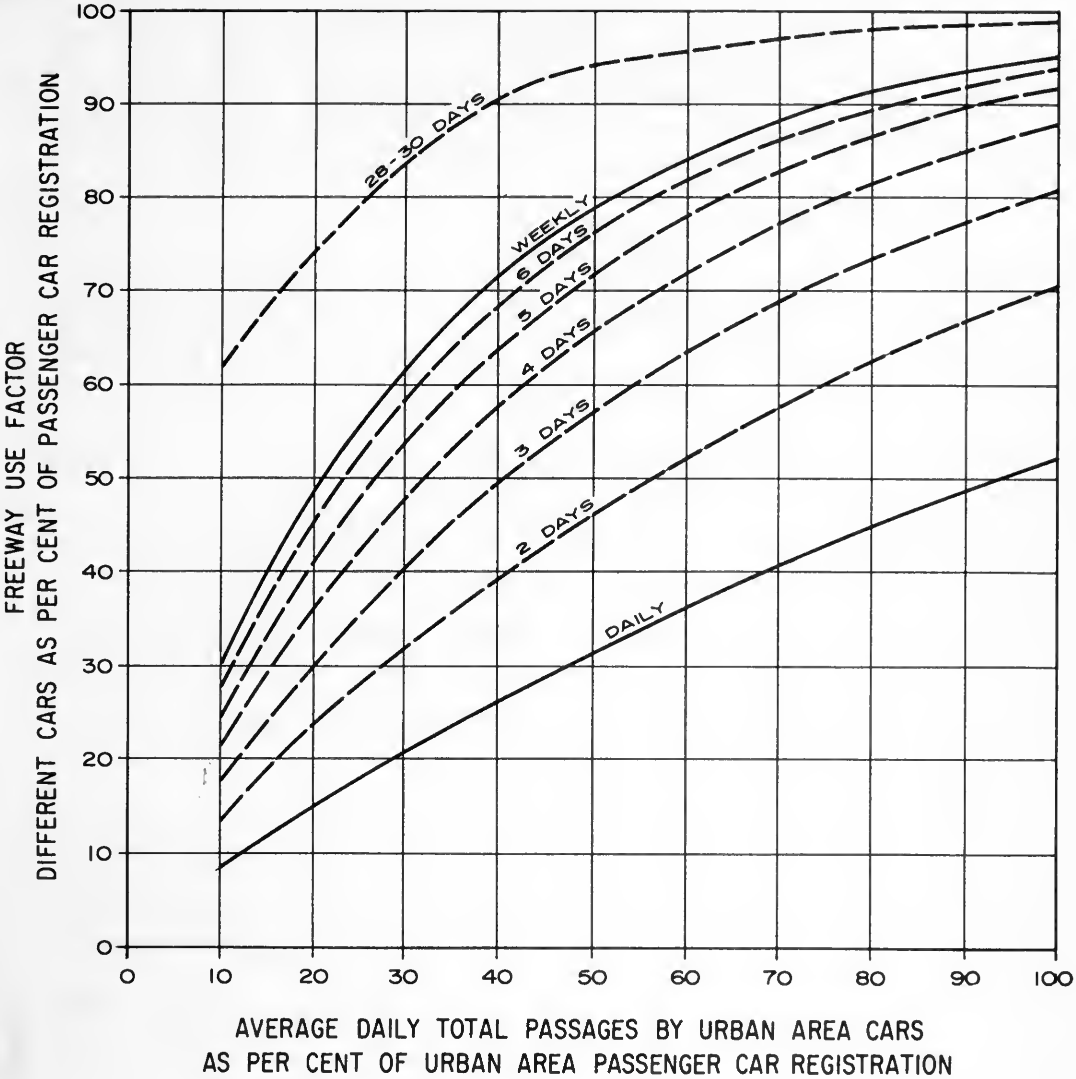


Figure 76
Urban Freeway Use Curves

The proportion of different or separate local cars on urban freeways each day ranges from 26 to 40 per cent of the registered passenger cars. It is reasonable, therefore, to anticipate that the separate local cars on the Interstate routes in these cities will approximate 20 per cent of the local car registrations.

For example, in Kansas City, local cars in the one-way, 24-hour 1980 freeway volumes at eight dispersed locations amounted to about 52 per cent of the registrations; based on the freeway use curves, the different local cars passing one or more of the freeway locations would amount to 32 per cent

Table 42

FREEWAY USE IN STUDY CITIES

Percentage of Separate Local Cars Appearing in a Day and a Week on Selected Sections of Urban Freeway Systems[1]

Urbanized Area	*No. of Locations*	*One-Way 1980 Freeway Volume (24 Hours)*	*Local Passenger Cars (70 Per Cent)*	*Local Car Registration*	*Freeway Vol. as Per Cent of Local Reg.*	*Per Cent of Separate Local Cars on Freeways*	
						Daily	*Weekly*
St. Louis	14	563,000	394,000	556,000	69.6	40	88
Kansas City	8	370,000	259,000	495,000	52.3	32	80
Nashville[2]	5	63,000	44,000	106,000	41.5	27	73
Charlotte	6	90,500	63,300	152,000	41.7	27	74
Reno	3	39,000	27,300	69,500	39.3	26	71

[1]Source: Estimates of 1980 traffic assigned to various freeway systems. Separate cars calculated from freeway use curves.

[2]Nashville volumes are for 1959 traffic assignments.

of the registered local cars. In the course of a week, 80 per cent of all local cars would be represented in the one-way freeway traffic passing the locations.

Frequency of Use — Many local vehicles will use the freeway often. This is apparent from Figure 77 which shows how frequency of highway use relates to local traffic volumes in Indianapolis. The family of curves indicates various seven-day volumes of local cars in traffic expressed as a multiple of the local car registration. (The vertical scale denotes the percentage of local cars that will appear in traffic the various number of times specified by the horizontal scale.)

There is every reason to believe that conditions found in Indianapolis are generally similar to those in other large urbanized areas. Therefore, the curves might be applied in a generalized way to freeway use in other cities.

For example, in Kansas City, the daily one-direction volume of local passenger cars at eight counting stations amounted to approximately 52 per cent of the local cars registered. The weekly, one-direction volumes would amount

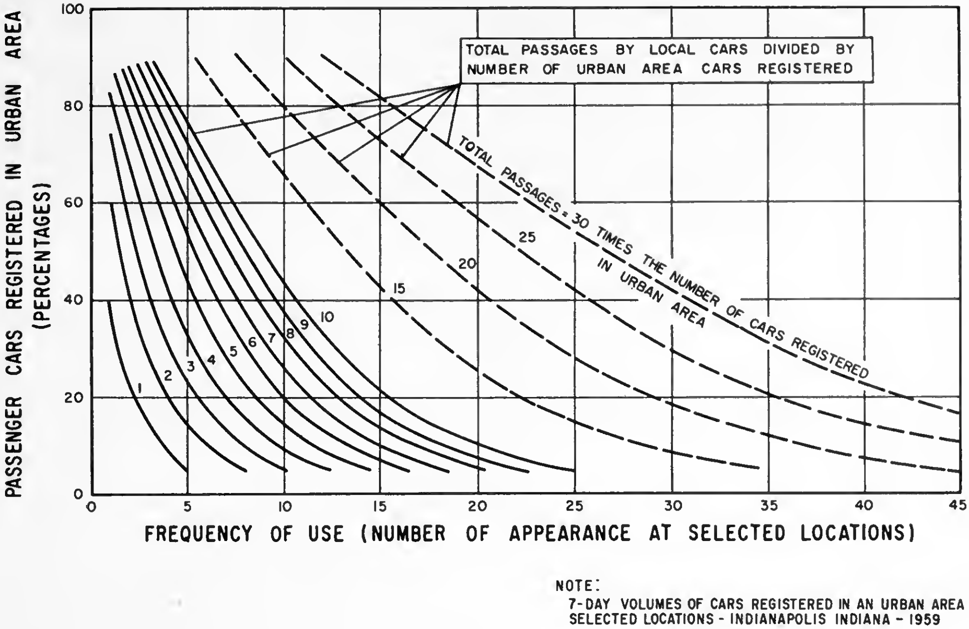


Figure 77
FREQUENCY OF URBAN HIGHWAY USE
INDIANAPOLIS, INDIANA

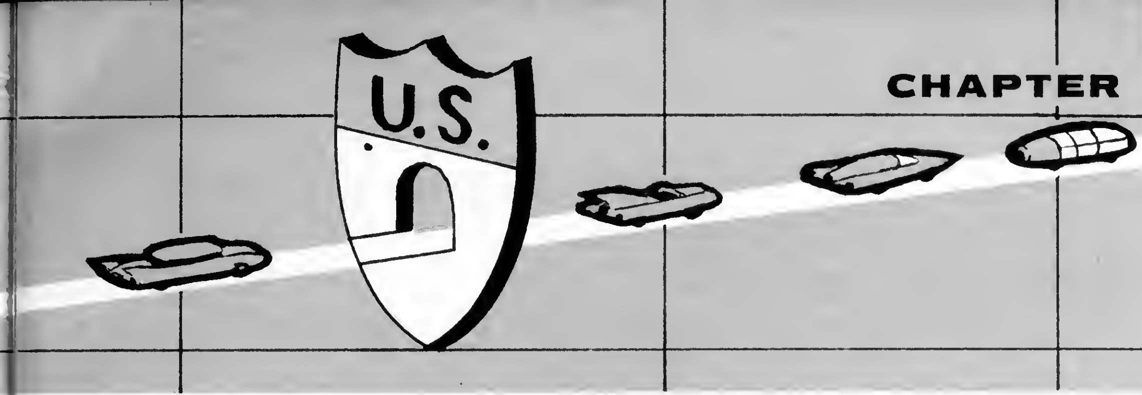
to about seven times this value, or 3.6 times the number of cars registered. Assuming that the weekly, one-direction volumes of local passenger car traffic at the counting stations amount to four times the number of local cars registered, about 32 per cent of all local cars would be expected to appear five or more times in the course of a week under these conditions; about 60 per cent of all local cars would pass the counting stations two or more times a week, about 80 per cent one or more times.[11]

Extension of Use Curves – The above study of urban freeways is concerned with only one section of each freeway route in an urban area. Many motorists who make trips on freeways may not happen to use any of these route sections past the maximum load points. Use of the freeway system could, therefore, be more extensive than the preceding analysis of the test sections indicates. The fact that traffic on freeways is two-directional will also increase the number of different freeway users. The results obtained from the curves represent a conservative estimate of freeway use. Nearly all motorists

[11]In this example, the chart is entered on the curve marked "4". The proportion of registered cars that will be detected five or more times during a week is determined by reading up to the curve from the frequency "5" on the scale at the bottom of the chart, then reading across to the left vertical scale from the point of intersection with the "4" curve.

in an urban area may be expected to use freeways if an integrated network were available for their use.

It is, therefore, reasonable to anticipate that urban Interstate highways will probably be used daily by most urban motorists. Similarly, the completed Interstate system would likely be used daily by nearly 40 per cent of all U. S. motorists, and within an average week, by about two thirds of all the nation's motorists.



CHAPTER 6

FUTURE TRAVEL and INTERSTATE SYSTEM USE

SUMMARY

FUTURE travel in the nation will reflect the increasing ownership and use of motor vehicles, and the changes in land-use patterns resulting from continued expansion of all urban areas. Existence of urban freeway systems will tend to increase urban travel by about 10 to 15 per cent as a result of freeway time savings, and freeway-originated land-use patterns.

From a detailed analysis of travel patterns in study cities, generalized estimates of future travel and freeway needs have been derived.

Present (1960) travel in the nation has been estimated to aggregate 728 billion vehicle miles annually, of which about half takes place in urban areas. With all needed freeways in operation, annual 1960 travel would approximate 811 billion vehicle miles — an increase of about 11 per cent over actual experience.

By 1980, an estimated 120 million registered vehicles will travel an annual 1,277 billion vehicle miles, assuming that the nation's freeway needs have been met. If only the Interstate system is completed by 1980, annual travel will total 1,230 billion vehicle miles.

The 1,277 billion vehicle miles of travel anticipated for 1980 will be distributed as follows: urban Interstate, 13 per cent; rural Interstate, 9 per cent; other urban, 47 per cent; and other rural, 31 per cent. In 1980, therefore, the Interstate system would serve about 22 per cent of the nation's annual travel.

Projections of urban travel point emphatically to the rapidly expanding freeway needs within urban areas. The proportion of travel in urban areas will increase to about 60 per cent by 1980, based on redefinition of urbanized areas to include new growth.

About 16,000 miles of freeways will be needed in urban areas for adequate accommodation of 770 billion vehicle miles of urban travel anticipated by 1980. Freeways in urban areas will serve over 35 per cent of all 1980 travel.

By 1980, urban Interstate routes will accommodate more than half of the vehicle miles potential to urban freeways. Approximately 9,600 miles of the 41,000-mile Interstate system will lie within expanded urbanized areas and will constitute more than half of the total needed urban freeway mileage. In addition to Interstate routes and about 800 miles of other existing urban freeways, approximately 5,600 miles of additional freeways will be required by 1980.

Rural Interstate highways are often constructed as links within the system to accommodate principal intercity travel movements, and will, therefore, be adequate for most rural travel that is expected to develop by 1975 or 1980.

By 1975-1980, the average volumes per mile of urban Interstate route will exceed 50,000 cars per day, whereas the average volumes of rural Interstate route will approximate 10,000 cars daily. Thus, each mile of urban Interstate route will be five times as heavily traveled on the average as each mile of rural Interstate freeway. Therefore, by 1975, the completed urban sections of the Interstate system will generally be operating at their capacities whereas most rural sections will have ample capacity reserves.

Since urban Interstate highways will provide only about half of the freeway mileage needed in urban areas by 1980, there will remain an urgent and continuing need for urban freeway construction even after the presently designated Interstate system is completed.

THE 41,000-mile National System of Interstate and Defense Highways connects most cities over 50,000 population. About 5,000 miles of this nationwide freeway network directly serve city populations and have been designated "urban"; essentially, they fall within the 1950 urbanized area limits as defined by the Bureau of the Census. The growth of suburban communities near most of the nation's cities during the decade 1950 to 1960 has greatly extended these urbanized areas, so that, in 1960, an estimated 6,700 route-miles of the Interstate system were within urban limits.[1] Urbanization will engulf additional mileage of the system during coming years.

The Interstate highway system is being designed to become an integral and essential part of the nation's highway network. Its high design standards, summarized in Table 43, will assure that Interstate highways remain efficient,

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[1]Burggraf, Fred, *The Merits of Limited Access Highways in Urban Areas,* British Road Federation, June, 1960, p. 10.

TABLE 43

SUMMARY OF DESIGN STANDARDS FOR INTERSTATE HIGHWAYS[1]

FEATURE	*TYPE AREA*			
	Flat	*Rolling*	*Mountains*	*Urban*
Design Speed[2]	70	60	50	50
Curvature: Desirable	30	50	70	70
Absolute Max.	40	60	90	90
Maximum Grades (Per Cent) (May be 2 Per Cent steeper in rugged terrain)	3	4	5	5
Medians	36′	36′	16′[3]	16′[3]
Shoulders	10′	10′	6-10′	10′

Side Slopes	4:1 Desired; 2:1 Maximum (Except in rock)
Lane Widths	- - - - - 12 feet - - - - -
Multi-lane Roads	For 1975 Design hour volumes over 700/hour

	Rural Rights-of-Way	
	Without Frontage Roads	*With Frontage Roads*
Two Lanes	150	250
Four Lanes (Divided)	150	250
Six Lanes (Divided)	175	275
Eight Lanes (Divided)	200	300

[1]Source: *A Policy on Design Standards — Interstate System, Primary System, Secondary and Feeder Roads,* American Association of State Highway Officials, Revised, September 1, 1956.

[2]*Design* speeds are those to which the system is designed; actual *operating* speeds are usually lower.

[3]May be narrower in urban areas, long bridges and mountainous terrain. Four feet — absolute minimum.

Figure 78
STATUS OF INTERSTATE HIGHWAY SYSTEM
SEPTEMBER, 1960

attractive and serviceable for a long period. Their location and design will enable them to attract a high proportion of the long-distance travel in the corridors they traverse. In addition, they will provide service to a large volume of short movements, especially in and around the many urban areas they serve.

STATUS OF SYSTEM

The status of the National System of Interstate and Defense Highways is fluid since each month additional miles are placed in operation or are put under construction. Its status, as of September 30, 1960, is depicted in Figure 78 and summarized in Table 44. It may be seen that work is underway on the system in almost every part of the country.

About 9,579 route-miles of the Interstate system (23 per cent) were open to traffic; 4,575 miles (11 per cent) were under construction; and preliminary engineering or right-of-way acquisition was underway for an additional 9,993 miles (24 per cent). Over-all, work was completed or in progress on 24,147 miles, or almost 60 per cent of the entire system, whereas no work has been done on the remaining 16,432 miles.

Table 44

STATUS OF NATIONAL SYSTEM OF INTERSTATE AND DEFENSE HIGHWAYS

SEPTEMBER 30, 1960[1]

STATUS		MILEAGE	PER CENT OF SYSTEM
Mileage improved and open to traffic:			
Completed to full or acceptable standards:			
With Interstate funds	3,688		
With other public funds	547	4,235	10.4
Improved to standards adequate for present traffic but additional improvement needed to meet full standards:			
With Interstate funds	1,274		
With other public funds	1,802	3,076	7.6
Toll facilities		2,268	5.6
Total mileage improved and open to traffic		9,579	23.6
Mileage under construction with Interstate funds		4,575	11.3
Preliminary engineering or right-of-way acquisition underway		9,993	24.6
Total mileage improved or with work underway		24,147	59.5
Remainder of System		16,432	40.5
TOTAL		40,579	100.0

[1]Source: U. S. Department of Commerce, Bureau of Public Roads, *Quarterly Report on the Federal Aid Highway Program, Sept. 30, 1960,* Washington, D. C., Nov., 1960.

More than 30 per cent of the 5,000 urban miles programmed for the system and about 20 per cent of the 36,000-mile rural system were open to traffic. It is significant that only about half of the presently available mileage has been developed with Interstate funds; the remainder represents roads built prior to the Interstate program, either with Federal Aid Primary funds or as toll roads.

BASES FOR FUTURE TRAVEL PROJECTIONS

Interstate highways and other freeways have a significant impact on community organization and development. It is essential, therefore, that they be adequately designed to accommodate the traffic demands that will develop during a substantial part of their useful life. Most highway planning studies are based on a 20-year projection — about the limit of reliable traffic estimation. Accordingly, projections of travel have been extended to 1980.

In anticipating future use of Interstate highways, it has been necessary to examine the present highway usage in the nation and to estimate future travel demands throughout the country, both for rural and urban travel. Discrimination between urban and rural travel is essential since the standards of highway design, the purposes and patterns of travel, and needs and capacity requirements differ on urban and rural roadways. It is, of course, realized that states vary administratively in differentiating between urban and rural mileage.

Analyses of travel characteristics and freeway use in the study cities, set forth in previous chapters of this report, provide the bases for appraising total future travel within the country's urban and rural areas, and the expected use of the Interstate highway system and other urban freeways. According to the population projections, these areas are expected to contain approximately 20 per cent of the population residing in major metropolitan areas by 1980; thus, they are a good sample of all urban travel.

Evaluation of future travel has been based on further analyses of the study cities, as supplemented with travel information obtained in other urban areas.

Urban Population Estimates — To provide a common basis for future travel projections, urban analyses have been based on a recent population study by the Urban Land Institute.[2] This estimate expects the population of the United States to reach 243 million by 1980, and is in close agreement with the Bureau of the Census projection of 245,409,000 by 1980.[3]

The proportion of population living in urban areas in 1960, and as anticipated for 1980 and 2000, are shown in Table 45. About 67 per cent of the total U. S. population now lives in urban areas; approximately 75 per cent

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[2]Pickard, Jerome P., *Metropolitanization of the United States,* Urban Land Institute, Washington, D. C., 1959.

[3]U. S. Department of Commerce, Bureau of the Census, *Statistical Abstracts of the United States,* Series III Projection, Washington, D. C., 1959.

Table 45

ANTICIPATED URBAN POPULATION DISTRIBUTION[1]

YEAR	MAJOR METROPOLITAN AREAS Number of Areas	MAJOR METROPOLITAN AREAS Per Cent of U. S. Population	ALL URBAN AREAS As Per Cent of U. S. Population
1960	78	48.3	67
1980	117	59.4	75
2000	145	65.9	85

[1]Sources: Pickard, Jerome P., *Metropolitanization of the United States,* Urban Land Institute, Washington, D. C., 1959; U. S. Department of Commerce, Bureau of the Census.

of the population can be expected to reside in urban areas by 1980; and by 2000, it is estimated that about 85 per cent will live in urban areas. The majority of these urban dwellers will be located in a relatively few major metropolitan areas; by 1980, almost 60 per cent of the nation's populace will live in 117 major metropolitan areas.

Travel Characteristics and Magnitudes — Characteristics of travel in the study cities were carefully evaluated, particularly as they relate to car ownership. These interrelationships are shown in Table 46 for present travel and in Table 47 for anticipated 1980 travel.[4]

Car Ownership — Car ownership ranged from about 270 cars per thousand population (Chicago, 1956) to 365 cars per thousand (Phoenix, 1957). These values represent cars actually "*in use*" by city residents when the surveys were made, but have been adjusted to include "fleet" cars owned by business establishments which account for four to five per cent of annual registration in the larger cities studied. Official yearly totals on vehicle registration are approximately 10 per cent greater than cars actually in use at any given time because of scrappage and registration transfer.

In projecting car ownership, it has been assumed that the economic trends of the past 20 years will continue, with largest economic gains by persons in the lowest economic strata as their purchasing power increases. As shown in Chapter III, the number of cars owned by the higher income populations in the suburbs appears to be approaching saturation levels.

[4]The projected traffic volumes vary somewhat from earlier projections for some cities, since the Urban Land Institute population estimates were used to attain consistency. In most instances, the estimates encompass larger areas and are generally higher than those used earlier. Travel characteristics have, therefore, been fitted to larger populations in these analyses.

TABLE 46

PRESENT DAILY PASSENGER CAR USE BY RESIDENTS IN STUDY AREAS[1]

(Weekday Travel)

METRO-POLITAN AREA	YEAR OF SURVEY	POPULATION (Thousands)	CARS OWNED[2] (Thousands)	CAR TRIPS (Thousands)	CARS PER 1000 POP.	TRIPS PER CAR	AVERAGE MILES/TRIP	AVERAGE MILES/CAR	ANNUAL VEH. MILES (Thousands)
Chicago	1956	5,169.7	1,396	5,015	270	3.60	5.0	18.0	25,100
Detroit	1953	2,969.0	876	3,470	295	3.97	4.4	17.5	15,350
Washington	1955	1,568.5	464	1,575	295	3.39	3.9	13.2	6,120
St. Louis	1957	1,275.5	382	1,625	300	4.25	4.4	18.7	7,140
Houston	1953	878.6	268	1,170	305	4.38	4.0	17.5	4,690
Pittsburgh	1958	1,472.1	412	1,510[2]	280	3.66[2]	3.6	13.2	5,400
Phoenix	1957	397.4	145	612	365	4.23	3.7	15.6	2,260
Kansas City	1957	857.6	279	1,100	325	3.95	3.9	15.4	4,300
Nashville	1959	357.6	111	542	310	4.88	3.4	16.6	1,840
Charlotte	1959	202.3	65	315	320	4.85	3.1	15.1	981
TOTAL		15,148.3	4,398	16,934	290	3.86	4.3	16.7	73,221

[1]Source: Origin-destination studies in each area.

[2]Pittsburgh "linked" trips expanded to represent "un-linked" travel for comparison with other data.

Note: Number of cars owned expanded to include cars owned by business (4 to 5 per cent of all registered passenger cars).
Number of trips expanded to meet "screenline" volumes, with allowance for trips by the cars owned by businesses.

TABLE 47

ANTICIPATED 1980 DAILY PASSENGER CAR USE BY RESIDENTS IN STUDY AREAS[1]

(Weekday Travel)

METROPOLITAN AREA	POPULATION (Thousands)	CARS OWNED (Thousands)	CAR TRIPS (Thousands)	CARS PER 1000 POP.	TRIPS PER CAR	AVERAGE MILES/TRIP	AVERAGE MILES/CAR	VEH. MILES (Thousands)
Chicago	8,053	2,656	10,800	330	4.1	6.0	25.0	66,400
Detroit	5,986	2,095	9,650	350	4.6	5.5	25.3	53,000
Washington	4,032	1,452	6,730	360	4.6	5.2	23.9	34,700
St. Louis	2,640	925	4,620	350	5.0	5.0	25.0	23,100
Houston	2,407	890	4,630	370	5.2	5.0	26.0	23,100
Pittsburgh	2,135	748	3,440	350	4.6	5.0	23.0	17,200
Phoenix	1,492	612	3,180	410	5.2	4.7	24.5	15,000
Kansas City	1,401	533	2,660	380	5.0	4.7	23.5	12,500
Nashville	557	212	1,190	380	5.6	4.3	24.1	5,100
Charlotte	427	166	930	390	5.6	4.0	22.5	3,730
TOTAL	29,130	10,289	47,910	353	4.7	5.3	24.7	253,830

[1]Source: Compiled from population estimates by Pickard, Jerome P., in *Metropolitanization of the United States,* Urban Land Institute, Washington, D. C., 1959; and from origin-destination studies in each area.

Since there is an upper limit of urban car ownership, cities with high car ownership, as Kansas City and Phoenix, are expected to have smaller increases in the ratio of cars to households than cities with relatively low ownership, as Washington, Pittsburgh and Chicago. Future ownership in the latter areas will be somewhat suppressed by the continued use of public transportation; transit will continue to play a significant part in the over-all transportation structure.

Over-all per capita car ownership is expected to increase about 22 per cent in the study cities. Projected 1980 car ownership in these cities (Table 47) ranges from 330 cars per thousand people in Chicago to 410 cars per thousand population in Phoenix. It should be noted that the estimates of cars "in use" are assumed to represent about 90 per cent of year-end "cars registered" in these areas.

Trip Frequency – The average number of trips currently made by passenger cars "in use" by city residents ranged from 3.4 trips per day (Washington, D. C., 1955) to 4.9 trips per day (Nashville, 1959). Trip frequency has been shown to increase as average levels of car ownership rise until car ownership reaches 1.4 to 1.5 cars per dwelling – the more cars, the higher the use per car.

Estimates of future trip frequency in each study area have given appropriate weight to expected car ownership and anticipated transit use. Average trip production per car is expected to increase about 20 per cent by 1980 in the study cities. A shorter work-week, augmented by higher purchasing power of urban residents at the lower end of the economic scale, will encourage more travel.[5] The 1980 estimates of trip frequency range from 4.1 trips per car per day in Chicago to 5.6 trips per car per day in Charlotte.

Trip Length – Auto driver trips in the study areas were shortest in small cities and longest in the big ones; trips ranged from an average of about 3.0 miles in Charlotte, North Carolina, to about 5.0 miles in Chicago.

Trips in future urban areas will be longer than at present as a result of increases in population and area. As new growth takes place in the suburbs, the average diameter of the urbanized area increases, and the opportunities for

[5]In developing trip frequency values, weight has been given to the adequacy of the origin-destination data for each city, and to the special handling accorded trips at the time they were reported. In all studies, the number of trips recorded by the interviewers proved to be less than the number actually made as found by field checks at screen lines and cordons. In some studies, the number of trips reported were further reduced by linking two or more trips which were basically parts of longer trips thus reducing the number reported. The number of auto driver trips, as reported according to home-interview survey procedures, will be about 10 per cent less than the actual trips in most areas.

longer trips increase. New urban freeway systems constructed during the next 20 years will also encourage the production of long trips.

Freeways will increase trip lengths as follows:

First, they will reduce travel time between many parts of the city, thereby increasing the mutual attraction of such areas. Workers will have access to larger employment markets and employers can choose from larger labor pools. They will also stimulate urbanization of undeveloped areas in their vicinity, thereby increasing the freeway orientation of the urban area and further reducing the time required to travel between many parts of the community.

Second, they will reorient trips for longer average distances by an average saving in trip time. Some indirection of movement by vehicles going to and from freeway interchanges will be induced. The added distances will, however, be more than compensated for in time saved by higher freeway speeds.

Studies of urban travel have shown that drivers seek the shortest time path between their origins and destinations, and often go out of their way to use freeways when they can save time. Since freeway travel is about twice as fast as travel along surface arterials, longer travel distances often result.[6]

The combined effect of the above influences will increase average trip length in urban areas by 10 to 15 per cent.

Vehicle Miles — Computed lengths of auto driver trips in existing study areas, when multiplied by the number of trips made by each car, showed average miles of travel per passenger car ranging from about 13 miles per day in Washington and Pittsburgh to over 18 miles per day in St. Louis and Chicago.

Increases in travel in all cities will result from growths in population and expansion of urbanized areas. The largest increases are anticipated in cities that will expand the most in area, and/or that currently exhibit higher-than-average transit usage according to their size and concentration. Higher rates of trip production anticipated in future years and the longer average length of trips are expected to increase average daily 1980 travel per car by about 50 per cent over present levels. Anticipated 1980 travel per car will range from about 22.5 miles in Charlotte to 26.0 miles in Houston.

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[6]The comparisons of trip length on freeways and arterials shown in Figure 75 substantiate this point. Similarly, test assignments of 1959 travel in Nashville found that about 23 per cent of all vehicle trips were assignable to some portion of the proposed freeway system, these assigned trips traveled about one third of a mile longer on the average; however, the average driver realized about a four-minute saving in over-all trip time.

Vehicle Miles Per Capita — The expected increase in car ownership, coupled with increased travel per car, will substantially increase the average daily vehicle miles of passenger car travel per resident. Daily *passenger* car travel per urban resident, made by cars owned by residents, averaged about five miles in the combined origin-destination data for 10 study areas. Daily urban vehicle miles by resident-owned passenger cars would, by 1980, average about 8.5 miles per person in the same cities.

Non-Resident Travel — The studies of urban travel, taken from the origin-destination surveys, describe only the routine weekday travel of the urban vehicle, including those portions of trips to and from areas outside the external cordon which fall within the home community. Neither the miles of travel in other urbanized areas nor the urban travel by rural residents is included. It seems likely that at least 10 per cent of the average urban car owner's non-routine travel is made within other urbanized areas. In heavily urbanized parts of the United States, as the North Atlantic region, the proportion of urban travel may be more than twice this amount; in rural western states, the urban portions of non-routine travel — especially recreational trips — may be much less than 10 per cent. Similarly, urban travel by rural residents probably exceeds 10 per cent of their annual mileage since a very high proportion of all trips by rural people begin or end in urban areas, according to recent studies.[7]

Truck Travel — The combined volume of urban passenger car travel by residents and non-residents accounts for approximately 85 per cent of the total vehicular travel in most cities. In projecting travel, it has been assumed that the miles of truck travel will reflect the proportion of commercial vehicles registered, and that truck travel will amount to 16.5 per cent of the total 1980 vehicle miles of travel in all urban areas.

Total Travel Per Capita — In the study cities, the total vehicle miles of travel by all vehicles, when expressed on a per capita basis, amount to about 6.5 miles per capita at present. Future travel in these urban areas would be slightly over 11 miles per capita. These values are confirmed by vehicle mile calculations for a somewhat different grouping of study cities, as set forth in Chapter V.[8]

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[7] U. S. Department of Commerce, Bureau of Public Roads, *Highway Transportation*, Background Information Prepared for National Academy of Sciences, National Research Council, Transportation Research Study, Aug. 1960, Woods Hole, Massachusetts, by Bureau of Public Roads — p. 82.

[8] In Chapter V, it was shown that the total urban vehicle miles, when expressed as a per capita basis, approximated 7 miles at present, and 10.5 miles in 1980; both values assumed the existence of complete freeway systems. Thus, the two sets of both estimates of urban travel fall within the same range.

Extension of Projections to Other Areas — Projections of travel in the study cities have been extended to other urban areas. Car ownership ratios and estimates of annual miles of travel per vehicle were prepared for the inhabitants of urban areas in the various population ranges, and the estimates in each range then aggregated.

Except for Los Angeles, which is expected to be more car-oriented than other very large cities (and which is expected to be the second largest city in the nation by 1980), the average annual miles of travel will be least in the largest cities and greatest in the smallest communities and rural areas. Analyses of urban travel characteristics have shown a higher proportion of travel via public transportation in the larger cities — a condition that will continue in relative terms, although it will possibly be less in magnitude. In addition, higher densities in large central cities will allow more trips to be made by foot, while difficulties and expenses of garaging private automobiles will tend to limit car ownership.

Consideration has been given to the travel that would be performed under varying systems of freeways. Trip-assignment studies made for several large metropolitan areas during recent years, including the study cities, and similar analyses of toll road and toll bridge potentials at a number of locations throughout the country, have shown that an adequate system of urban freeways will encourage vehicular travel throughout an urban area ranging from 10 to 15 per cent. These increases will result from longer trips and changes in origin-destination patterns, and in some cases through car purchases encouraged by availability of better roads. Car ownership levels consistent with the expected level of freeway development were prepared and that level of ownership adhered to for all conditions analyzed at each projection date.

Increases in trip length under the several basic conditions of freeway development were applied only to routine daily travel, although recreational and other forms of intercity travel will also be encouraged by the completion of a national freeway network. The magnitude of these additional increases appears to be relatively small, insofar as over-all time savings on rural portions of such trips are concerned.

The current average annual miles traveled per car (about 9,500 miles per registered vehicle or about 10,500 miles per vehicle "in use"), has been assumed to increase about 10 per cent by 1972, primarily because of the completion of the Interstate highway system; however, the average travel per vehicle has been held constant after 1972. While the average trip length in each category is expected to continue increasing as the remaining freeway needs are met, anticipated declines in the average number of trips per vehicle should offset any increase in average miles traveled by each vehicle. This condition will arise as an increasing proportion of households acquire two or more cars (the number of trips per vehicle may tend to decrease as more vehicles become available to serve each family).

ANTICIPATED FUTURE TRAVEL

Anticipated future vehicular travel in the nation's rural and urban areas in 1972, 1975 and 1980 have been determined for several alternate conditions: These conditions assume (1) no further construction of freeways beyond those now built, (2) a completed system of Interstate highways, (3) travel that might take place if the Interstate system were supplemented with all other needed freeways. Projections anticipate a continuance of present economic trends.

At its inception, the National System of Interstate and Defense Highways was approved for completion by June 30, 1972; this remains the earliest likely date for completion of the system. Recently, there have been proposals to defer completion to 1975 so that costs of construction can be "stretched out" over a longer period of time. Accordingly, estimates of 1972 travel have also been prepared for this condition. Detailed estimates of travel for the 13 different conditions are set forth in Appendix A.

Total Future Travel – Anticipated trends in population, vehicle registrations and passenger cars "in use" are summarized in Table 48. They are graphically compared to future travel in Figure 79.

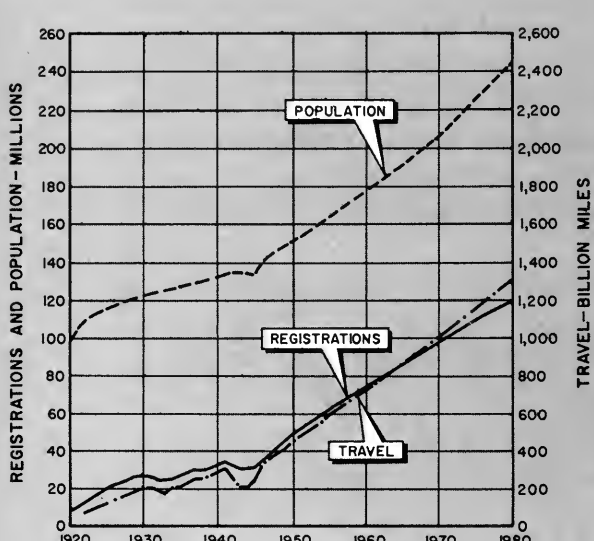

Figure 79
SUMMARY OF FUTURE TRAVEL TRENDS

Population and Car Ownership – By 1980, about 75 per cent of the nation's population is expected to live in urbanized areas; the urban population will number about 180 million persons, and be equivalent to the nation's total 1960 population. The car population will continue to increase more rapidly than people. In 1980, about one person is anticipated for every two registered motor vehicles; total registration

TABLE 48

SUMMARY OF ANTICIPATED POPULATION, REGISTRATION AND TRAVEL[1]

ITEM	YEAR 1960	1972	1975	1980
Population	179,500,000	217,600,000	225,500,000	243,000,000
Total Vehicles Registered[2]	74,000,000	103,400,000	109,500,000	120,000,000
Persons Per Vehicle	2.4	2.1	2.1	2.0
Passenger Cars Registered	61,600,000	86,460,000	91,410,000	100,650,000
Cars in Use[3]	56,000,000	78,640,000	83,100,000	91,500,000
Cars in Use Per Thousand Population	312	361	369	376
Vehicle Miles Traveled (Millions)	728.0[4]	1,058.5[5]	1,117.5[5]	1,277.5[6]
Per Cent Urban	47.6	56.4	57.6	60.6

[1]Source: Calculations based on Tables 45 to 47, and Appendix A.

[2]Includes trucks.

[3]The year-end number of cars registered are about 10 per cent greater than the cars "in use." The difference is attributable to cars removed from use (junked or wrecked) during the course of a year; duplicate registration (licensed in more than one state due to migration of residents); cars held for resale on used-car lots; etc.

[4]With existing road systems. See Appendix A.

[5]With Interstate system complete.

[6]With all freeway needs complete.

will exceed 100 million. Cars "in use" will number about 376 per thousand population compared with approximately 312 in 1960, an increase of about 20 per cent. About 70 per cent of all cars will be owned in urban areas.

Aggregate Travel — Detailed projections of the future travel under the various programs of freeway development are shown in Table 49 and Figure 80. Total travel in the country is expected to increase from about 728 billion vehicle miles annually in 1960 to about 1,277 billion vehicle miles in 1980, an increase of more than 75 per cent.

TABLE 49

ESTIMATES OF VEHICLE MILES OF TRAVEL IN UNITED STATES 1960-1980[1]

Year	Assumed Status of Freeway Program	U. S. Population (millions)	Cars Owned Per Thousand Population	Vehicle Miles of Travel (billions)	Urban Vehicle Miles as Per Cent of Total	Per Cent of Urban Travel on Interstate System	Per Cent of Rural Travel on Interstate System	Per Cent of Total Travel on Interstate System
1960	Present Status	179.6	312	728.0	47.6	10.3	11.2	10.8
1972	Interstate Stretch-out	217.6	361	1050.0	56.2	21.8	17.9	20.1
1972	Interstate Built	217.6	361	1058.5	56.4	24.8	21.8	23.5
1975	Interstate Built	225.6	369	1117.5	57.6	25.0	22.0	23.8
1980	Interstate Built	243.0	376	1230.0	60.6	25.2	22.2	24.0
1980	All Needed Freeways Built	243.0	376	1277.5	60.3	22.3	21.4	22.0

[1]Source: Appendix A.

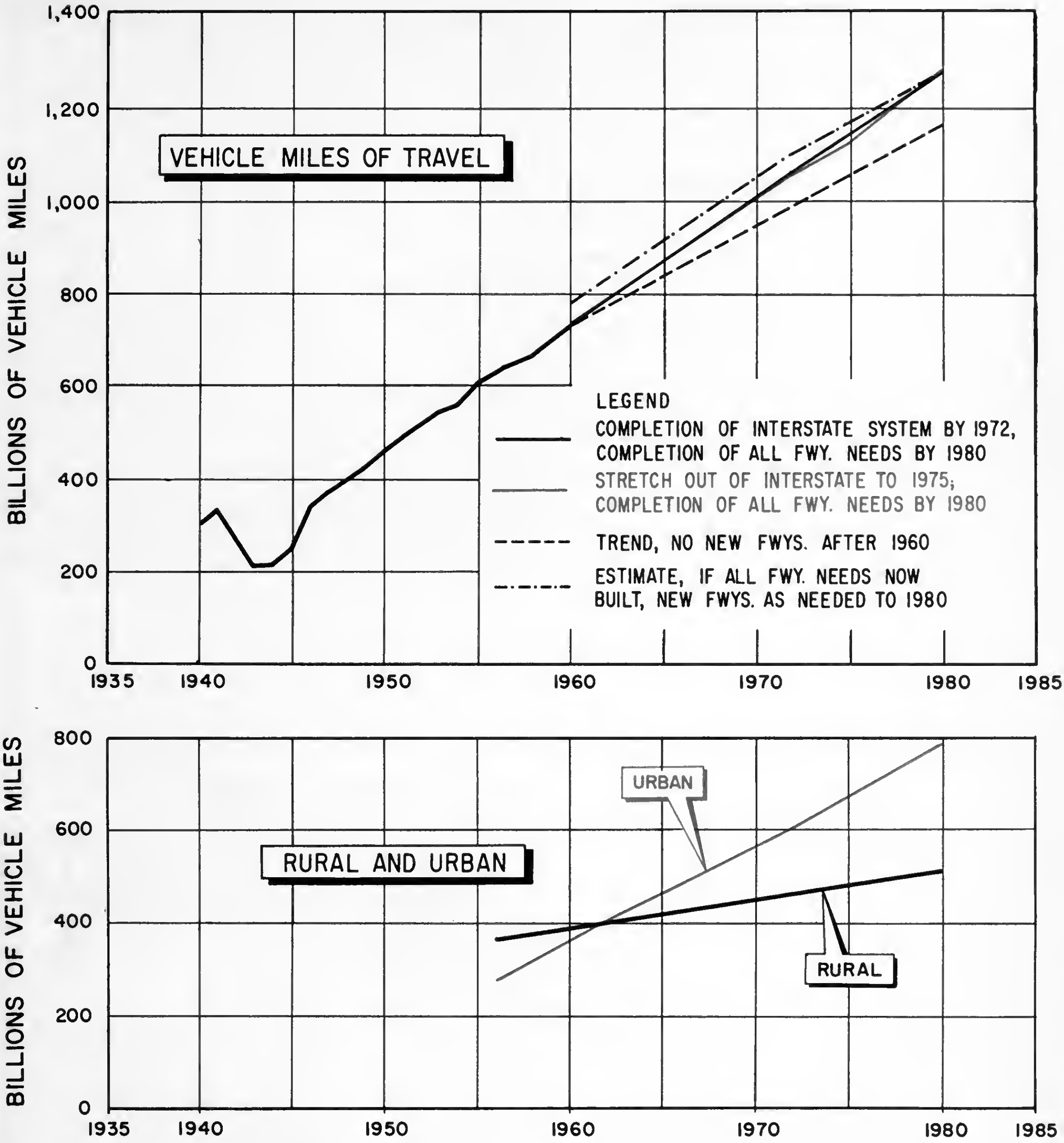

Figure 80
VEHICLE MILES OF TRAVEL IN UNITED STATES
1940-1980

The 1980 estimate of annual vehicle miles of travel assumes that *all* of the nation's freeway needs will be met by that year. It is about five to six per cent lower than the aggregate of the 1956 future travel estimates prepared by the states. However, growth of travel beyond this level within the next 20 years would assume unrealistic increases in auto ownership and use.

Urban Travel – Today, almost 50 per cent of all highway travel takes place within urban areas, according to annual estimates published by the U. S. Department of Commerce, Bureau of Public Roads. By 1980, urban roads and streets can be expected to accommodate about 60 per cent of all vehicular travel. This figure assumes redefinition of urban areas to include expected new growths within the next 20 years.

Interstate System Travel – The 1,277 billion vehicle miles of travel anticipated for 1980 on the nation's roads and streets will be distributed as shown in Table 50 and Figure 81. They will include about 13 per cent Interstate urban, 9 per cent Interstate rural, 9 per cent other urban freeways, and 5 per cent other rural freeways; other urban travel will comprise 38 per cent and other rural travel, 26 per cent.

Over-all, about 22 per cent of all 1980 vehicle miles of travel appear to be assignable to the Interstate system; and travel on other freeways will amount to another 14 per cent. Thus, in 1980, more than one third of all the nation's travel would probably be served by freeways if all needed freeways were constructed.

Upon its completion in 1972, the Interstate highway system will serve about 24 per cent of the nation's annual travel.

TABLE 50

SUMMARY OF ANTICIPATED 1980 TRAVEL[1]
IN UNITED STATES

	BILLIONS OF VEHICLE MILES OF TRAVEL			
FACILITY	*Urban*	*Rural*	*Total*	*Per Cent*
Interstate Highways	172.0	108.8	280.8	22.0
Other Roads and Streets	598.0	398.7	996.7	78.0
TOTAL	770.0	507.5	1,277.5	100.0
Per Cent	60.3	39.7	100.0	
Per Cent on Interstate	22.3	21.4	22.0	

[1]Source: Appendix A. Estimate assumes all freeway needs are met.

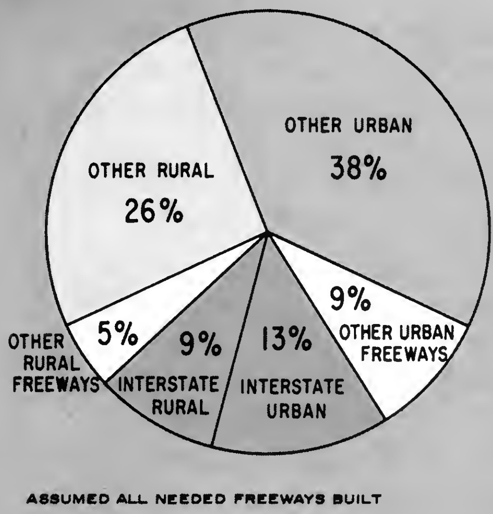

Figure 81
ANTICIPATED DISTRIBUTION OF 1980 TRAVEL

Effects of Alternate Construction Programs — Estimates of total vehicular travel for several alternate programs of freeway construction are graphically compared in Figure 82, and detailed in Appendix A.

1960 Travel Potential — In 1960, travel on all the nation's streets and highways has been estimated to approximate 728 billion vehicle miles. This includes travel on the freeways and parkways in urban areas (about 30 per cent of the actually needed freeways) as well as on other facilities. About 9,000 rural miles of freeways and toll roads, probably representing half or more of the present actual rural freeway needs, are also included in the existing highway network on which this travel was performed.

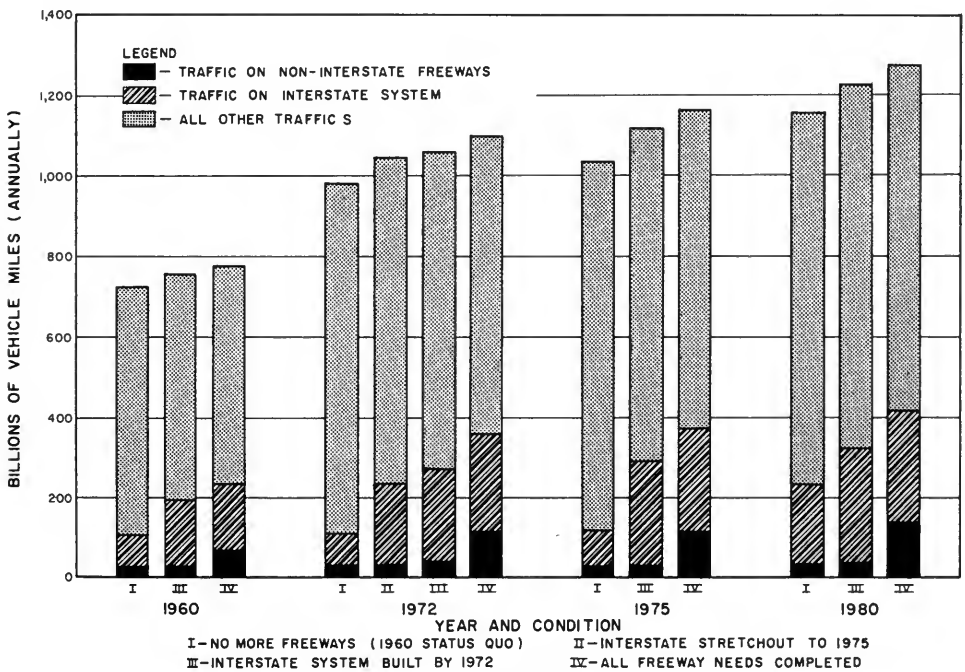

Figure 82
VEHICLE MILES OF TRAVEL ON INTERSTATE SYSTEM IN UNITED STATES
1960-1972-1975-1980

If the Interstate system were in operation today, the additional urban miles of freeways would represent almost 75 per cent of the total urban freeway needs. Very little rural freeway deficiency would remain. The system would be expected to generate about 780 billion vehicle miles of travel – seven per cent more than actually take place. More than half of this increase would be in urban areas despite the much larger amount of rural freeway mileage.

It is estimated that about one and one half million more passenger cars would be "in use" if the entire Interstate system were in existence in 1960. Adjusting for trucks and assuming "ownership" as 90 per cent of "registered cars", the total additional vehicles registered would number about two million. This value is approximately three per cent over actual 1960 registrations.

If the remaining freeway needs in urban areas were completed, 1960 travel would approximate 811 billion vehicle miles; *this corresponds to an increase of about 11 per cent over actual experience.* Approximately two thirds of this increase would be in urban areas.

1972 Travel Potentials – Four conditions have been examined for 1972: the first considers the probable miles of travel that would be performed if all new freeway construction were halted at the end of 1960; the second condition estimates travel that would occur if the Interstate system completion were delayed three years, 1972 to 1975; the third condition assumes completion of the Interstate system by 1972; and the fourth visualizes the completion of all freeway needs in the nation (including another 2,600 miles of rural freeways not on the Interstate system).

Under each assumption for 1972, taken in the order given, an increasing volume of travel would develop. Annual travel will total about 983 billion vehicle miles with no additional freeways constructed, 1,050 billion vehicle miles with Interstate construction deferred, 1,058 billion vehicle miles with all Interstate freeways built, and 1,100 billion vehicle miles with all needed freeways in operation. Approximately 11 per cent more vehicle miles are anticipated, if all freeway needs are met, over the travel that would be generated on a system to which no freeways had been added since 1960.

With a 1972 completion schedule, the volume of travel on the nation's highways by 1972 is expected to be about 45 per cent greater than the volume of travel actually experienced in 1960 (approximately 1,058 billion vehicle miles compared with 728).

More than 56 per cent of all 1972 travel in the United States would be expected to take place in urban areas under all four conditions.

The aggregate use of the Interstate system and the traffic benefits gained would be substantially less under a construction stretch-out to 1975. Under the delayed program, about 22 per cent of all 1972 urban travel would be performed on urban Interstate highways; whereas if the Interstate system were complete, about 26 per cent of urban travel would be on the system.

The complete Interstate system (urban and rural) in 1972 would likely carry about 18 per cent more travel than would be accommodated on the finished portions of a system based on a 1975 completion schedule — 248 billion vehicle miles compared with 211. Cost penalties resulting from a stretch-out are detailed in Chapter IX.

1975 Travel — Total 1975 travel would approximate 1,163 billion vehicle miles annually if all needed freeways were completed. However, if only the Interstate system were completed, travel would aggregate about 1,118 billion vehicle miles. With only existing 1960 freeways, annual 1975 travel would total 1,037 billion vehicle miles.[9]

Thus, by 1975, the completed Interstate system, without other new freeways, would probably generate approximately eight per cent more vehicle miles of travel throughout the nation than would be realized without any new freeway construction between 1960 and 1975. With all of the freeway needs met in 1975, an additional four per cent increase is anticipated in annual travel. A halt of all new freeway construction in 1960 would likely tend to reduce ownership in 1975. Approximately 58 per cent of all 1975 travel will be in urban areas.

1980 Travel — Similar relationships have been anticipated for 1980 travel. By 1980, about 1,277 billion vehicle miles of travel would be performed annually in the nation, provided that all needed freeways had been completed. If only the Interstate system were completed, annual 1980 travel would be about four per cent less, aggregating about 1,230 billion vehicle miles.

In 1980, if *only* the Interstate system were completed, about 204 billion vehicle miles would be potential to urban freeways, whereas if all freeway needs were met, 286 billion vehicle miles would be potential. Thus, the travel potential to a complete and adequate system of express highways would be about 40 per cent greater than if only the Interstate routes were completed. Other urban freeways would, however, be more heavily traveled and would tend to be more frequently overloaded. Some freeway use would represent marginal benefits by motorists who would receive substantial economies if the entire freeway system were available.

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[9]Since the Interstate system will probably be completed by 1975 under any of the current proposals, estimates have not been prepared for a stretch-out beyond that date.

URBAN FREEWAY NEEDS

Detailed analyses of the prospective 1980 highway needs in the study cities have been set forth in Chapter V of this report. These studies indicate that, on the average, in cities of every size and type, the expected increases in car ownership and extension of low-density land uses justify about one mile of freeway for every 10,000 urban residents. On this basis, today's urban population of approximately 120 million people should be served with about 12,000 miles of freeway; by 1972, almost 15,600 route-miles would be needed and by 1975, the needs would have risen to approximately 16,500 miles. Therefore, the anticipated 1980 urban population of more than 180 million would need about 18,000 miles of express highways.

Obviously, any such generalization of freeway needs will require some modification when applied to the high-density central cities of the largest and oldest metropolitan areas (such as Philadelphia, Boston, New York, Chicago) where public transportation provides effective service and where a sufficient network of freeways might be uneconomical to develop. Just as it is difficult to extend their transit potentials, carte blanche, to all other urban areas, it is similarly difficult to apply nationwide freeway criteria without certain modifications.

It is also apparent that urban populations in most communities under 50,000 population do not generally create sufficient need to justify freeways to serve internal travel.[10] This does *not* imply that freeways should not be constructed in these areas, but rather that the general criteria should again be modified. Heavy traffic movements through small cities, especially where they are located along a traffic corridor that serves larger urban areas, often warrant freeway construction. Similarly, more remote towns situated along Interstate highways or along other freeways should, of course, be provided with these high-capacity facilities in the interest of system continuity.

Except for the very high-density central cities and small isolated communities, freeway needs of urban areas conform to the general criterion of one mile per 10,000 residents. Over-all urban area freeway needs projected on this basis should, therefore, be adjusted downward by about 2,000 miles to allow for the cited extreme conditions.

Estimated urban freeway needs, therefore, approximate 10,000 route-miles for 1960; about 13,600 for 1972, and about 14,500 miles for 1975. *By 1980, approximately 16,000 route-miles of urban freeways will likely be required.*

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[10]See, for example, Figure 73.

It is clear that the existing mileage of freeway-type routes in urban areas falls far short of anticipated future urban needs. Of about 6,700 miles of Interstate route currently located in urbanized areas, only about 2,100 miles are currently open to traffic.[11] Other urban freeways and parkways not on the Interstate system account for about 800 miles. Thus, the entire urban freeway mileage presently in use amounts to almost 3,000 route-miles, less than 30 per cent of the 10,000 miles that appear needed.

Urban Interstate System — Although, as presently defined, urban Interstate highways comprise about 5,000 miles, about 6,700 miles of the system currently lie in areas that are essentially urban in character. Urban growth in the next 20 years will probably take place at low densities (about 2,500 persons per square mile), thereby doubling the present urban land area. The expansion of urbanization will increase the average diameter of cities and engulf a corresponding amount of rural Interstate mileage on the radial routes that serve each community.

Additional miles of the Interstate system will be progressively incorporated within the urban definition. By 1972, about 8,400 route miles of the presently defined Interstate system will probably fall in this category; by 1975, about 8,850 miles; and by 1980, approximately 9,600 miles. Thus, about 62 per cent of the route-miles of urban freeway needs would probably be met if the Interstate system is completed by 1972.

The 9,000 to 10,000 miles of the designed Interstate system located within urbanized areas by 1980 represents over half of the freeway mileage that will then be needed in urban areas. By 1980, urban Interstate routes would, therefore, accommodate half or more of the vehicle miles potential to freeways in urban areas.

Other Urban Freeways — Urban Interstate freeways constitute a large part of the urban need, but by no means do they serve all of the critical traffic corridors in the cities. The proposed Page-Easton freeway route in St. Louis, for example, would be located in the heaviest traffic corridor but is not on a designated Interstate route; prospects for its early construction are not good, although it is a vitally needed facility. An intermediate circumferential highway to serve the Washington area located just inside the District of Columbia limits is a vital component of the freeway system, but is not a part

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[11]The 2,100 miles includes portions of Interstate routes located in urban areas, but officially designated as "rural".

of the Interstate program. Similar conditions exist in nearly all of the metropolitan areas examined in this study.

Thus, the non-Interstate routes are often as vital to the urban community, as those on the system. After the Interstate program has been finished, about 40 per cent of the urban freeway needs will remain. These studies show clearly that there will be need for continued urban freeway construction long after the presently-designated Interstate system is complete.

Relation of Needs to Assumed Construction Schedule — To provide the needed freeways, an active program of highway construction will be required.

Construction to 1972 — Based on this target date for completion of the system, approximately 32,600 miles of Interstate routes will lie in rural areas by 1972. About 7,500 miles of these routes are presently open to travel, leaving 25,100 miles to be built in the next 12 years, or an average rate of about 2,100 miles per year.

Similarly, of the 8,400 Interstate route miles that would be built in urbanized areas by 1972, approximately 2,100 miles are already constructed. An additional 525 miles would have to be added annually to complete the 8,400 urban Interstate miles by 1972.

Additional Construction to 1980 — Freeway construction necessary to complete the Interstate system by 1972 would have to be maintained at substantially the same level for another eight years to satisfy all 1980 freeway needs. If Interstate construction were stretched out to 1975, an accelerated program would be called for to meet all the nation's freeway needs by 1980.

Necessary freeway construction between 1972 and 1980, assuming that no new freeways other than those on the Interstate system are built between now and 1972, are shown in Table 51. It is estimated that about 5,600 additional urban miles and about 5,400 new rural miles will be needed to satisfy all freeway needs by 1980. Urban freeways would have to be added to the system at the rate of approximately 700 miles per year, and rural highways at almost the same rate to meet the 1980 schedule. Total freeway construction after 1972 would approximate 1,400 miles per year.

The assumption that only Interstate freeways will be built in 1972 is, of course, conservative; the preceding estimates of needed freeway construction after 1972 may, therefore, be slightly greater than actually required. In a number of states, notably California, freeway construction on other parts of the primary system and continued construction of new parkways is rapidly adding to the needed freeway mileage; toll road development is also increasing freeway mileage.

Table 51

ANTICIPATED MILES OF FREEWAY CONSTRUCTION IN UNITED STATES NECESSARY FOR 1980 NEEDS[1]

ITEM	*URBAN MILES*	*RURAL MILES*	*TOTAL MILES*
Anticipated 1980 Freeway Needs	16,000	38,400	54,400
Freeway Miles Provided by Completed Interstate (1972)	9,600	31,400	41,000
Other Existing Freeways (1960)	800	1,575	2,375
Other Freeways Constructed[2] 1960-1972	0	0	0
Needed Freeways To Be Constructed 1972-1980	5,600	5,425	11,025
Total Miles Provided	16,000[3]	38,400	54,400

[1]Source: Appendix A.
[2]Assumed as zero.
[3]Assumes redefinition of urban areas to include new growth.

Similarly, adverse effects of a stretch-out of Interstate highway construction on projected travel estimates would be partly offset by continued construction of other freeways. The projections also tend to slightly underestimate potential travel if the 1972 construction schedule is maintained. However, the gains or losses to the national economy resulting from a 1972 completion, or a three-year stretch-out, of the Interstate system are not significantly affected by these special considerations.

FREEWAYS IN RURAL AREAS

The greatest concentrations of people and cars, the most severe problems of congestion, and the most rapid growths are found in urban areas. It is only natural, therefore, that this study has placed primary emphasis on urban needs. Freeways and other high-type roads will, of course, be required in rural areas to provide the desired accessibility and the needed traffic capacities.

Urban Influences on Rural Traffic — Within most rural areas, traffic and travel patterns and the need for freeways are strongly influenced by their proximity to neighboring towns and cities. Travel by Californians, for example, is dominated by the metropolitan area of Los Angeles and the San Francisco Bay region which together generate two thirds of the state's vehicle miles.[12] People in the Los Angeles region contribute nearly 43 per cent, and residents of the San Francisco Bay region, 24 per cent; travel by these urbanites extends to every region in the state and contributes a substantial proportion of all traffic in nearby counties.

A traffic profile for U. S. 40 in the environs of Reno, Nevada, shown in Figure 83, clearly denotes the impact of urban centers on traffic demands. Traffic volumes build up rapidly as the route passes through the Reno-Sparks area. Whereas rural volumes along Route 40 are generally under 5,000 cars per day, volumes increase to almost 20,000 cars per day in Reno, and 10,000 in Sparks.

Across the country, in a Connecticut area strongly contrasting in topography, economy and size, a similar pattern exists. Traffic volumes and population in a two-mile-wide strip between Waterbury and New Haven, shown in Figure 84, are closely correlated when superimposed. Both volumes and population

[12]California Department of Public Works, *The California Freeway System*, a report to the Joint Interim Committee on Highway Problems of the California Legislature, September, 1958.

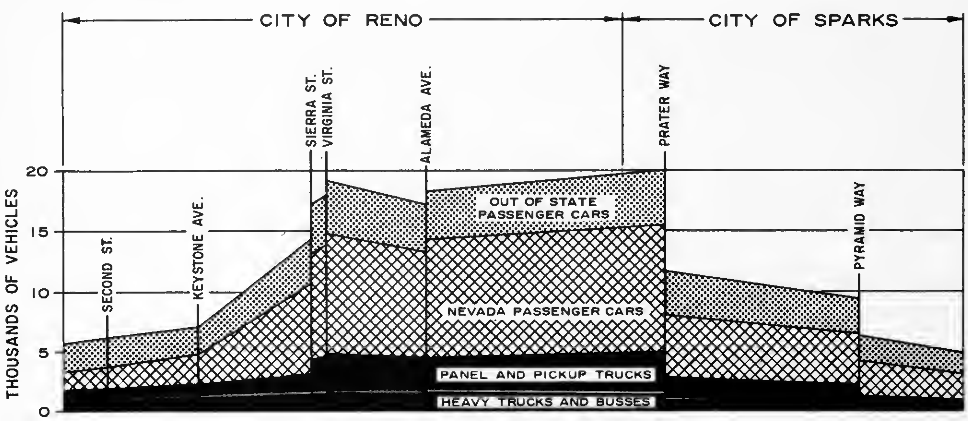

Figure 83
Traffic Volume Profile
U. S. Route 40
Reno, Nevada

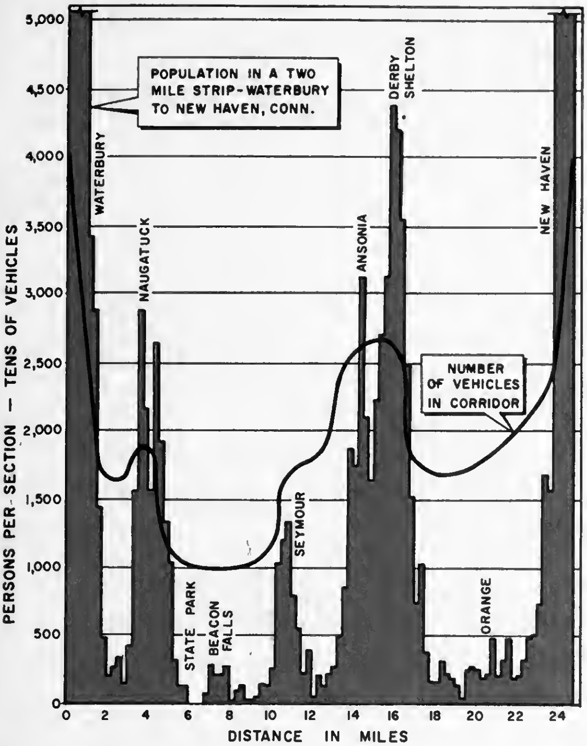

Figure 84
POPULATION AND TRAFFIC BETWEEN WATERBURY AND NEW HAVEN, CONNECTICUT

have peaks in urbanized areas and low points in rural areas between cities. The changes in volumes show less variation than population because of the "through traffic" and overlapping zones of influence.

Traffic approaching cities on rural highways has destinations diffused throughout the urban area. Urban destinations of city-bound rural traffic, summarized in Table 52, show how this dispersion takes place.

When a city is studied in terms of concentric ring areas outward from its center, the proportion of total traffic destined to the area dimensioned by the inner quarter of the radius decreases as the population of the city increases, although the actual vol-

TABLE 52

DISTRIBUTION OF CITY-BOUND TRAFFIC ON APPROACHING RURAL HIGHWAYS[1]

CONCENTRIC RINGS WITHIN CITY MEASURED OUTWARD FROM CBD	PER CENT OF APPROACHING TRAFFIC WITH LOCAL DESTINATIONS — Population Group: 100,000	1,000,000
Ring 1 — First Quarter	57	22
Ring 2 — Second Quarter	25	36
Ring 3 — Third Quarter	13	25
Ring 4 — Fourth Quarter	5	17
TOTAL	100	100

[1]Source: U. S. Department of Commerce, Bureau of Public Roads.

umes may be higher. This finding appears consistent with the decreasing proportions of CBD-destined internal trips as an urban area expands.

For example, 57 per cent of all city destinations are in the inner ring in cities of 100,000 population compared with 22 per cent in cities of two million population. Destinations in the outer ring on the perimeter of the city amount to about five per cent of the total city-bound traffic in cities of 100,000 population, and increase to 17 per cent in cities of a million population. In all but the very smallest cities (less than 8,000 population), the proportion of approaching traffic that has destinations in the central areas is greater than the proportion of bypassable traffic. Again, the need for freeways to serve urban areas, rather than to circumvent them, is apparent.

External Origins of City Traffic — The relative import of the various rural counties surrounding an urban area, as determined by their relative representation in urban traffic, is shown in Figure 85.[13]

Market Attraction — "Market attraction" is stratified in ring-like structures of decreasing magnitude around the urban area. Urban market areas can be delineated by the sharp and sudden changes in the relative degree of travel as reflected in the proportional representation of out-of-county (rural) cars in the city traffic stream.

The "primary" market area is, of course, the "home" county in which the urban center is located. The surrounding traffic influence area generally coincides with a line drawn around all counties with over 10 per cent of their cars in the observed traffic. Thus, it is reasonable to assume that the traffic influence area for each market includes all counties with about 10 per cent of their car registrations in the daily city traffic based on the weighted scale. (Although this value varies somewhat from city to city, it is generally indicative of the outer limit of the influence area.)

In Waterloo, Iowa, for example, the effect of competition is clearly illustrated: the "zone of influence" on the south does not extend beyond Black Hawk County because of competitive influences of the Des Moines and Cedar Rapids marketing centers.

The low attraction from the second ring of counties surrounding Lima, Ohio, results from the competitive influences of major cities as Toledo, Dayton and Fort Wayne.

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[13]Wilbur Smith and Associates, *Final Technical Report-Market Research Study*, Outdoor Advertising Association of America, 1958. The origins of traffic passing a series of dispersed locations in the central city were expressed as percentages of each county's registration. To place all markets on a comparable basis, representation of local cars has been factored up to 100 per cent, and the representations of all other counties were adjusted accordingly.

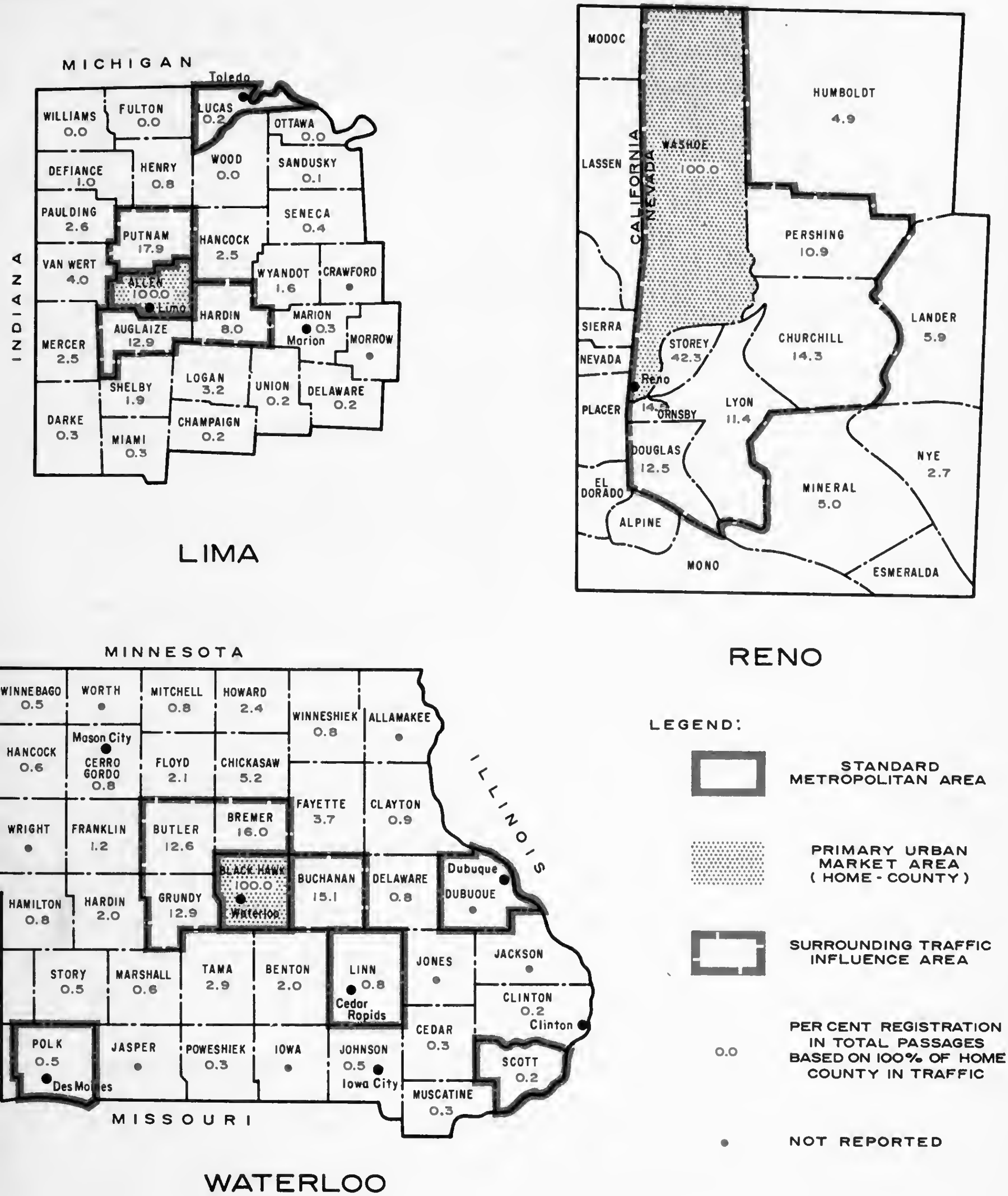

Figure 85
Traffic Delineation of Urban Markets

Reno's extended pull and dominant position is readily apparent from the representation of many Nevada counties in that city's traffic. Reno attracts cars from a wide area largely because there are no nearby competing markets.

In all of the cities (shown in Figure 85), most cars observed in traffic had local origins or destinations. Most out-of-county cars had origins in areas immediately surrounding the urban area – many of which are gradually becoming urbanized.

Freeways in these areas will, therefore, primarily serve local traffic. In most cases, the proportions of through, long-distance rural, or interurban traffic will be quite small.

Interactance of Traffic – It is clear that the frequency of travel to an urban center decreases as the distance from it increases – i. e., the rate of attraction of non-local traffic diminishes rapidly as the distance gets longer. This inverse effect of distance on the rate of travel is somewhat similar to the decreasing pull of gravity on an object that moves outward from the center of the earth. When formulated mathematically, the concept is often referred to as an "interactance" or "gravity" model.[14]

In its idealized form, the model shows that in general "the amount of travel generated between any two areas is directly proportional to the product of their population and inversely proportional to the time-distance between them".[15]

Three typical interactance curves, depicted in Figure 86, clearly show how distance (and time) between origin and destination influences traffic volumes; relative effects of distance on representation in traffic (cars per 1,000 registered vehicles) appear consistent from area to area – representation decreases as distance increases.

Interstate highways will decrease driving times and tend to increase attraction between two areas. However, since total traffic at any location on a highway depends on the size as well as distance of various communities, the importance of urban centers is again apparent.

Rural Interstate Needs – Many miles of rural Interstate highways traverse

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[14]Reilly, William, Jr., *The Law of Retail Gravitation,* second edition, Pilsbury Publishers, Inc., New York, 1953.

[15]The basic exponential relationship when plotted on a double logarithmic (log log) scale, is transformed to a linear (straight line) trend. The logarithmic expression for the interactance relationships is:

$\text{Log } V_{1,2} = \text{Log } K + X(\text{Log } P_1 + \text{Log } P_2) - Y \text{ Log } D_1$

Where

P_1 and P_2 are the population (or vehicle registrations of the two communities 1 and 2;

D_1 is the distance or time between them;

K, X and Y are empirical constants which have been found to vary from city to city.

$V_{1,2}$ is the relative amount of travel between the two communities – 1 and 2.

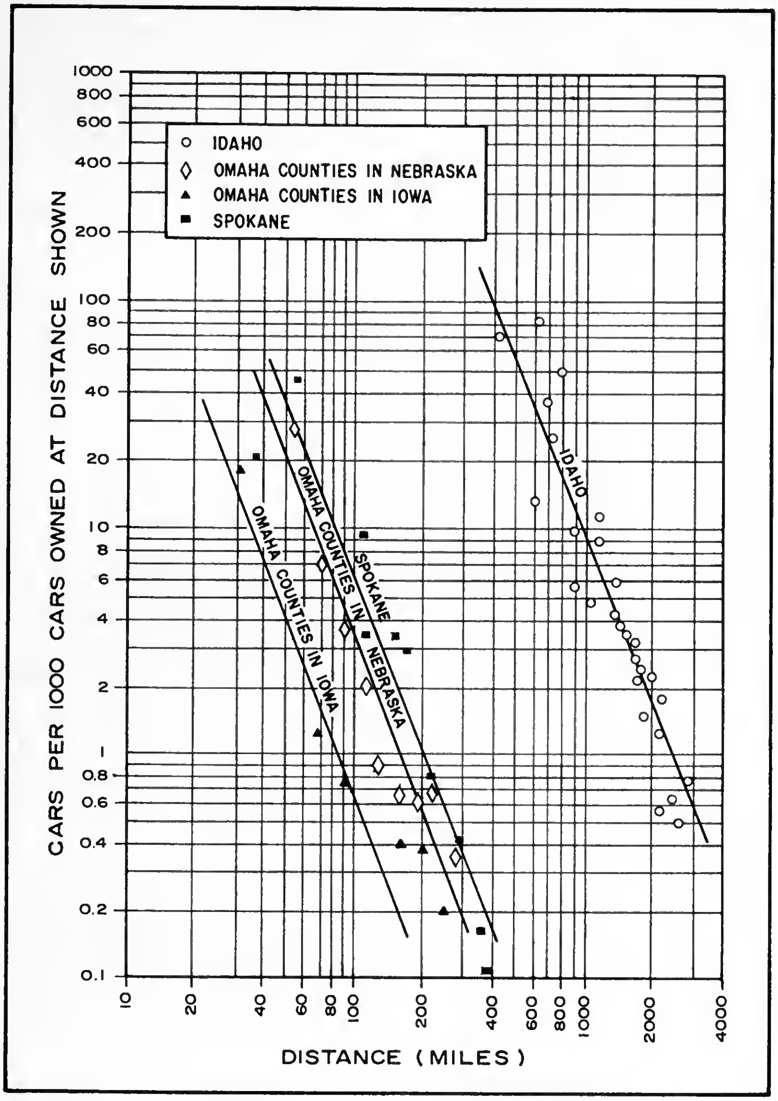

Figure 86
TYPICAL INTERACTANCE RELATIONSHIPS

heavy intercity travel corridors, and will be heavily used; some may ultimately require parallel facilities.

Often rural Interstate highways, however, are being built to complete links within the system rather than because of traffic demands. (For example, the Interstate routes traversing sparsely settled western states.) Other sections of the rural system are being built to multi-lane standards to afford high levels of service; they will provide substantial reserves in capacity in the corridors they serve.

Although rural Interstate highways will accommodate principal intercity travel movements, they will not receive the volumes anticipated for urban sections. They will, therefore, be adequate capacitywise for most rural travel expected to develop by 1975 or 1980. Heaviest travel and greatest needs on rural Interstate highways will usually be near large metropolitan areas on the fringes of urbanization.

While many cities with populations under 100,000 may not require freeway systems, full advantage should be taken of Interstate routes where they traverse the environs of these areas. Wherever the predominant travel is to or from the urban area, Interstate highways will usually provide the greatest benefits when they penetrate the city. This is especially true as cities get larger, and an increasing proportion of approaching traffic has urban origins or destinations.[16]

It is, therefore, very desirable to have freeway routes enter smaller cities rather than bypass them where local travel patterns predominate. By providing direct access to the established central city, the freeway will preserve the business district and other principal land uses. A through-city Interstate route will serve more traffic and provide greater capacity relief to existing streets. Conversely, a bypass facility attracts new uses to itself, often decentralizing the community in a most undesirable fashion by encouraging new freeway-oriented shopping centers and industrial parks that may intercept movements to older centers. Land-use controls and utilities are frequently lacking in areas traversed by bypass routes, leading to uncontrolled and low-standard new developments that may adversely affect the entire community for many years.

Comparative Capacity Requirements — When the anticipated annual travel is related to the miles of urban and rural Interstate highway, the comparative utilization of each system is obtained. If all needed freeways were constructed by 1980, average volumes per mile of urban Interstate highway would approximate 51,000 cars daily.[17] Each mile of rural Interstate route would carry about 9,900 cars daily. Thus, each mile of urban Interstate routes will carry five times the volume of rural highways.

Therefore, when the Interstate system is completed, many urban sections will be operating at their capacities whereas most rural sections will have ample capacity reserves. In general, only about half of the capacity along rural routes will be required by 1980.

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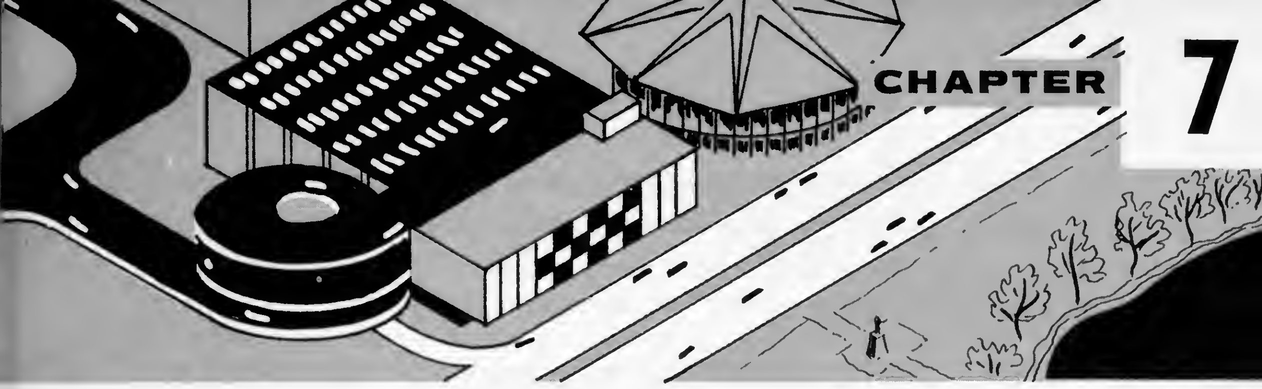
[16]*Interregional Highways,* Message from the President of the United States Transmitting a Report of the National Interregional Highway Committee, Outlining and Recommending a National System of Interregional Highways, House Document No. 379, 78th Congress, Second Session. In most cities of more than 10,000 people, approximately three fourths of all approaching traffic was found to have city destinations.

[17]If *only* the Interstate system were completed by 1980, urban Interstate volumes would average 55,000 cars per mile per day; in 1975, urban Interstate volumes would approximate 49,000 vehicles per mile with all needed freeways built, and 52,000 with only the Interstate constructed.



CHAPTER 7

COMPLEMENTS TO URBAN INTERSTATE HIGHWAYS

SUMMARY

THE American city of the future will be oriented to the automobile to an even greater extent than it is today. Interstate freeway systems in urban areas, therefore, will need to be extended and supplemented by other freeway facilities to provide desired capacities and to complete freeway networks. Many complementary services will also be required to enable freeways to function effectively, including improved arterial and collector streets, downtown terminal facilities, and, in some cases, transit.

To be properly related to other elements of the *total* transportation system — parking areas, arterials, collector streets, and transit — freeways should be planned, designed, and operated as an integrated system consistent with over-all community objectives. Freeways and major thoroughfares should encourage logical community development and help preserve productive land uses.

The size, shape, function, past history and future mission of an urban area is important in developing an optimum and total transportation plan and freeway network; no one system will be universally preferable.

Where topographic interferences are not critical, the over-all need for freeways will be largely dependent on average population densities throughout the urban region; for example, with an over-all density of 10,000 persons per square mile, the average freeway grid spacing should approximate four miles for eight-lane freeways. Criteria for the variations of freeway grids must be carefully appraised by comparing vehicle miles (or volumes) anticipated with capacities that can be provided.

Modern urban freeways can serve about three times as much traffic as arterial streets, and provide daily passenger-carrying capacities in terms of actual use that are often comparable to those of many rapid transit lines.

Within the city, freeways should generally be constructed outward from the core areas, consistent with land-use planning. Downtown freeway loops and selected radials should be given priority since downtown distributor loops intercept non-CBD traffic and remove these volumes from downtown streets.

Freeways will be valuable in attaining integrated transportation planning in urban renewal projects and in preventing traffic congestion from minimizing the benefits of redevelopment.

The "market potentials" of the downtown retail district will depend on the purchasing power that can be tapped by successive increments of travel time. Consequently, freeways serving new close-in, high-density residential areas will improve downtown's position as a retail center. Revitalization of downtown through street closures, pedestrian malls, sidewalk cafes and other pedestrian amenities will be desirable where economically feasible. Success of downtown revitalization will, however, be contingent on accessibility.

Terminal facilities, especially in the central business district, are necessary to complete the total transportation system. Parking areas should be attractively designed and carefully related to Interstate and other freeways. Garages may often be connected to the core area by shuttle buses.

Most central business districts will be able to accommodate a large proportion of people in private vehicles and provide necessary highway and parking capacities without destroying the generating characteristics of the downtown areas. The complementary role of transit will become more significant as the concentrations of downtown destinations increase. Where central business districts retain *present* forms and densities, some transit services will likely be required to stabilize parking demands and complement freeways during peak-hours.

THE economy of the entire urban area will become increasingly reliant on the use of cars and trucks for the movement of people and goods. Topography, population density and distribution, and the over-all juxtaposition of land uses will necessarily influence future urban transportation. But, in virtually every metropolitan area, private motor vehicles will dominate, and freeways will form the backbone of the area's transportation system. The future American city will be an automobile-oriented metropolis, although transit will assist freeways in larger urban areas.

While urban Interstate highways are vitally needed in the nation's cities, additional urban freeways will be required to provide desired capacities, and to complete total freeway systems. Many "complementary" services will also be required to enable freeways to function effectively – these include arterial and collector streets, downtown terminal facilities, and, in some cases, transit.

FACTORS IN SYSTEM PLANNING

A comprehensive system of *total metropolitan area transportation* is necessary, particularly in larger urban regions. Planning should be consistent with community objectives and, therefore, must consider the inter-effects of transportation and land use. Metropolitan land use and transportation plans should be prepared simultaneously with constant reference to each other, and carefully integrated.[1] Plans should assure the maximum utilization of existing facilities; guide the development of new facilities to complement existing ones; obviate the need for widening local and collector streets through residential areas; balance capacities against future traffic demands; guide the logical and economical expenditures of available public funds; assure major route continuity regardless of corporate limits; provide for the most expeditious, efficient, and safe movement of people and goods; and serve as an effective guide and stimulus for orderly urban growth and development.

Freeway Planning Considerations – Freeways should form an interconnected network of radial, circumferential and downtown-distributor routes, linking residential, commercial and industrial areas, and should be continuous in character, capacity, and design. They will be especially valuable in serving urban areas when properly related to other elements of the total transportation system – parking areas, arterial and collector streets, and transit. Freeways should be planned, designed, and operated as an integrated system, taking into account all of these complementary elements.

Freeways and major thoroughfares should encourage logical community

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[1]Mitchell, Robert B., *Metropolitan Planning for Land Use and Transportation,* Office of Public Works and Planning, The White House, Washington, D. C. 1960, p. 40.

development and help preserve productive future land use. This can be achieved by minimizing the acquisition or disruption of public and quasi-public land uses (churches, schools, parks, etc.) and integral planning areas (school districts, commercial areas); by utilizing rights-of-way to separate and contain incompatible land uses wherever possible; and by avoiding creation of isolated land parcels.

Freeways stimulate development of new land uses along their right-of-way, and, when properly planned, enhance the over-all community. Parkways in Chicago, New York City, Westchester County, Boston, and Kansas City have created pleasant atmospheres in their environs, and clearly depict the over-all benefits of roadway facilities to community appearance. At the same time, they are heavily traveled and provide important traffic services.

Freeways relieve local streets of "through" traffic and thereby reduce volumes in residential neighborhoods. In many cases, they will permit changes in traffic patterns that are desirable from a land-use standpoint — again contributing to community solidarity.

Freeways and Redevelopment — Success of urban renewal plans requires careful coordination with traffic and transportation planning. Establishment of new traffic generators requires new facilities to accommodate extra loads since congestion that would otherwise occur could nullify attractive features of redevelopment areas. Similarly, accelerated freeway programs, major street improvements, and even mass transportation plans will not attain their full objectives — unless carefully integrated with urban renewal and redevelopment programs.

Freeways afford excellent opportunities for the renewal of urban areas. Moreover, it is possible to obtain a design in which freeways are carefully blended with various land-use elements. Coordinated planning can achieve unified design of freeways, parking areas, civic, and commercial developments.

In Chattanooga, for example, a new freeway was coordinated with slum clearance, utility expansion, and new community facilities fringed by light industry.[2] Total costs of a planned 403-acre renewal project will be considerably less than estimated for the various component programs if they were undertaken separately.

Freeways and Arterial Streets — In every urban area, systems of arterial streets will supplement freeways and serve as freeway access routes. A high level of service will be essential on both existing and proposed arterials — freeways will not obviate the need for extensive traffic engineering.

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[2]Barkley, R. E., "Integrated Improvements for Chattanooga," *Civil Engineering*, October, 1960.

Needed arterial street improvements and extensions should be carefully attuned to freeway development and design. Adjustments in the design of arterials, where they lead to or from freeways, will enable all facilities to operate at maximum efficiency as an integrated roadway system.

Freeway Patterns — In planning freeway systems, consideration should be given to the various possible freeway patterns and their over-all implications on land-use and traffic patterns. The various types of freeway systems planned or in operation are depicted in Figure 87.

Gridiron Pattern — Gridiron freeway networks permit regularity of spaceing and equal tributary areas; provide constant travel times to and from freeways throughout an area; avoid convergence of routes and consequent capacity complications; permit conventional interchanges (viz. high-type cloverleafs) between freeways; tend to equalize "growth opportunities" for all parts of an area, thereby stimulating some decentralization; and discourage concentration on key sections of roadway. They do not fully conform to the general radial character of urban development and growth, focus on major points of traffic generation in the area, nor adapt to areas with restricted topography.

Radial Pattern — Radial systems of freeways conform to radial patterns of urban travel; generally involve convergence of freeway routes; reduce vehicle miles of travel for CBD-oriented trips; adapt to varying conditions of topography; generally have variable spacing between routes, although tributary populations may be about the same; and encourage tentacle-type expansion of an area. They also engender high concentrations of traffic on close-in portions of freeways; require varying amounts of surface street travel to reach the freeway system; and funnel all traffic into system focal points, even traffic with origins or destinations outside the central area.

Radial Pattern with CBD Loop — Radial freeways linked with CBD loops, as found in Kansas City, provide for transference of traffic between elements of the system and adapt well to smaller communities where the loops also serve as outer circumferentials. In addition, downtown distributor loops intercept non-CBD traffic, and remove these volumes from downtown streets.

Radial-Circumferential Pattern — The radial-circumferential freeway network is commonly found in large urban areas. Such a system vastly improves the accessibility, market potentials, and "tributary area" of downtown. Its inner loop and other circumferentials provide needed cross-town travel and help divert non-radial traffic. It naturally fits desired urban travel patterns, radial and other, thereby providing complete and direct access to all parts of the urban area. It generally adapts to topography; encourages satellite centers where var-

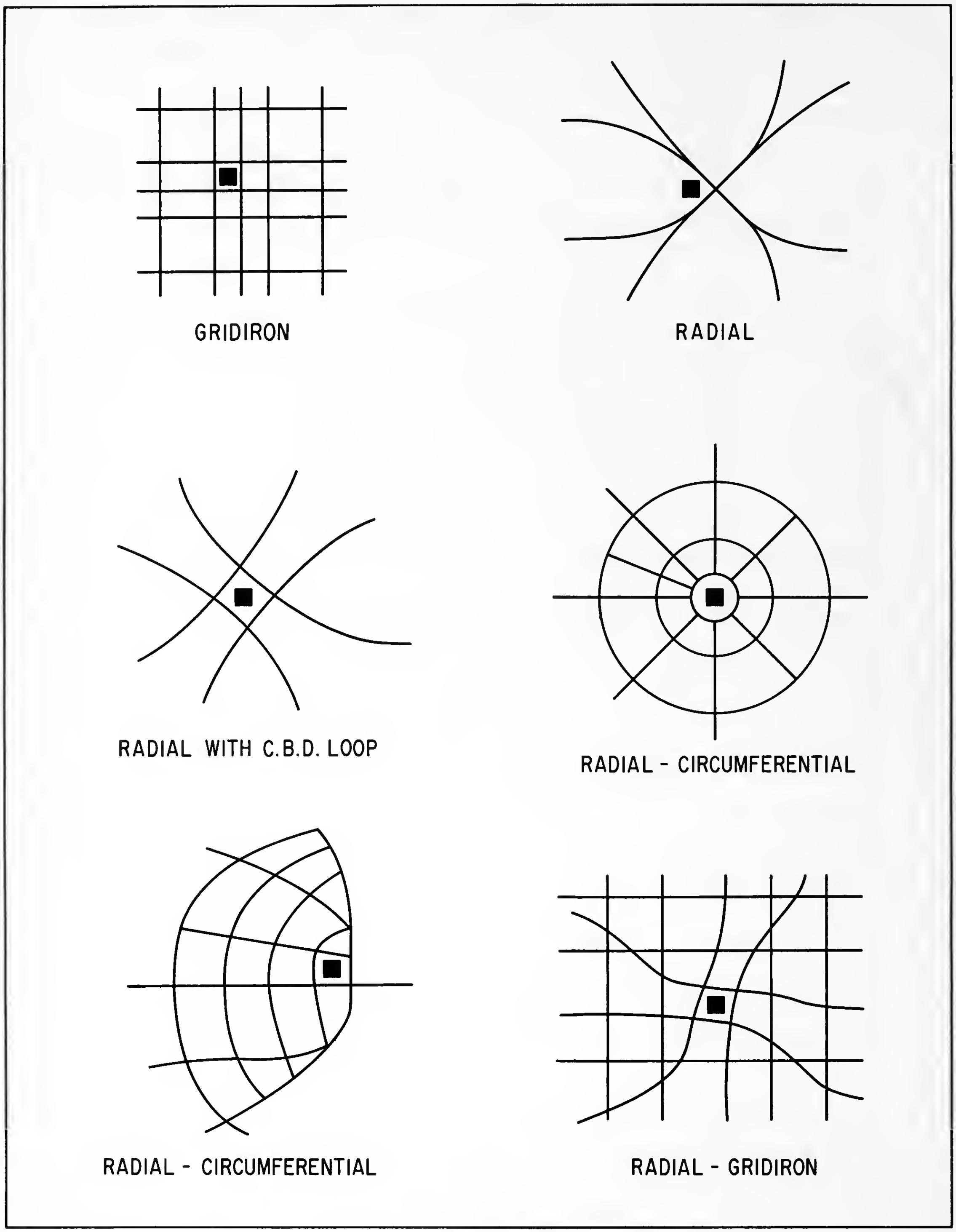

Figure 87
TYPES OF FREEWAY SYSTEMS

ious radial and circumferential freeway routes interchange; fosters intensification of land use, and peripheral industrialization along circumferentials; and provides for interception of non-radial traffic.

This pattern may also involve some convergence of urban routes, achieve high concentrations of traffic on close-in freeway sections; involve complex interchanges where routes converge; have varying tributary areas between routes, although populations may be the same; and require varying distances of surface travel to and from freeways.

Radial-Gridiron Pattern — The radial pattern superimposed on a gridiron network affords the advantages of both patterns, combining the focus of the radial system with regularity of the gridiron network. It avoids concentration of routes in the central area, yet still provides direct access to the CBD.

Adaptation to Specific Areas — The size and configuration of an urban area is important in developing an optimum form of freeway network; no one system will be universally preferable. An important factor is the relation of the freeway system to the urban street pattern, since the two should be in general accord. In most areas some form of circumferential, crosstown, or downtown loop freeway is desirable.

Freeway Capacity — Modern urban freeways can serve about three times as much traffic as arterial streets. They are generally designed for the movement of 1,500 vehicles per lane per hour with reasonable facility of flow. Actual peak-hour "operating volumes" can average 1,800 vehicles per lane per hour, although individual lanes have been reported to carry volumes in excess of 2,000 vehicles per hour. Surface streets usually carry about 400 to 600 vehicles per lane per hour, about one third the volume of a freeway.

Freeways have high capacities, both in terms of the vehicles and *people* they transport daily. Many eight-lane freeways carry more than 150,000 vehicles, about 250,000 persons daily, a number comparable to that carried by many rapid transit lines. Capacities are further increased where transit vehicles use freeways and where turn-outs, bus lanes, or exclusive rights-of-way are provided. In some cases, multi-lane frontage roads flank freeways and further increase capacities.

Speeds are often reduced as heavily used freeways become congested. This is not a criticism of freeways, but rather an indication of their popularity with motorists — a demonstration of their ability to attract travel. Overloading merely shows the need for more mileage and for accelerated urban freeway development. No major city has yet built its entire projected and needed system, and probably no city ever will. As new mileage is opened to traffic, and the over-all network is completed, volumes are more equally distributed over the system, and peak-hour overloading tends to diminish.

Freeway Spacing – Many factors influence the spacing and design of freeways. These include the type and intensity of land use, location with relation to surrounding areas of trip generation, and topographic conditions that create concentrations of traffic within specific corridors. Densely developed areas obviously generate the most trips, and require closer spacing of freeways than areas of less land utilization. The magnitudes of traffic within *specific* communities may, however, often be more affected by travel through the area than by the number of trips generated – and these position factors must be considered in any generalization of urban freeway spacing.

Criteria for the variations of freeway grids within urban areas must, of course, be carefully appraised by comparing vehicle miles (or volumes) anticipated with capacities that can be provided.

Where topographic interferences are not critical, the over-all need for freeways will be largely dependent on average population densities throughout the urban region. For such conditions, a series of curves has been developed showing theoretical over-all spacing within an urban area. These freeway spacing curves, depicted in Figure 88, show in a generalized way how the average spacing of freeways varies directly with the number of lanes provided, and inversely with the average length of freeway trip and population density. The curves should not, however, be used for units smaller than an entire city or urban area. Where the unit to be served is small, position factors may exert a strong influence on freeway needs, and will modify requirements as determined from the curves.[3]

As shown on the curves, for an over-all density of 10,000 persons per mile, the average freeway grid spacing should approximate four miles for eight-lane freeways; for an over-all density of 20,000 persons per mile, the average grid spacing should be about two miles. This latter value is about the closest spacing permissible under most conditions, and the minimum spacing commensurate with adequate geometric designs. It appears, therefore, that an over-all urban area or central city density of about 20,000 persons per square mile is the maximum population range that can be accommodated totally by freeways. There are, however, comparatively few cities with densi-

[3]The curves assume that an equilibrium is attained between the vehicle miles provided and the vehicle miles required. They assume approximately six miles per capita per day (about 50 per cent of all travel) on freeways, and an average freeway capacity of 60,000 cars per day for a four-lane freeway.

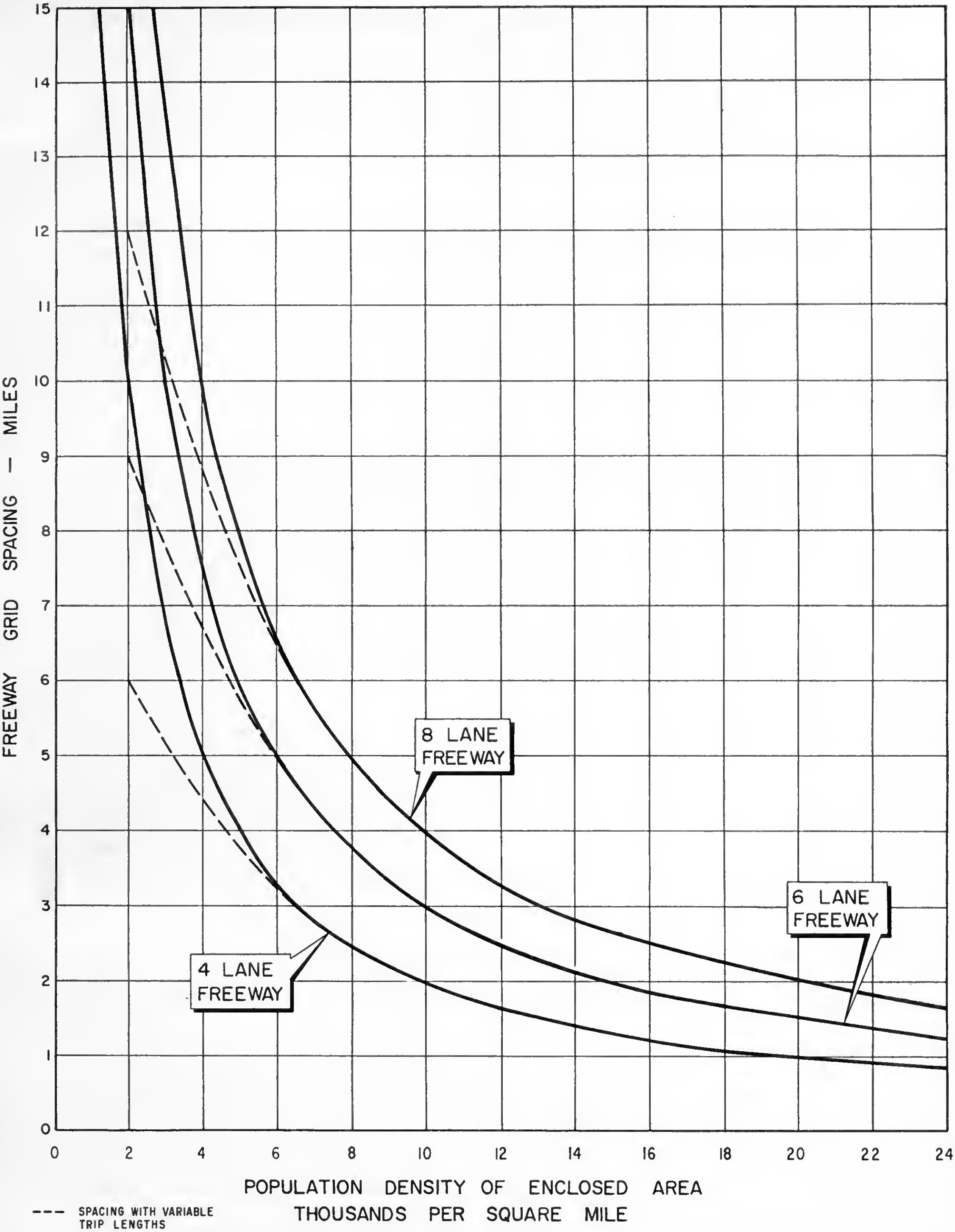

Figure 88
GENERALIZED FREEWAY SPACING CRITERIA

ties beyond this range. In all cases, the grids attained from the curves encompass enough people to form community planning units.

A similar approach to freeway spacing was developed by the California Division of Highways in which travel in a hypothetical 16-square-mile area was assigned to a four-mile freeway grid.[4]

An analysis of "minimum-cost" spacings of freeways and arterials prepared as part of the Chicago Area Transportation Study also denoted the importance of population density as a factor in freeway spacing.[5] The densely settled inner rings of the central city required closer freeway spacing than the outer suburban rings. The study indicated that it would be desirable to provide semi-expressways in low-density areas to permit more frequent expressway spacing and thereby reduce volumes on arterial streets.

The theoretical relationships clearly indicate the basic factors affecting freeway spacing. Under actual conditions of variable population densities, land uses, topography and traffic demands, adjustments and modifications would, of course, be made. The curves may be applied with relatively greater certainty where entirely new developments will take place, and where there are no serious physical or economic controls. The results obtained are generally consistent with the California standard of four-mile freeway spacings in urban areas.

Generalized Construction Priority — Freeway routes in urban areas should be located where they will afford the greatest traffic services, alleviate the greatest traffic deficiencies, and best relate to land-use planning. Many contend, and with some validity, that because urban needs are so great, immediate attention should be turned to development of urban facilities where the heaviest pressures are apparent.

It would appear from analyses of urban growth and structure, that freeways should be developed progressively *outward* from key focal points such as

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[4]Peterson, James M., "Freeway Spacing in an Urban Freeway System", *Proceedings of the American Society of Civil Engineers, Journal of the Highway Division,* Vol. 86, HW 3. Assuming a 16-square-mile area with a four-mile freeway grid and a population density of 8,859 people per square mile, it was found that 38 per cent of all trips and 59 per cent of the total vehicle miles were assigned to the freeways; the average one-direction daily traffic approximated 27,000 vehicles. For an area of this density, over 80 miles in length and width, the maximum one-way average daily traffic totaled 85,000. A four-mile spacing of freeways was found to give good service to the area.

[5]Creighton, Roger L.; Hoch, Irving; Schneider, Morton; and Joseph, Herman: "Estimating Efficient Spacing for Arterials and Expressways," *Traffic Origin and Destination Studies, Appraisal of Methods*, Bulletin 253, Highway Research Board, National Academy of Sciences, National Research Council. "Minimum cost" spacings are those in which all travel costs are minimized.

downtown. Each stage of development should, however, provide an interconnection of routes to maximize system continuity and should be consistent with land-use plans. The priority of construction will obviously vary from community to community; elements of cost, political expediency and public support will have to be assessed; similarly, the relation of existing facilities to new routes will influence priorities.

The following sequence represents a desirable construction priority:

First Priority — Downtown distributor loop and selected radial routes should generally be given first priority.[6] These facilities will improve accessibility to, from, and around downtown, thereby improving its zone of influence. They will relieve arteries serving downtown and will enable these arterials to serve close-in, short-distance traffic. They will equalize the accessibility of all sides of the central business district; facilitate the distribution of traffic within the central area; interconnect all arterials and freeways, both existing and planned; serve peripheral parking areas and transit; and accommodate traffic having origins and destinations in areas adjacent to downtown.

The downtown freeway loop also has many land-use planning advantages. It will help eliminate blight since blighted areas surrounding downtown often afford good route locations. It will help contain the central business district and stimulate commercial development and industrial plant modernization within its environs. It, therefore, becomes a positive influence on land uses within the central business district, and surrounding areas.

More than half of all vehicles entering central business districts have destinations elsewhere in the urban areas. Inner-loop freeways will remove this through traffic from downtown streets, and free these streets for local cars.

Second Priority — The intermediate circumferential route should generally be given the second construction priority. This route will improve accessibility and stimulate redevelopment of "gray" or conservation areas within the established central city. It will also help decongest radial routes leading into downtown, and will serve through traffic currently using conventional streets in densely populated areas.

Third Priority — Other radial routes should have third priority. These routes will complete the basic system of radials and will further improve access to downtown.

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[6]The concept of a distributional roadway circumscribed around the central area of a city has been long established. It was a primary street planning objective long before the advent of expressways as typified in the "Inner Quadrangle" of Burnham's plan for Chicago. Boston, New York, Chicago, Cleveland, Baltimore, Detroit, Kansas City, Washington, D. C., Philadelphia, Fort Worth, Miami, Tulsa, and Tampa are among the larger urban areas that embody new loop freeways in their plans and systems.

Fourth Priority — Outer circumferential routes should be constructed last. These routes will contribute relatively little toward the improvement of access in the central city, but are valuable from a long-range regional standpoint. They will serve to stimulate development in the urban hinterlands, and should, therefore, be carefully related to total land-use planning in suburbia. It is desirable to acquire property and protect rights-of-way for these routes well in advance of actual construction.

CENTRAL AREA PARKING

The present stabilization of downtown attraction is *not* related to greater car use, but rather to the changing structure of the metropolitan area. As urban populations disperse, an increasing number of outlying commercial areas become easily accessible; sometimes their development is encouraged by inadequate downtown parking and by congestion on downtown streets.

Accessibility improves the competitive position of the central business district. Downtown's position and role in the urban economy will, therefore, be strengthened by the provision of attractive access and terminal facilities, by new freeways, improved public transit, and new off-street parking areas all carefully interrelated.

The "market potentials" of the downtown retail district will depend on the purchasing power that can be tapped by successive increments of travel time. *Consequently, freeways serving new close-in, high-density residential areas will improve downtown's position as a retail center.* Revitalization of downtown through street closures, pedestrian malls, sidewalk cafes and other pedestrian amenities will be desirable where economically feasible. Success of downtown revitalization will, however, be contingent on accessibility.

Because so many people choose to travel downtown by car, it follows that attractive terminal facilities should be provided, commensurate with future needs of the core area.

Types of Parking — Growing freeway networks will create a greater dependence on auto travel. In most cases, it will be possible to serve these demands by the provision of new off-street parking facilities in or adjacent to the central area. Terminals are essential for complete transportation services and should be integrated with freeway development, particularly in downtown areas. In larger areas, parking facilities on the edge of central business districts and adjacent to freeways may be linked to core areas by shuttle buses.

Direct Ramp Connections — Ramps joining freeways with parking facilities, where they can be provided, advantageously minimize surface travel to and from freeways. However, problems of ramp spacing, geometric design, and cost, especially in central areas, will limit direct connections to major parking structures where adequate reservoir capacity can be provided.

Although functionally desirable in many instances, direct connections between freeways and parking areas (where federal highway funds are used) are discouraged by present policies. Changes in these policies cannot be easily effected since they involve many administrative and legal decisions, and basic problems of equity. Private versus public operation of parking would become very important in decisions.

Direct ramp connections are being provided to a 1,000-car garage at Detroit's Cobo Hall, and to a garage of similar capacity in Hartford. Plans for parking facilities in downtown Philadelphia call for direct ramp connections to an off-street bus terminal. Several regional shopping centers and outlying employment areas have direct or semi-direct access to freeways; these include the Pentagon in Washington and Roosevelt Field Shopping Center in Long Island.

Adjusted City Street Connections – These treatments usually involve the improvement of a connecting street between the parking facility and the freeway. The one-way street routings to serve a major parking area in Detroit, and the widening of Chicago's Michigan Avenue to provide direct ramp connections to the 2,500-car Grant Park Garage, are illustrative examples. Large, single traffic generators (as the new Milwaukee Stadium) may sometimes require additional ramps.

Parking Over or Under Freeways – This type parking affords an opportunity for economy in cost and land use, conservation of an area's tax base, and stimulation of adjoining land development. There may or may not be a direct functional relationship between the parking area and the freeway.

Under certain conditions, public agencies sanction the use of right-of-way on the Interstate system for parking. The conditions usually specify that parking be for public use and under state or city control. Section III, Title 23, of the Consolidated Federal Highway Acts, specifies that agreements between the Secretary of Commerce and a state highway department for the construction of Interstate projects "may authorize the state or political subdivisions, thereof, to use air space above and below the established grade line of highway pavement for parking of motor vehicles providing such use does not in any way interfere with the free flow of traffic on the Interstate system".[7] Design difficulties, however, often preclude parking under or over freeways in many central areas.

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[7]Kohl, John C., *Freeways and Parking, 1960,* Workshop Conference on Expressways and Parking, Transportation Institute, University of Michigan.

Viaduct parking is practiced in a number of cities — under the James Lick Freeway in San Francisco, the Central Traffic Artery in Boston and the Ponchartrain Expressway in New Orleans. New York City plans to establish parking beneath downtown sections of the Brooklyn-Queens, and Bruckner Expressways. Orlando, Florida, has sold bonds to provide parking areas under elevated sections of the downtown Interstate expressway.

In California, the Division of Highways permits the use of space under freeway structures for parking when it does not interfere with the prime purpose of the structure or create at-grade traffic problems.

Extensive parking areas available and in use under the elevated freeways in San Francisco provide 5,700 spaces: there are about 2,400 spaces under the James Lick Freeway, 1,000 under the Embarcadero Freeway, 850 spaces beneath the Thirteenth Street Freeway extension, and 1,400 spaces under the Bay Bridge approaches; in the future, 1,500 additional spaces will be available under the Embarcadero and Central Freeways. In Oakland, about 1,350 spaces are available and more will be provided as freeway construction proceeds.

Downtown Revitalization — More than 80 cities are currently engaged in some form of downtown revitalization. While downtown "revitalization" plans vary from community to community, all embody "integration of transportation forms" and "functional segregation of classes of traffic". Freeways and parking are basic to the implementation of these plans.

A traffic-free pedestrian-oriented core, surrounded by parking areas and freeways is a primary planning objective of most revitalization plans. This concept is embodied in Pittsburgh's Golden Triangle redevelopment, Philadelphia's Center City Plan, Hartford's Downtown Renewal, and New Haven's Church Street Redevelopment.

Philadelphia — The Center City plan for downtown Philadelphia exemplifies the concept of *total* transportation, and carefully coordinates improved rapid transit, suburban railroads, freeways, and off-street parking facilities.[8]

As shown in Figure 89, a network of freeways circumscribes the central city: the existing Schuylkill Expressway on the west, an improved Vine Street Expressway on the north, the Delaware Expressway under construction on the east, and the proposed South Street Expressway on the south.

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[8]Wilbur Smith and Associates, *Analyses of Central City Access Plans, Philadelphia, Penn.*, 1959; Rannells, John, "Transportation Planning," *Journal of the American Institute of Planners,* August, 1960, Vol. XXVI, No. 3.

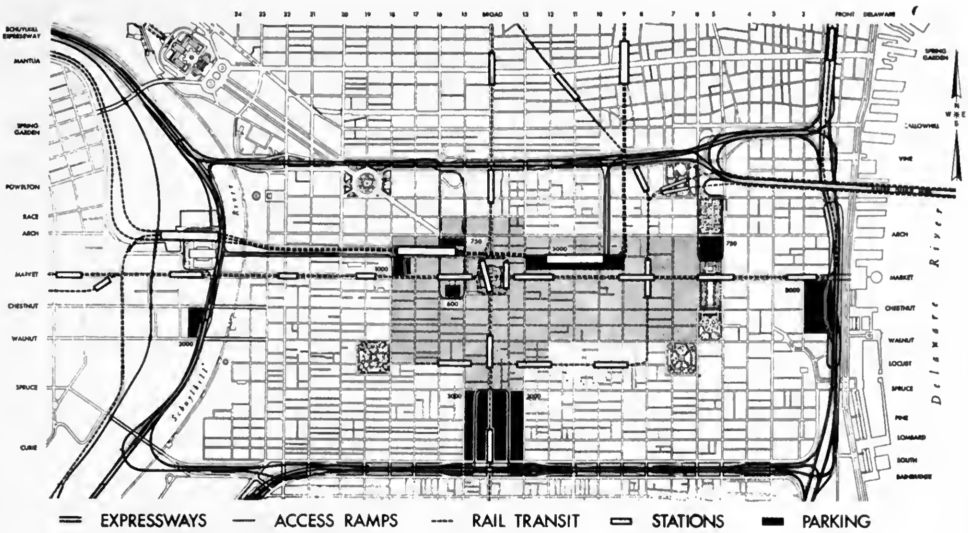

Figure 89
Center City Access Plan
Philadelphia, Pennsylvania

Planned off-street parking facilities with a combined capacity of over 10,000 cars are related to each freeway. Plans call for providing direct access between major parking facilities and the freeways, whereas smaller off-street parking areas will be interspersed throughout the center city. In addition to the existing subway lines, an underground link between the Pennsylvania and Reading Railroads is planned to permit integrated suburban railroad operations and removal of the existing Reading embankment.

The long-range plans focus all transportation facilities on the proposed Market East Plaza. This development, shown in Figure 90, includes a combined bus terminal, parking garage, and commercial development; access ramps will connect the facility directly with the Vine Street Expressway.

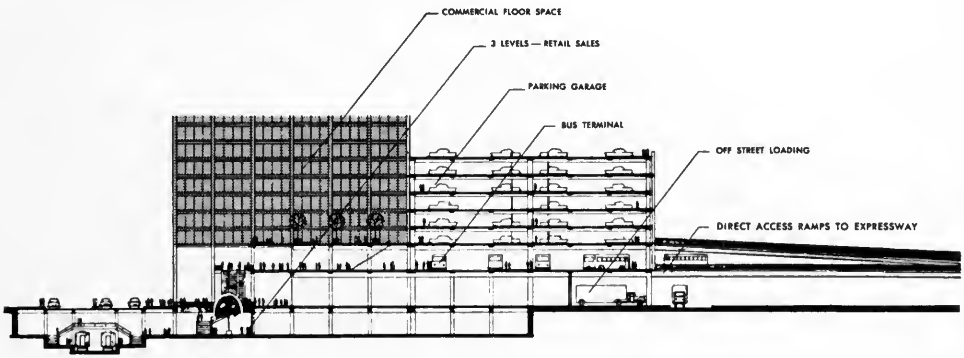

Figure 90
Proposed Transportation Terminal
Philadelphia, Pennsylvania

St. Louis – An integral part of the comprehensive transportation plan proposed for downtown St. Louis, Missouri, is the provision of off-street parking areas directly related to the express highway system.[9] As shown in Figure 91, proposed garages are linked directly to the two-level Daniel Boone Express Highway by a pair of high-type ramp connections. Freeway-connected garages were also recommended on the north side of the core area, and free shuttle bus service would link major parking facilities to the core commercial areas.

[9]W. C. Gilman and Company, *St. Louis Metropolitan Area Transportation Study, 1957-70-80,* St. Louis, Mo., 1959.

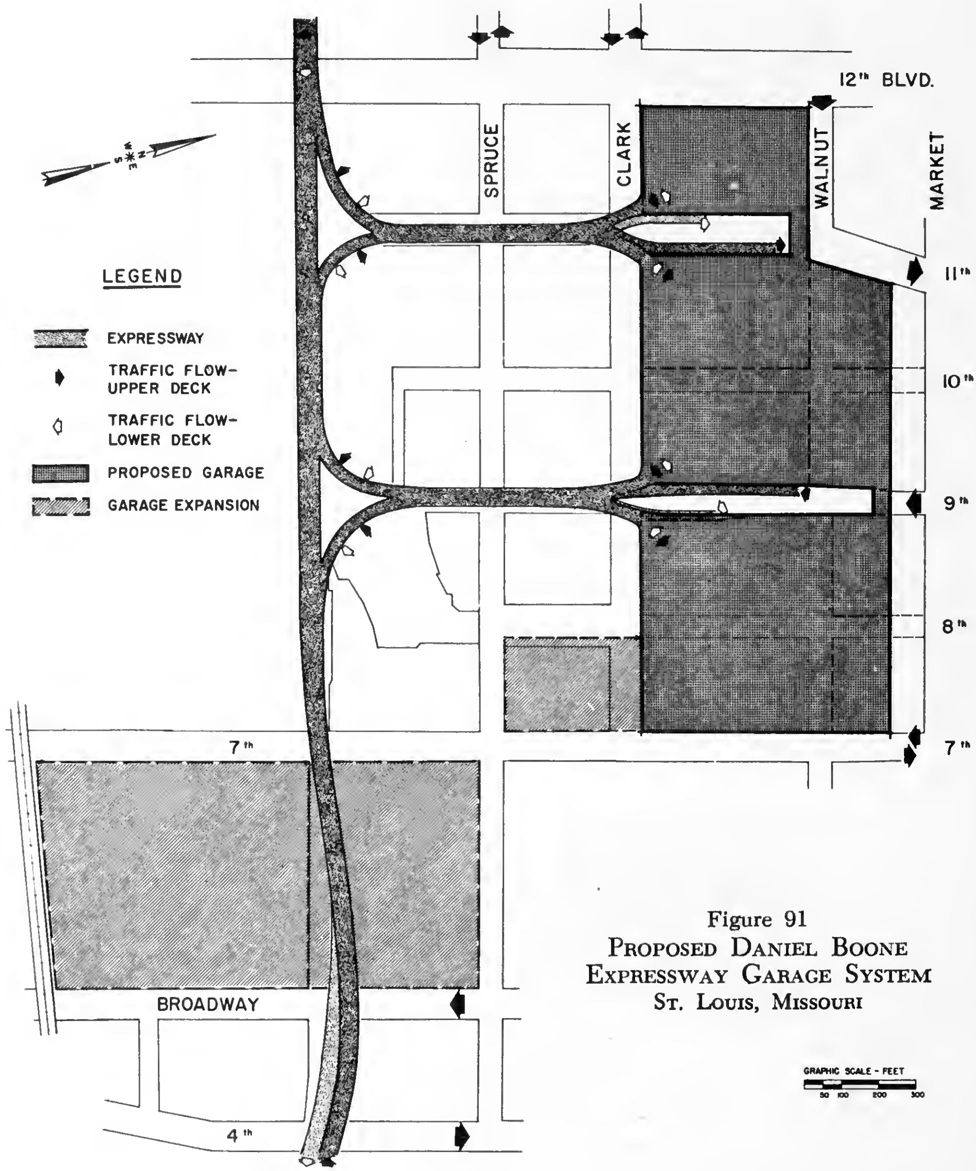

Figure 91
PROPOSED DANIEL BOONE
EXPRESSWAY GARAGE SYSTEM
ST. LOUIS, MISSOURI

Providence – A recently prepared plan for downtown Providence, shown in Figure 92, reaffirms the importance of transportation and parking to down-

Figure 92
PROPOSED PLAN FOR DOWNTOWN
PROVIDENCE, RHODE ISLAND

town.[10] Revitalization of the central area is contingent on extended freeway development, expanded off-street parking facilities, relocation of the railroad station, and improved transit service.[11]

Three freeways circumscribe downtown: one existing, one planned, and one (Interstate 95) under construction that will remove about half of all through traffic from downtown. Local transit is retained and special peak-hour bus lanes provided. About 16,000 off-street parking spaces would be provided, both within the core area and on the perimeter adjacent to freeways. The proposed relocation of the New Haven Railroad tracks and station and elimination of the embankment is basic to the implementation of the plan since they permit expansion of the downtown, regularization of street patterns, and provision of needed parking areas.

Exclusive of freeways, half of the program's estimated $102 million cost would be for transportation and parking facilities. About 28 per cent would be

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[10]Providence City Planning Commission, Housing and Home Finance Agency, Urban Renewal Administration, Downtown Business Coordinating Council, *Downtown Providence, Master Plan Project — A Demonstration Grant Study, Downtown Providence, 1970,* Providence, R. I.

[11]Wilbur Smith and Associates, *Trade, Transit and Traffic, Downtown Providence, 1957.* In 1957 it was recommended that new off-street parking areas be developed in relation to freeway construction and be linked to the core area by a free shuttle bus. Peak-hour bus lanes were also recommended. The current plan extends the earlier concepts.

The new Oak Street Expressway, which reaches out from the Connecticut Turnpike, gives easy access to New Haven's central business district. As shown below, extensive renewal has accompanied the highway improvement.

Figure 93
Downtown Circulation and Parking Plan
New Haven, Connecticut

for relocation of the railroad and another 20 per cent for parking garages and decks.

New Haven – New Haven's downtown redevelopment project, shown in Figure 93, is now under construction. Pedestrian traffic will be on an elevated mall and commercial vehicles will serve business establishments via an underground roadway. By intercepting freeway movements, a proposed $4.5 million, 1,500-car garage will reduce travel on city streets and provide parking in the heart of the central business district. A total of 3,000 parking spaces are being provided at a total cost of approximately $7 million.

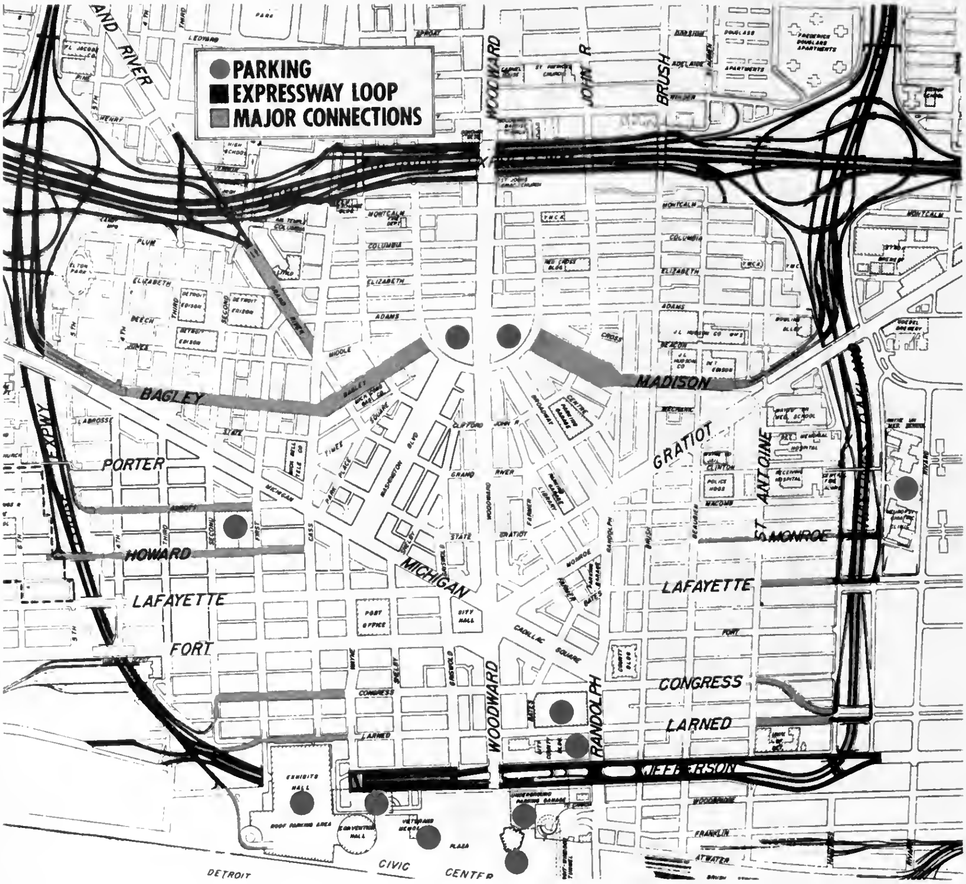

Figure 94
Downtown Circulation and Parking Plan
Detroit, Michigan

Detroit — As shown in Figure 94, a freeway loop circumscribes the Detroit central business district and is carefully related to parking garages. The west and south legs of the freeway loop are currently open and the east leg is under construction. Major streets have been made one-way to serve large parking areas near the Lodge Expressway, and ramp connections have been adjusted to fit the one-way system.

Tulsa — As shown in Figure 95, an Inner Dispersal Expressway Loop will circumscribe the Tulsa central business district.[12] The north and west

[12]Source: Tulsa Metropolitan Area Planning Commission, *Central Mall Feasibility Study, 1960.*

legs of the expressway loop are part of the city's Interstate routes, and are currently in the advanced planning stages. Plans call for implementing a 12-block pedestrian mall when the expressway loop is completed, since the loop is expected to remove more than half of all traffic currently on downtown streets. Over 3,000 new parking spaces will eventually be linked with the Inner Dispersal Expressway Loop by means of a one-way street system.

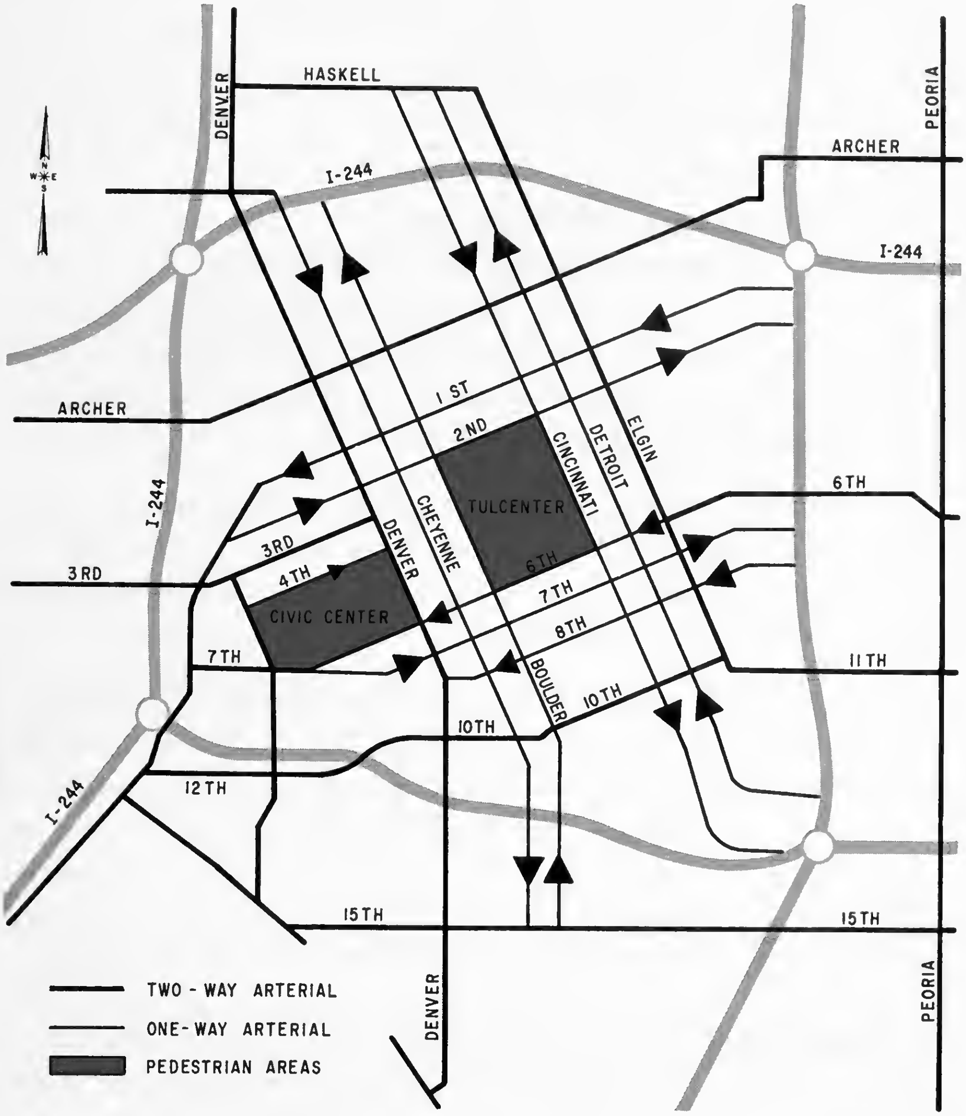

Figure 95
Proposed Street Plan
for Downtown Tulsa, Oklahoma

HIGHWAYS AND DOWNTOWN GENERATION

It has been shown that improvements in mobility provided by urban freeways contribute to the well-being of the American city and its central business district. Nevertheless, questions often arise as to the extent that automobiles and freeways can serve downtown. Exploratory analyses have, therefore, been made of the interrelationships between downtown generation and parking space and freeway capacity requirements. These interrelationships are shown in Figure 96. They indicate that freeways will be able to serve most urban needs, although in larger areas transit will be important in accommodating peak-hour surcharges.

Parking Requirements – The chart clearly shows that as the number of downtown daytime destinations per square mile increases, there is a corresponding increase in the land areas required for streets and parking purposes. The proportion of land devoted to parking increases gradually when there are under 250,000 destinations per square mile; it then increases rapidly, particularly when the destinations per square mile exceed 500,000.[13]

In cities with downtown attractions of 250,000 persons or less per square mile, an area equal to about 20 per cent of the square mile area would be required for parking, assuming 100 per cent travel by car, and multi-level parking. (This area may be located within the square mile or adjacent to it.)

Where downtown densities range upward from 500,000 to 1,000,000 persons per square mile, an area equivalent to about 40 to 60 per cent of a square mile would be required to provide parking in garages averaging three-and-one-half to four levels, assuming everyone came by car. For the few downtowns with densities in this range, extensive use of transit is mandatory; however, only the cities with long established rapid transit have such huge downtown concentrations of population. Fortunately, most downtown densities are lower.

Highway Capacity – The chart also shows the relation between downtown daytime population density, equivalent freeway capacity, and transit usage.[14] The

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[13]The chart assumes that all parking would be off-street.

[14]The chart assumes a maximum of 16 equivalent freeway lanes *serving* downtown with a peak-hour capacity of 2,000 persons per lane, per hour. Twenty-five per cent of the downtown daytime population is assumed to move in the peak hour.

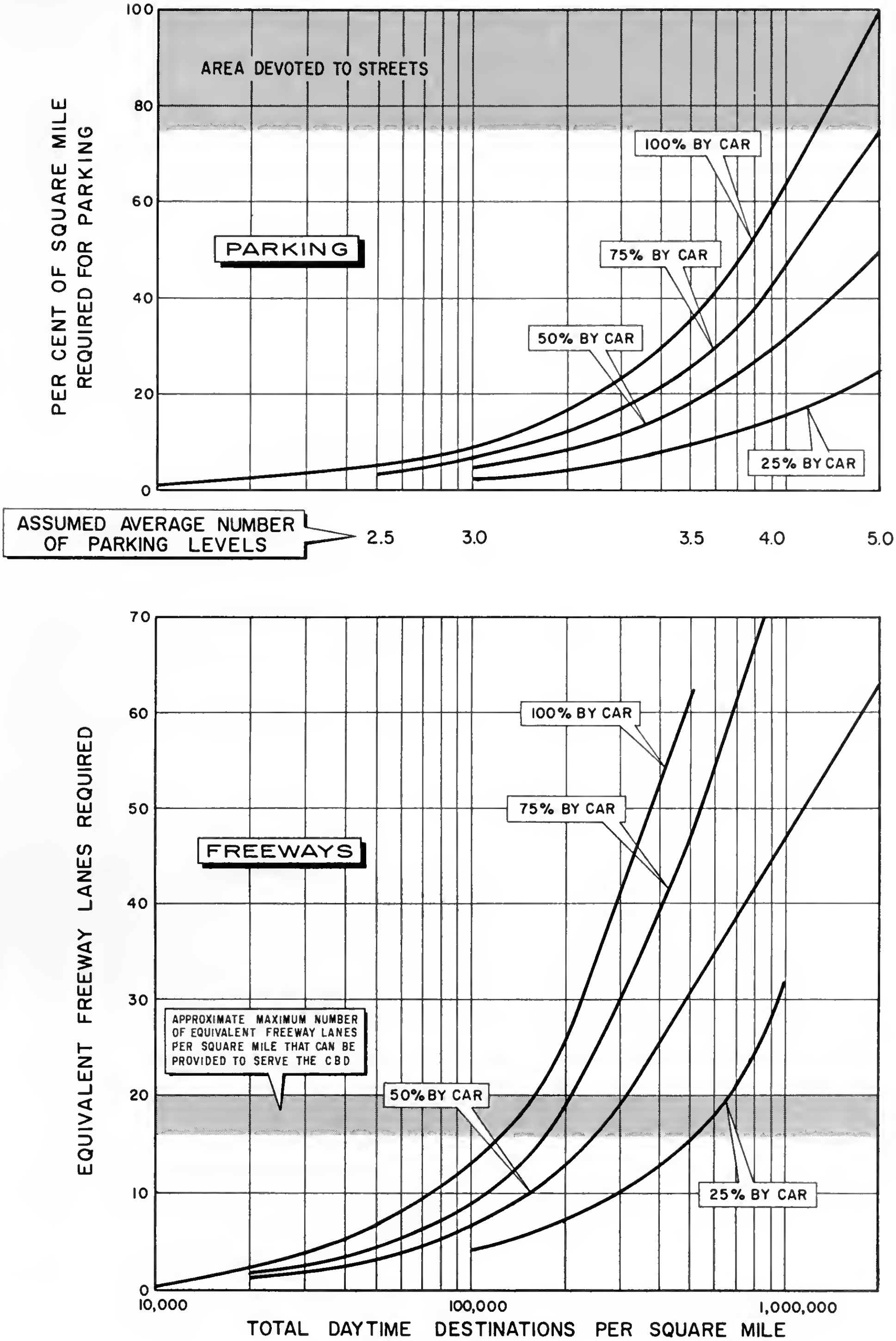

Figure 96

CENTRAL BUSINESS DISTRICT FREEWAY AND PARKING AREA REQUIREMENTS importance and necessity of transit increases in proportion to the peak-hour concentrations of person-movements. For cities with daytime population densities of under 100,000 per square mile, ample highway facilities can be provided to serve virtually all people. Beyond this density, the proportion of essential peak-hour transit riders increases from about 25 per cent at 150,000 destinations per square mile to about 75 per cent at 500,000 destinations per square mile. Use of transit in the study cities, cited in Chapter III, appears commensurate with these densities.

Implications – Urban freeways and related off-street parking areas will enable most cities to adapt to the automobile in a planned and orderly manner. *It is clear that the majority of American urban areas can provide substantial downtown parking without destroying the generating characteristics of the central business district, and that they can accommodate large proportions of downtown trips in passenger cars.* In most cities, adequate systems of freeways and arterials can provide capacity to accommodate most of the people traveling to and from central business districts.

Intensive land use in some larger cities may make it infeasible to accommodate private transportation under *all* circumstances and public transportation will, therefore, complement freeways in serving the peak-hour movements to and from the downtowns. Unlimited peak-hour mobility of the automobile may not always be possible.[15]

Congestion in central areas may be reduced by increasing the capacity of the facilities that serve it; on the other hand, it may be more economical to reduce congestion by encouraging some decentralization of business and industry; freeways attain both objectives.

Enlarging capacity of transportation facilities in central areas is, of course, desirable but the effectiveness of such measures will be diminished if increasing densities and unplanned arrangements of land use are permitted without regard to their effect on the movement of people and goods. Land-use generation should, therefore, be carefully balanced against transportation capacities.

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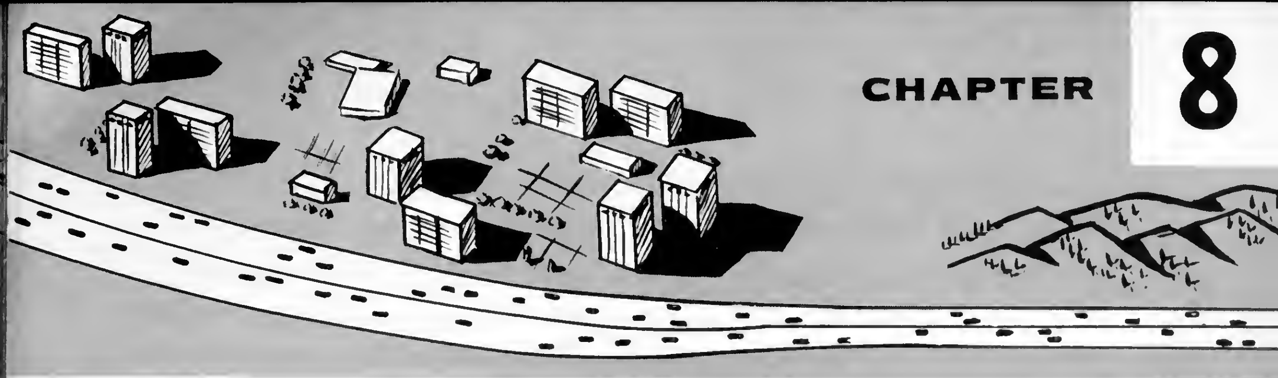
[15]This conclusion is consistent with relations between city size and maximum freeway volumes found in Chapter V.

CHAPTER 8



TRAFFIC GENERATION AND LAND-USE IMPACTS OF SELECTED HIGHWAYS

SUMMARY

ECONOMIC and land-use benefits that accrue from construction of specific express highways have been appraised from a series of special field investigations. These studies show how freeways have exerted a positive and constructive influence on land-use patterns and how intensification of land use has "generated" travel. They reaffirm the urban character of traffic.

Along the Wilbur Cross Highway near Hartford, Connecticut, and the Nimitz Freeway near Oakland, California, travel increases have outpaced over-all area growths. Traffic volumes on both freeways diminish as the routes proceed outward from urban areas.

The increase in residential construction in the Town of Vernon, Connecticut, on the Wilbur Cross Highway, appears directly related to accessibility afforded by the freeway for residents employed in Hartford. Similarly, the Nimitz Freeway has encouraged both residential and industrial development in Alameda County and has contributed to the economic vitality of the area.

In Los Angeles, with each extension of the Hollywood, Santa Ana and San Bernardino Freeways, residential development progressively moved farther from downtown, until freeway capacities were reached and time-savings were minimized. Subsequently, some close-in redensification occurred.

The Interstate-85 studies in North and South Carolina have evaluated the impact of a rural Interstate highway on travel in a corridor flanked by several urban communities. They have clearly shown that local short-distance trips predominate, that most trips are

relatively short and that few drivers travel interstate. Again, it is apparent that nearly all trips begin or end in urban centers.

Throughout the country, "free" express highways have been found to generate as much as 60 per cent new traffic, whereas toll roads have usually generated as much as 30 per cent. Intensification of land use and reduction of travel barriers have helped to stimulate most of this traffic.

HISTORICALLY, the improvement of transportation facilities, whether by water, rail, air or highway, has resulted in an intensification of land development. Good accessibility stimulates land development, which in turn, generates travel.

Modern highways affect the communities they serve in a variety of ways. Generally, their impacts are beneficial, although initially they may be somewhat disruptive, abolishing structures and severing properties as rights-of-way are acquired. The advantages or disadvantages to property in the vicinity of roadways are reflected in new land uses, in the urbanization of newly accessible fields and wooded areas, and in increased sales values. The more elaborate the roadway system, the more pronounced its impact and the more extensive its area of influence, as in the case of the National System of Interstate and Defense Highways. The provision of new Interstate highways in the nation's most heavily traveled corridors will make these areas even more attractive as sites for industrial and commercial centers and other developments.

Most freeway construction has been undertaken since World War II. In this period, there have been relatively few opportunities to measure and evaluate the impacts of new facilities on the communities they serve. Accordingly, a series of special studies was undertaken for this report to further define these impacts:

> In the Hartford, Connecticut, metropolitan area, the impact of the Wilbur Cross Highway on residential development, land values and travel patterns has been determined. Increases in residential construction and land values along the new freeway, (Route 15) since it was opened to travel, have been compared with the rates of growth in an important corridor that has no freeway access to Hartford.

The Nimitz Freeway (I-5) in Oakland, California, was analyzed for land-use changes and developments that have occurred since the route was opened in 1952.

A 200-mile segment of Interstate Route 85 (I-85) in North and South Carolina was studied to determine the characteristics of intercity travel in the corridor served by the new freeway.

Data were obtained on a special analysis made of land development in relation to extension of radial freeways in the Los Angeles area.

These studies show how each freeway has exerted a positive influence on community development and travel. In reviewing the analyses, it should, however, be noted that it was often difficult to fully isolate variables and develop definitive conclusions.

WILBUR CROSS HIGHWAY

Hartford, with a 1960 population of 161,077, is the center of a capitol region encompassing more than half a million people. Within the past decade, the capitol region has grown about 27 per cent, in contrast to a nine per cent decrease in central city population.

The Wilbur Cross Highway, Connecticut Route 15, is one of several important radial highways serving the rapidly expanding Hartford Metropolitan Area. A four-lane freeway, it connects the Charter Oak Bridge at Hartford with Route 20 and more recently, the Massachusetts Turnpike on the east. Together with the Merritt Parkway, Wilbur Cross Parkway, and Berlin Turnpike, it forms Connecticut's major trans-state link in the New York-Boston express highway system. The present 34-mile route between Hartford and Massachusetts was developed in stages during the period 1941-1948, and fully developed as a four-lane divided freeway in 1954.

The freeway's impact on land development and travel patterns has been appraised from analyses of new dwellings and other taxable properties within its influence area. Comparisons have also been made with other routes serving portions of the Hartford area.

Traffic and Travel — The study section of Route 15 is related to other routes in the Hartford Area as depicted in Figure 97. The major highways converging on Hartford include Routes 15, 2 and Interstate 91, all developed to freeway standards, and U. S. Routes 5, 6 and 44, which are two and four-lane arterials.

Driving Times — The five-minute driving time contours (isochrones) in Figure 97 depict the areas of equal accessibility from downtown Hartford, and

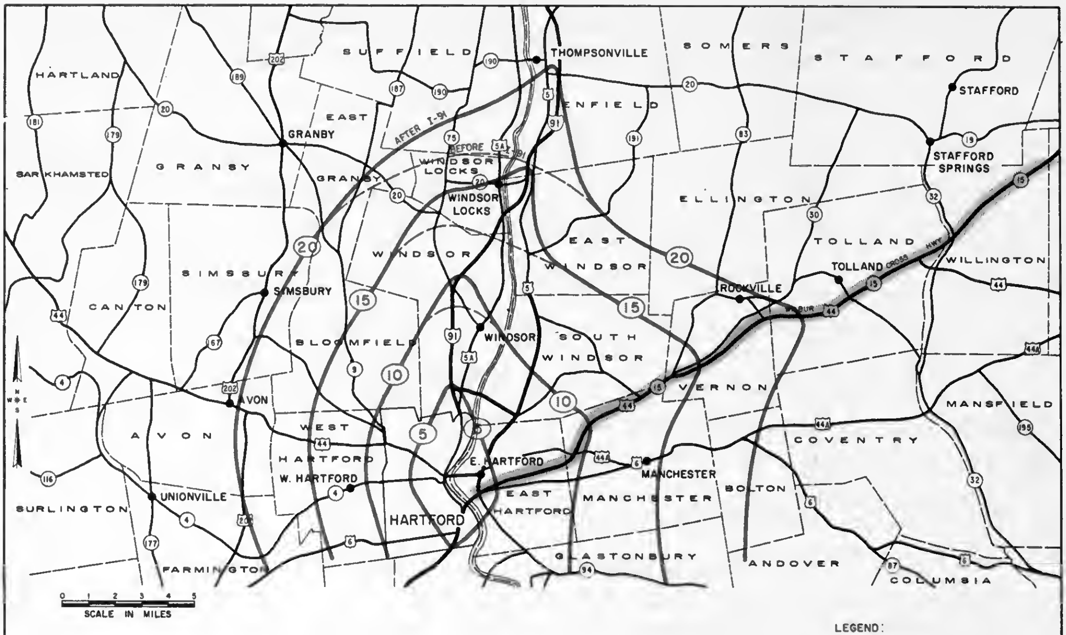


Figure 97
DRIVING TIMES FROM HARTFORD, CONNECTICUT
1960

clearly show how the Wilbur Cross Highway and Interstate 91 have improved access to points east, north and south. These express highways bring a wide area within a relatively short driving time of Hartford. Freeway travel is about twice as fast as travel over conventional arterial routes.

Volumes – The influence of urban centers on traffic magnitudes is apparent from Route 15 traffic flow patterns shown in Figure 98. Hartford is the focus of travel within the region. Traffic volumes, both in 1959 and 1947, decreased rapidly along Route 15 as distance from Hartford increased.

In 1947, volumes along Route 15 increased from about 4,000 vehicles per day at the Massachusetts state line to about 15,000 at East Hartford; whereas in 1959, the range was from 14,000 to 48,000 vehicles per day. During this 12-year period, average volumes per mile increased about 200 per cent – from 6,700 in 1947 to 20,000 in 1959.

Travel Trends – Vehicle miles of travel along the Wilbur Cross Highway in recent years have increased about twice as rapidly as the statewide average, thereby reflecting the increased popularity of the freeway and the growing settlements within its influence area. Travel trends along Route 15 northeast and south of Hartford, along U. S. 44 to the west of Hartford, and over-all

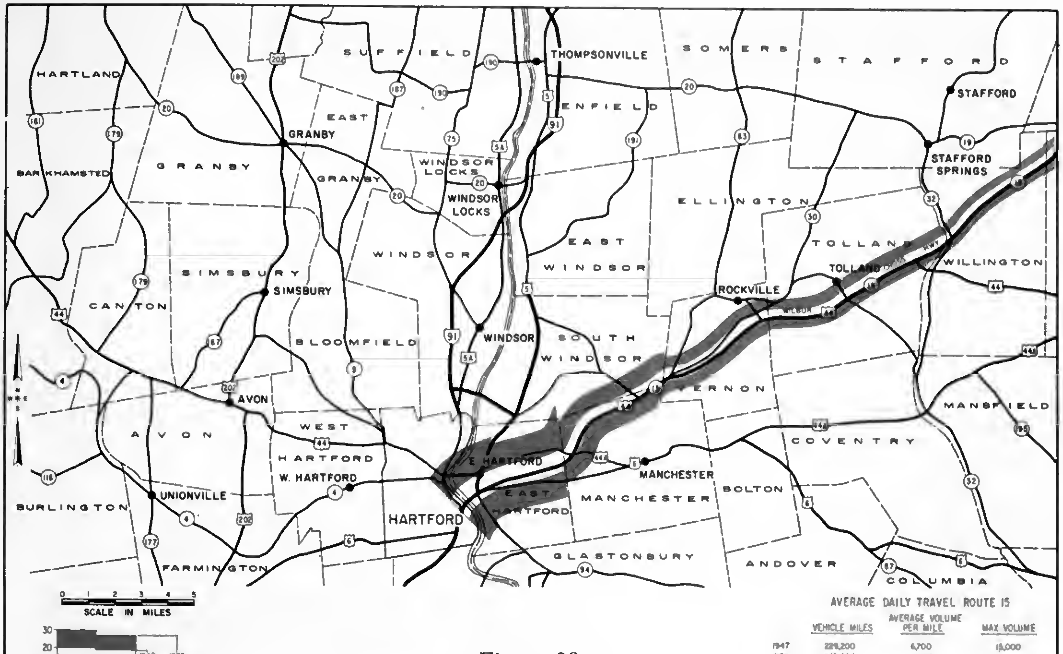


Figure 98
ROUTE 15 TRAFFIC VOLUMES
EAST OF HARTFORD, CONNECTICUT

statewide travel, are compared in Figure 99. Between 1947 and 1959, annual statewide travel increased from about 526 million vehicle miles to 1,023 million miles, a growth of 94 per cent. Daily vehicle miles on Route 44 were generally consistent with statewide trends, increasing 120 per cent, from about 90,000 vehicle miles per day in 1947 to about 200,000 in 1959. In the same period, the daily vehicle miles on Route 15 (northeast of Hartford) increased 195 per cent — from 229,000 to 675,000.

Origins of Work Trips — An origin-destination survey of work trips along the Wilbur Cross Highway at the Manchester-Vernon town line (about 10 miles east of Hartford) was conducted during a summer, 1960 weekday. Results of interviews with drivers residing in the Rockville-Vernon-Ellington-Tolland-Stafford Springs area are summarized in Table 53 and depicted in Figure 100. About 38 per cent of all persons interviewed lived in Rockville, 37 per cent in Vernon, and 25 per cent in other nearby areas. Some 41 per cent worked in Hartford, 36 per cent in East Hartford, and 23 per cent in other areas. Thus, Hartford and East Hartford are the major employment centers for workers in the Rockville-Vernon area. Some reorientation of labor force around East Hartford has occurred.

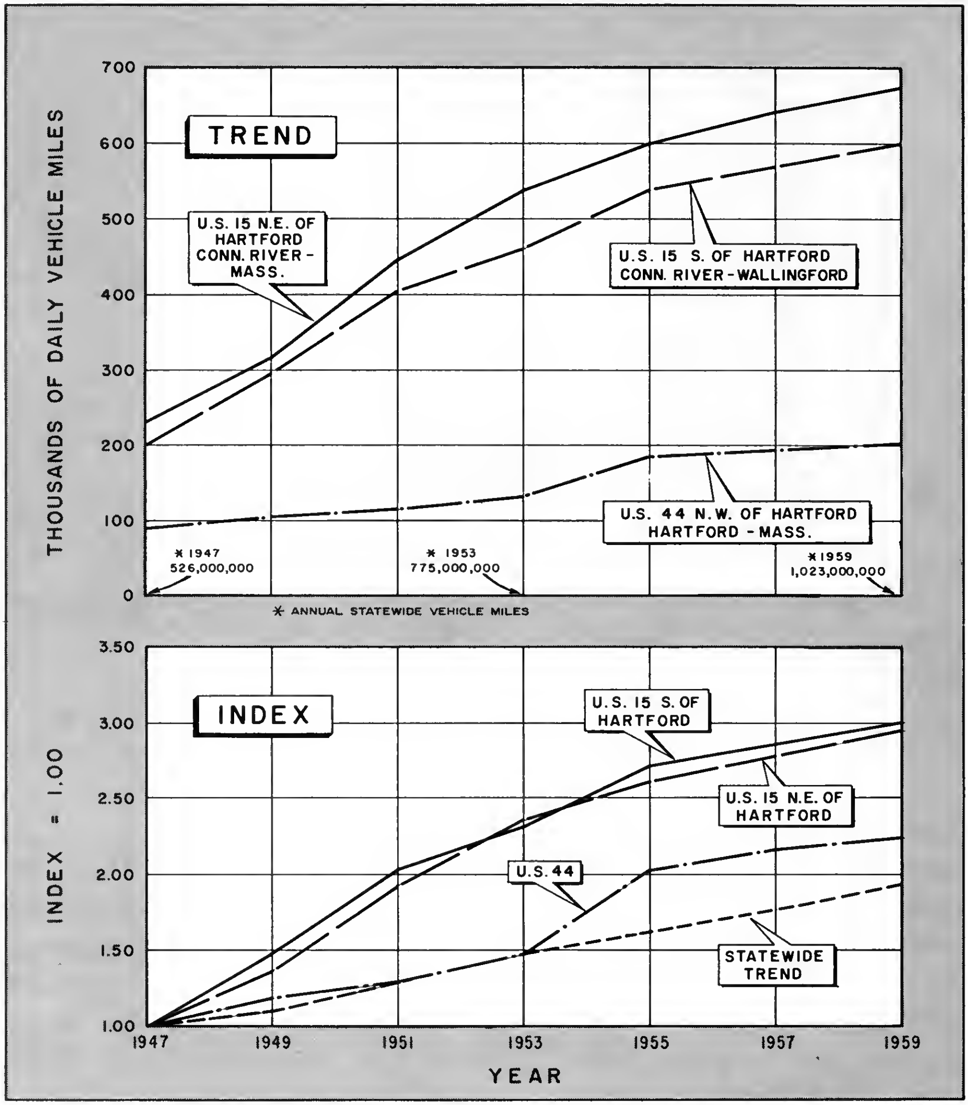


Figure 99
Trends in Vehicle Miles of Travel
Routes 15 and 44
Hartford, Connecticut

Trip Length — The average work trip of drivers interviewed was approximately 16 miles long and took about 21 minutes. Trip times are consistent with those for other work trips in the Hartford area, especially trips made by transit. But, the distances are much longer. Thus, the Wilbur Cross Highway has extended the radius of work trips, making commuting attractive from more distant points.

TABLE 53

PERCENTAGE DISTRIBUTION OF "LOCAL" WORK TRIPS ROUTE 15 AT MANCHESTER-VERNON TOWN LINE, CONNECTICUT

Typical 1960 Day[1]

PLACE OF RESIDENCE	PLACE OF WORK								TOTAL PER CENT	AVERAGE TRIP[2] LENGTH, MILES	AVERAGE TRIP[2] LENGTH, MINUTES
	Hartford	E. Hartford	Manchester	W. Hartford	Wethersfield	New Britain	Newington	Beyond			
Rockville	16.4	12.0	2.2	0.7	0.4	0.7	0.4	5.1	37.9	15.6	18.6
Vernon	15.3	13.1	1.1	1.5	1.5	—	0.7	3.7	36.9	13.0	16.7
Ellington	4.0	2.9	—	—	—	0.4	—	1.8	9.1	18.0	24.2
Tolland	1.5	4.4	0.4	—	—	—	—	0.7	7.0	18.6	21.9
Stafford Springs	3.3	3.6	—	0.4	—	—	—	1.8	9.1	27.6	34.0
TOTAL	40.5	36.0	3.7	2.6	1.9	1.1	1.1	13.1	100.0	16.1	20.6
Avg. Trip Length, Miles	16.6	15.5	8.2	20.2	16.4	25.6	19.3	—[2]	16.1[1]		
Avg. Trip Length, Minutes	21.3	19.6	13.4	27.4	22.2	31.6	24.7	—[2]	20.6[1]		

[1]Source: Special origin-destination study of eastbound traffic, summer, 1960, conducted for this report by Wilbur Smith and Associates. The Manchester-Vernon town line is 10 miles east of Hartford.

[2]Trips "beyond" Hartford area excluded.

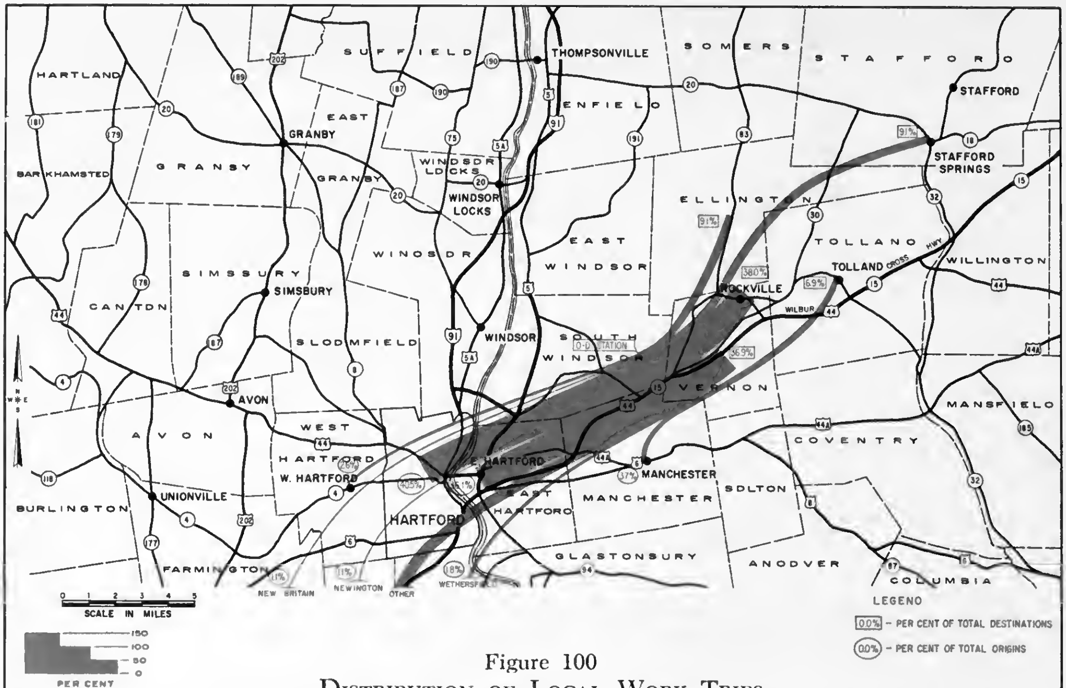


Figure 100
DISTRIBUTION OF LOCAL WORK TRIPS
ROUTE 15, TOWN LINE BETWEEN MANCHESTER AND VERNON, CONNECTICUT

Land Development — The effects of the Wilbur Cross Highway on the distribution of new populations, dwellings and other taxable properties within its influence area were compared with land development along non-freeway routes serving Hartford. The comparative growths along Route 15 to the northeast, Route 5 to to the north, and Route 44 to the west are shown in Figure 101, which depicts 10-year increases (since 1927) in dwelling units per square mile of area in the towns along each route.

It is apparent that patterns, rates, and character of growths in the area have been influenced by both topographic and transportation factors. Land undulates both east and west of the Connecticut River; the Wilbur Cross Highway, however, traverses rolling hills with a minimum of travel impedances. It has extended the areas of rapid suburban expansion well beyond the ring of towns adjacent to Hartford.

In the 10-year period, 1927-1937, very little housing was built in any of the towns in the Route 15 corridor. In the Route 5A corridor, the town of Windsor Locks experienced some development; along Route 44, the Town of West Hartford, contiguous to Hartford, had considerable growth.

During the decade 1937-1947, which included pre-war and post-war conditions, most growth occurred along the Route 15 corridor in the towns of East

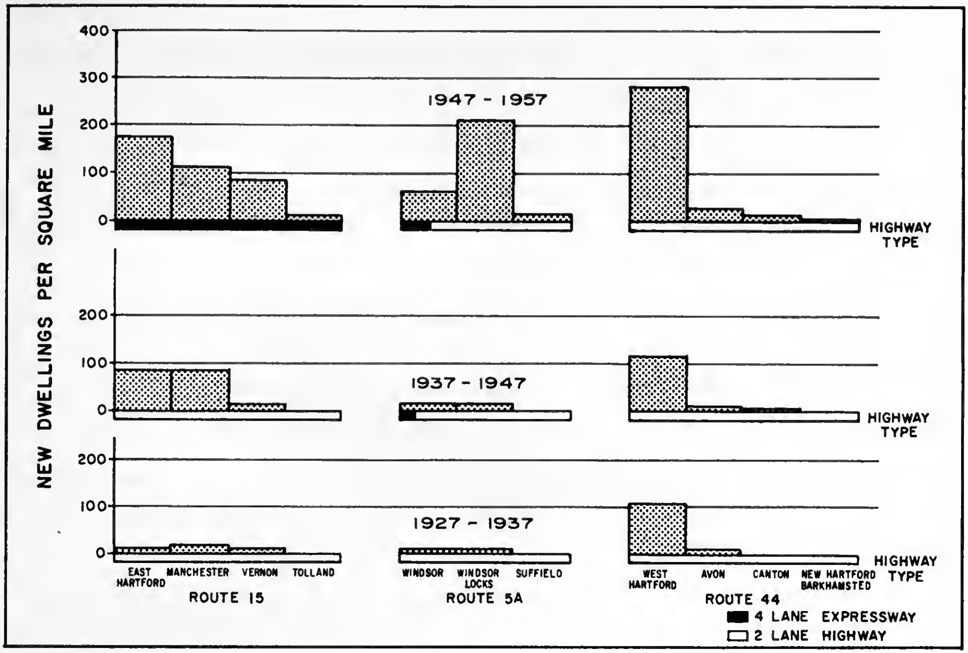


Figure 101
INCREASE IN NUMBER OF DWELLINGS
ROUTES 5, 15, 44 CORRIDORS, HARTFORD, CONNECTICUT

Hartford and Manchester, resulting from the rapid expansion of the Pratt-Whitney aircraft plant in East Hartford. However, growth was also influenced by the opening of the Charter Oak Bridge across the Connecticut River in 1942. West Hartford, a "choice" residential area, continued to grow, whereas other areas along Routes 44 and 5A grew in the same proportion, but at a slightly faster rate, than during the previous decade.

Early in the decade 1947-1957, Route 15 was constructed to freeway standards through East Hartford, Manchester, Vernon and Tolland; the new highway encouraged a high rate of residential construction in the Town of Vernon and continued settlement in East Hartford and Manchester. Growth in West Hartford continued mainly as high-income development. In Windsor Locks substantial post-war growth resulted from the wartime establishment of new industry in the town and the availability of nearby housing; some increases also occurred in Windsor.

The comparative stability of Avon, Canton, New Hartford and Barkhamsted, throughout the 30-year period, largely reflects unchanging highway access to these communities and topographic barriers to land development.

The increase in residential construction in Vernon, however, appears directly related to the accessibility provided by the Wilbur Cross Highway — as measured in driving times. Vernon, via the freeway, is about the same driving time from downtown Hartford as West Hartford. Thus, Vernon has become more accessible to Hartford and is experiencing growth rates found in areas physically closer to Hartford.

Recent growth patterns in the Hartford area clearly reflect the realignment of places of residence closer to centers of employment – often made possible by improved highway access. Proximity has been frequently evaluated in terms of driving time, rather than miles of travel.

Population Density – The Wilbur Cross Highway is encouraging low-density development of areas within its influence zone. This is apparent from Figure 102 which relates density, in terms of houses and building units per square mile to driving time and distance from downtown Hartford.

The pattern of decreasing densities is similar to that in other urban areas throughout the country.[1] Densities decrease rapidly as distance and time from the Hartford central business district increase. The declines appear more rapid along Route 44 than along Route 15 when measured by distance. However, the patterns are generally similar when measured in driving times, and when the high-density areas within West Hartford are not considered.

Assessments – Unit assessed valuations in the Route 15 and Route 44 corridors, when related to driving times, tended to decrease as driving time from Hartford increases, with relatively low-unit assessments in many of the most rapidly growing areas surrounding Hartford.[2]

The long-range effect of freeways will, therefore, be to increase value of remote areas by reducing driving times. In the interim period, rapid settlement is taking place in outlying areas because of lower land costs.

Summary – The Wilbur Cross Highway has tended to stimulate settlement at increased distances from Hartford, Connecticut, the region's focal point. Growths in traffic along the route have been double the statewide increases and reflect, in good measure, the continued settlement of adjacent and tributary areas.

Driving times via the freeway have made long-distance commuting attractive, and have consequently extended the labor market. As a result, there has been some reorientation of the labor force to take advantage of improved highway mobility.

While suburban areas continue to grow with improved accessibility via

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[1]See Chapter 1 for density patterns in other urban areas.

[2]Since *unit* assessed valuations represent the *total* assessments divided by the number of dwelling units, they also reflect increases resulting from commercial and industrial properties in the specific communities.

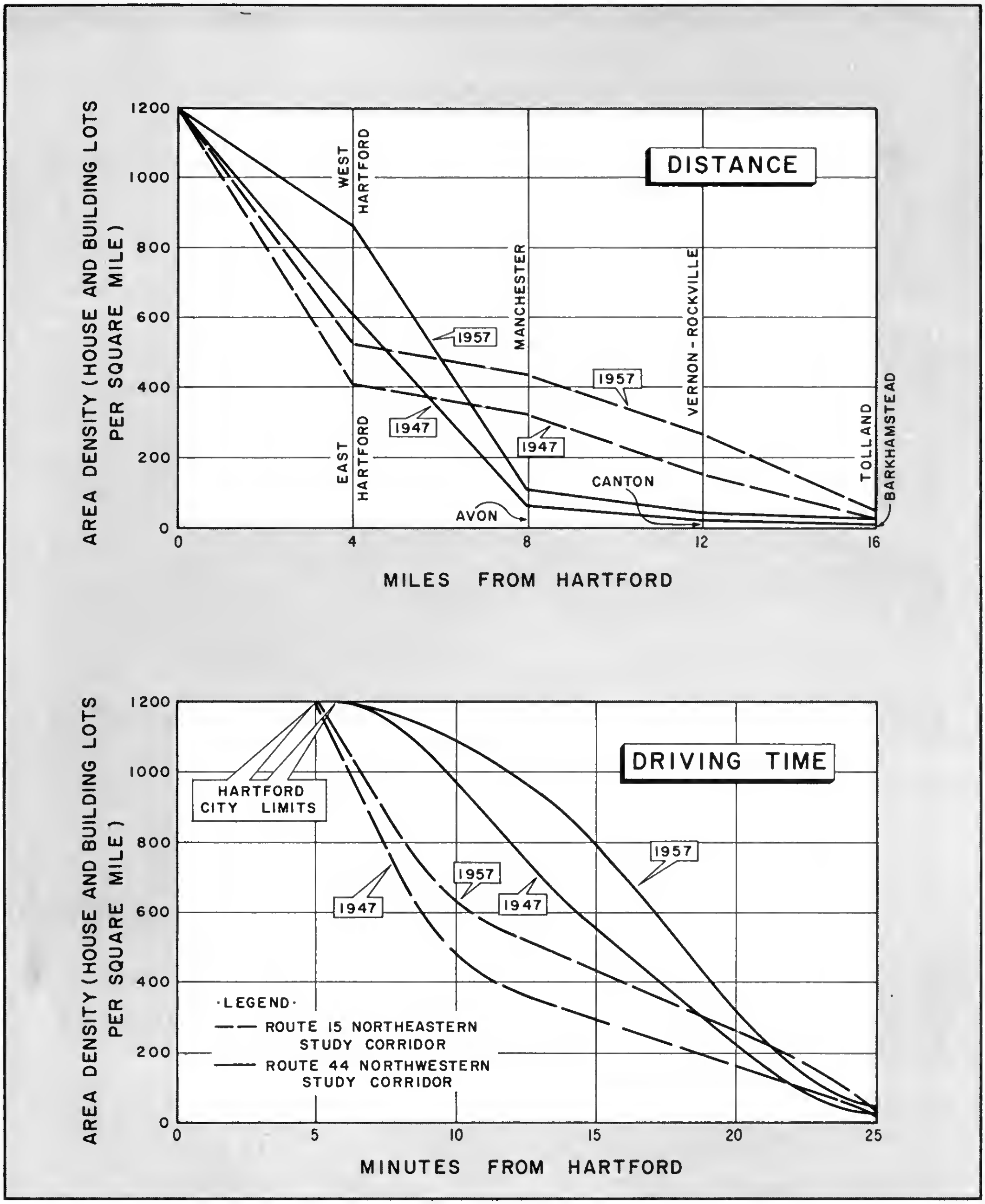

Figure 102
DENSITY OF HOUSE AND BUILDING LOTS
RELATED TO DRIVING TIME AND DISTANCE
FROM HARTFORD, CONNECTICUT

freeways, population declines have been reported in the transit-oriented central city.

Patterns of decreasing land density, as distance from downtown increases, are consistent with those found in other urban areas. Thus, the freeway appears to have stimulated settlement at low and relatively homogeneous densities.

NIMITZ FREEWAY

The Nimitz Freeway is the principal north-south highway in Alameda County, California. As shown in Figure 103, it leads directly from the San Fran-

NIMITZ FREEWAY
Oakland, California

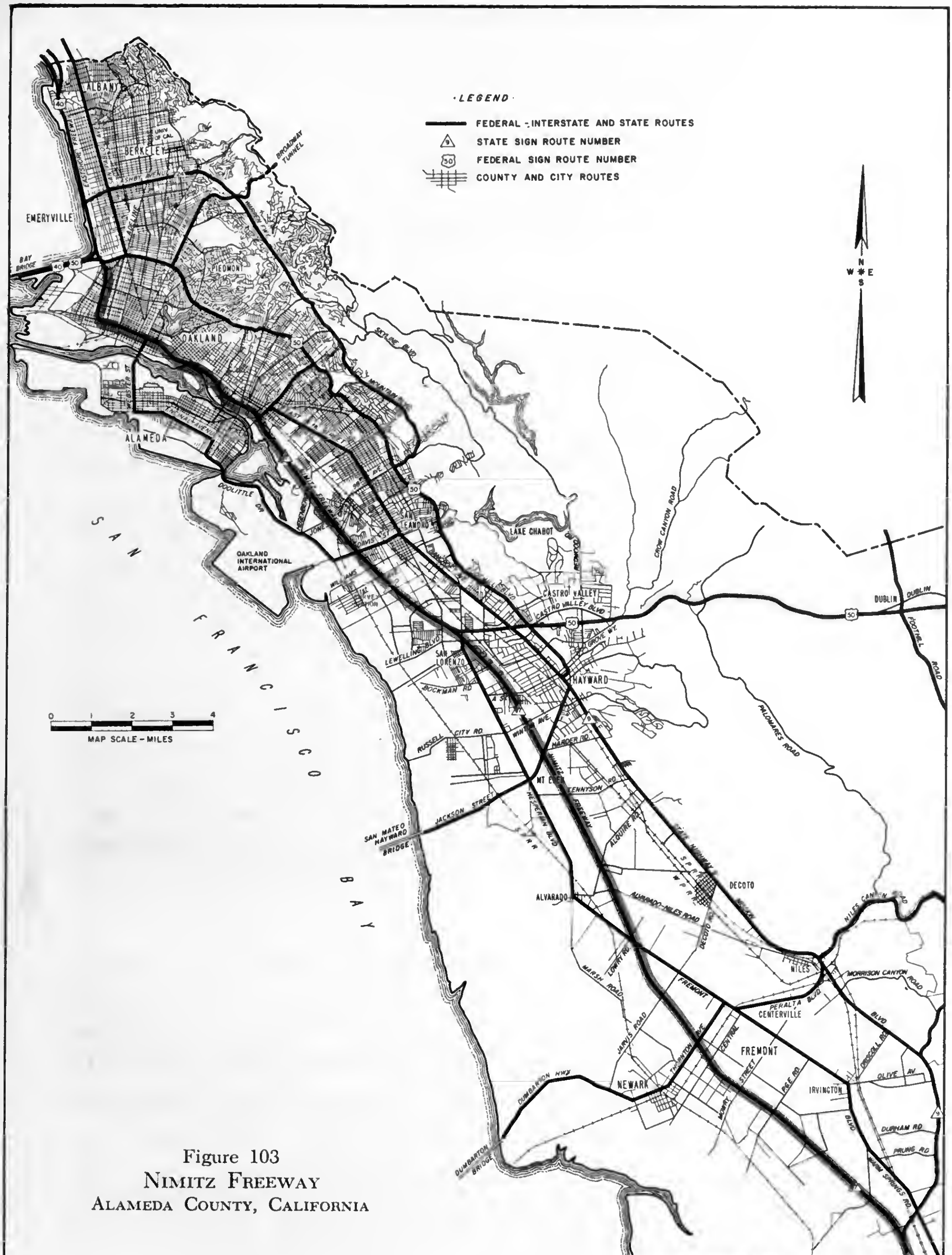

Figure 103
NIMITZ FREEWAY
ALAMEDA COUNTY, CALIFORNIA

cisco-Oakland Bay Bridge southerly through Oakland, San Leandro, Fremont and Warm Springs, interconnecting most of the major population concentrations in the East Bay area.

The Nimitz Freeway opened in 1952 and has since been extended and widened. In November, 1958, a final 10-mile link in southern Alameda County was opened, completing the highway between the Bay Bridge and San Jose. The freeway provides six and eight lanes in Oakland, and four lanes in the southern part of the county.

Studies have been made of the land-use changes and developments that have occurred since the freeway opened. These impacts have been related to the rapid growth of the area.

Population and Registration – The population of Alameda County increased nearly 20 per cent in the decade, 1950 to 1960 – from 740,315 to 886,636. All of this growth took place outside the boundaries of Oakland Township, the heavily urbanized northwest corner of the County; the population of Oakland decreased more than seven per cent, from 593,421 persons in 1950 to 551,534 in 1960. In 1950, Oakland Township accounted for 80 per cent of Alameda County's population, whereas in 1960, only 62 per cent of the county's population resided in the township.

Nearly all of the new population in Alameda County has concentrated in a corridor less than 10 miles wide; between the bay and the Oakland Hills and Walpert Ridge. The corridor extends south from San Leandro, just south of Oakland, to the Santa Clara County line north of San Jose. The improved accessibility resulting from the Nimitz Freeway in conjunction with favorable topographic conditions, has been a stimulus to the rapid urbanization of this corridor.

Alameda County motor vehicle registrations have increased more rapidly than the population. As shown in Table 54, the 1959 motor vehicle registrations totaled 437,386, representing a 42 per cent increase over 1950. The number of trucks and truck-trailers more than doubled, emphasizing the industrial growth that has accompanied the population expansion, whereas passenger auto registrations increased more than 36 per cent.

Traffic Patterns – The Nimitz Freeway is the most important traffic facility in the Oakland-San Jose corridor. More than two thirds of all arterial traffic immediately south of San Leandro uses the freeway. In August, 1960, traffic volumes totaled approximately 120,000 vehicles per day on the combined facilities of Foothill Boulevard, East 121st Street, and Nimitz Freeway (Washington

TABLE 54

MOTOR VEHICLE REGISTRATION TRENDS
ALAMEDA COUNTY, CALIFORNIA[1]

YEAR	*AUTOS*	*TRUCKS*	*TRAILERS*	*TOTAL VEHICLES*[2]	*INDEX 1950 = 1.00*
1950	265,183	25,685	15,514	308,560	1.00
1951	279,922	28,369	16,774	327,232	1.06
1952	285,074	29,923	17,694	334,765	1.08
1953	296,588	33,873	19,170	351,646	1.14
1954	302,481	32,966	20,272	357,724	1.16
1955	321,346	35,794	22,474	381,720	1.24
1956	332,905	36,738	23,586	395,467	1.28
1957	339,921	38,848	25,648	406,866	1.32
1958	344,973	40,653	28,995	417,322	1.35
1959	361,627	31,700	31,011	437,386	1.42

[1]Source: Department of Motor Vehicles, prepared by Research Division, Oakland Chamber of Commerce, Oakland, California, February, 1960.
[2]Includes motorcycles.

Avenue traffic was not recorded). Of these vehicles, about 85,000 (70 per cent) traveled on the freeway. Volumes diminish as the route proceeds southerly from Oakland, again clearly indicating the urban character of freeway traffic.

Growths — Traffic volumes along the Nimitz Freeway, as recorded at a survey station south of San Leandro, have more than doubled since the route was opened for travel. Volumes increased from about 37,000 vehicles daily in 1953, to about 80,000 in 1960. At High Street in Oakland, freeway volumes approximated 50,000 vehicles per day in 1952, and have since doubled.

Increases in freeway travel in the Oakland-San Jose corridor have outpaced total population and vehicle ownership in the East Bay Area. These rapid increases are attributable to the popularity of the freeway, and to its strategic location with regard to topographic barriers, population concentrations, and new urban developments. Topography has restricted extension of the Oakland metropolitan area to the east and west; at the same time, the Nimitz Freeway has made Eastshore areas more accessible. Undoubtedly the freeway has made an important contribution to the area's growth pattern.

Traffic Origins – Use of the Nimitz Freeway by Alameda County residents was determined through studies of northbound traffic passing the survey station at the south city limits of San Leandro on a typical August. 1960, weekday. License numbers of California passenger cars were recorded and addresses of vehicle owners determined. More than 30,000 California passenger cars passed in a northbound direction during the daylight hours, 7:00 A.M. to 7:00 P.M.

The geographic distribution of Alameda County residents who passed the survey station is shown in Figure 104, in terms of average daily cars per thousand residents.[3] The highest rates of travel (i.e. – proportional origins) are from areas in San Leandro near the survey station and adjacent to the freeway. When the distance between the freeway and residential communities increases, streets paralleling the freeway are used increasingly for corridor travel.

Although urban trips within the Oakland metropolitan area average about five miles in length, it is evident that freeway traffic includes many cars from distant points. Cars using the freeway, therefore, make longer-than-average trips.

The origins and hourly variations of the 30,000 northbound California passenger vehicles are shown in Table 55. Local cars dominate the traffic during all hours. About two thirds of the cars (68 per cent) were registered in Alameda County: 46 per cent were licensed south of San Leandro; 8 per cent in San Leandro and in Oakland south of High Street; and 14 per cent were registered in part of Oakland and other communities north of High Street.

A graphic portrayal of the hour-by-hour traffic generated in the above three areas is depicted in Figure 105. About 37 per cent of the 12-hour trips from homes south of San Leandro are made during the morning peak hours, 7:00-9:00 A.M.; these 5,200 vehicles comprise about 87 per cent of the 6,000 Alameda trips made in this period and about 67 per cent of the total northbound travel (7,700 cars). They clearly represent suburban workers inbound to jobs in Oakland.

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[3]1960 population estimates in each of several Alameda County "zones", the number of cars from each zone at the survey station, and the car per thousand residents (as plotted in Figure 104) are shown in Table A-39, Appendix C.

Figure 104
PROPORTIONAL ORIGINS OF NIMITZ FREEWAY TRAFFIC
ALAMEDA COUNTY, CALIFORNIA

Table 55

HOURLY VARIATIONS OF NORTHBOUND PASSENGER CARS BY PLACE GARAGED

Nimitz Freeway at South City Limit of San Leandro

Typical Weekday – August, 1960 – 7:00 A.M. - 7:00 P.M.[1]

	CALIFORNIA PASSENGER CARS						
	Alameda County Cars						
HOUR	*North of High St.*	*South of High St. (Survey Station)*	*South of San Leandro*	*All Alameda*	*Out-of-County Cars*	*Total Traffic*	*Per Cent of 12-Hour Total*
7-8 A.M.	195	195	2997	3387	843	4230	13.9
8-9	304	74	2210	2588	890	3478	11.4
9-10	150	79	1430	1658	728	2387	7.9
10-11	175	110	1219	1504	608	2112	6.9
11-12	194	125	707	1026	799	1825	6.0
Noon	190	142	852	1184	625	1809	5.9
1-2 P.M.	237	134	769	1140	831	1971	6.5
2-3	323	176	931	1430	747	2177	7.2
3-4	378	180	736	1294	1265	2559	8.5
4-5	905	427	664	1996	790	2786	9.2
5-6	798	394	634	1826	957	2783	9.2
6-7	562	231	810	1603	644	2247	7.4
TOTAL	4411	2267	13,959	20,637	9727	30,364	100.0
Per Cent of Alameda Co. Cars	21.4	11.0	67.6	100.0	–	–	
Per Cent of California Cars	14.5	7.5	46.0	68.0	32.0	100.0	

[1]Source: Special license plate study conducted for this report by Wilbur Smith and Associates, August, 1960.

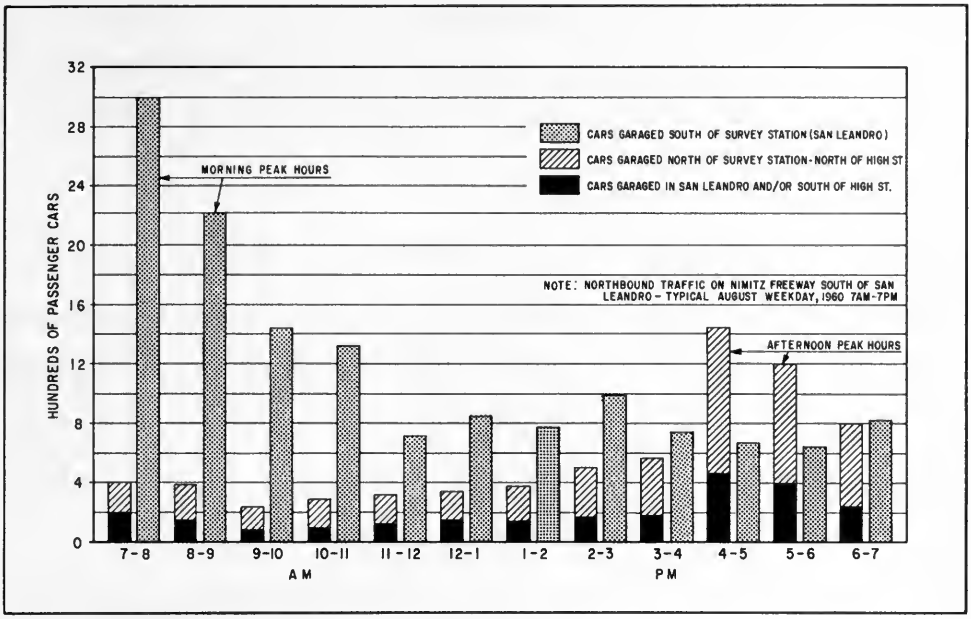

Figure 105
HOURLY DISTRIBUTION OF ALAMEDA COUNTY PASSENGER CARS
NIMITZ FREEWAY, (SOUTH OF SAN LEANDRO, CALIFORNIA)

There is evidence of "reverse commuting" by workers living in Oakland and working in new industrial plants along the Nimitz Freeway south of San Leandro. Between 7:00 A.M. and 7:00 P.M., cars owned by residents of San Leandro and areas of Alameda County north of the survey station accounted for 6,678 northbound vehicles; more than 2,500 cars (38 per cent) passed during the evening peak hours, 4:00-6:00 P.M. Thus, traffic by cars from north of the station developed almost exactly the same proportion of daily use in evening peak hours as attained by cars garaged south of the station during the morning peak period. Cars garaged north of the station accounted for only half as much traffic through the station as cars garaged to the south. Consequently, "reverse commuting" traffic appears to be about half as great as inbound commuter volumes.

Industries that have developed south of San Leandro will undoubtedly provide more new job opportunities for workers who live in Oakland. The Nimitz Freeway, and other highways scheduled for construction in the Oakland-San Jose corridor (the Foothills Freeway and the Shoreline Expressway), will provide the necessary linkage between labor force and employment centers.

Industrial Development – Coincident with the development of the Nimitz Freeway, there has been an expansion of industrial activity within the East

Table 56

SUMMARY OF INDUSTRIAL GROWTH IN ALAMEDA COUNTY, CALIFORNIA[1]

1950-1960

TYPE	*PROJECTS*	*INVESTMENT*	*JOBS*	*PAYROLL*
New	458	$107,973,300	12,840	$48,336,200
Expansion	1,214	238,801,742	16,967	60,807,600
TOTAL	1,672	$346,775,042	29,807	$109,143,800

[1]Source: Alameda County Planning Commission.

Bay Area. As shown in Table 56, between 1950 and 1960, 458 new plants were constructed in Alameda County, and 1,214 other plants expanded, with an aggregate investment of over $346 million, and a total payroll of $109 million. A high proportion has located in industrial areas served by the freeway.

The relation between the Nimitz Freeway and the existing population distribution in the urbanized portions of Alameda County (greater Oakland metropolitan area) is illustrated in Figure 106. The map divides the urbanized portions into four parts:

Zone I includes Northern Oakland (north of High Street), Alameda, Piedmont, Emeryville, Albany, and Berkeley — these are the older sections within the urbanized area.

Southern Oakland (south of High Street) and the town of San Leandro comprise Zone II, where a large amount of new industrial development has occurred since the Nimitz Freeway was constructed.

South of San Leandro, to the Santa Clara County Line, is a third part of the metropolitan area, Zone III, which has recently begun to experience rapid growth.

Zone IV includes the easternmost parts of Alameda County, with the town of Livermore its principal focus. The area is not yet urbanized.

New industrial growth in the four zones is depicted in Figure 107. The dollar investment in new and expanded industry is summarized in three-year periods; 1951-1953, 1954-1956, 1957-1959. During the nine years, 1951 to 1959, industries invested more than $90 million in new plants in the Oakland area. Expan-

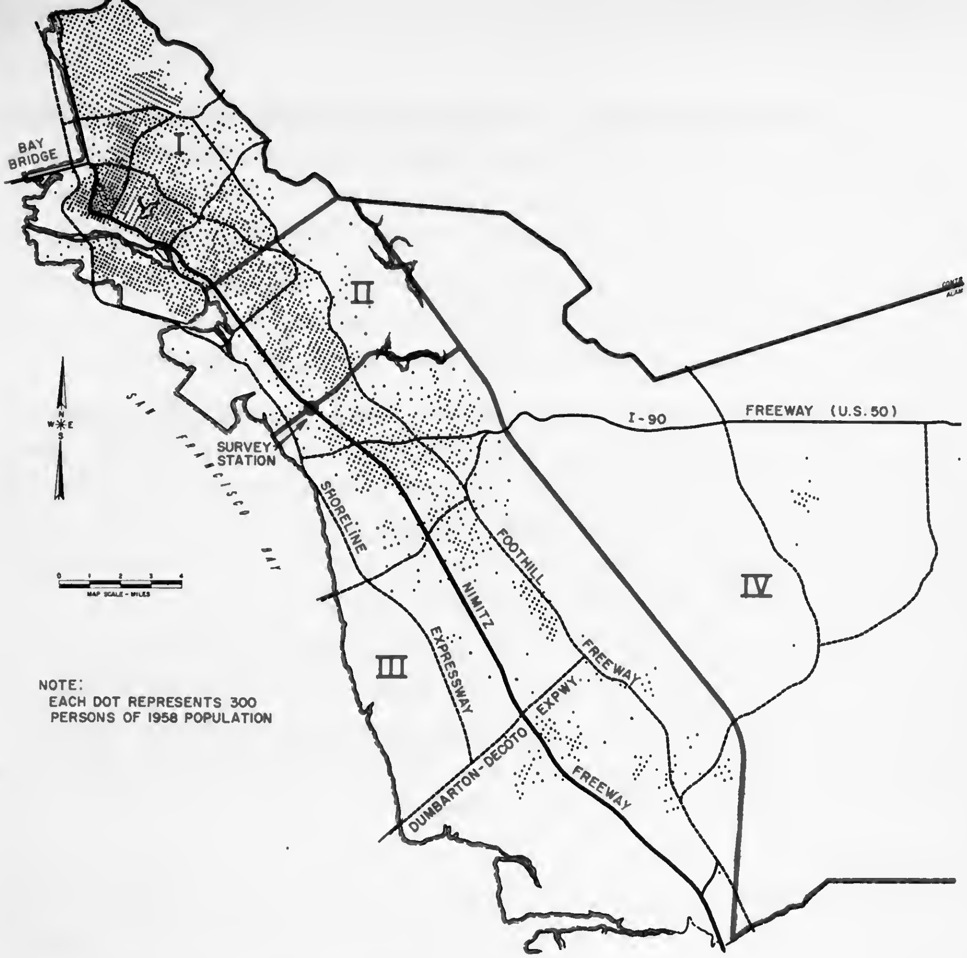

Figure 106
Population Distribution in Relation to Nimitz Freeway
Alameda County, California

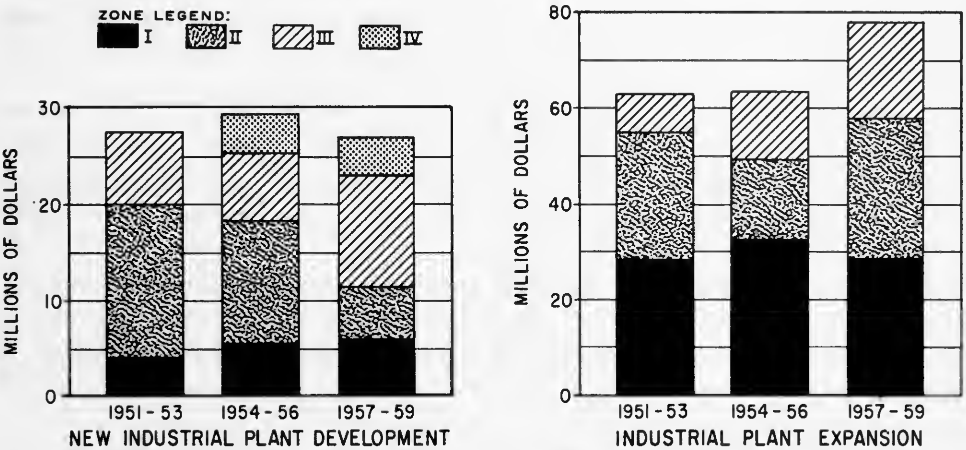

Figure 107
Investment in Industrial Development
Alameda County, California

sion of existing industry (including additional developments in many new industries established during the early years of this period) amounted to more than $220 million.

New Investments — Investments were nearly equal during each three-year period, but the nature and amount of investment in each zone varied considerably. A relatively small proportion of new industry has located in Zone I, although the amount has increased in each successive three-year period.

More than half of the new investments during the years 1951-1953 were made in Zone II, although this proportion decreased in each successive period. Its industrial growth appears to be directly related to the construction of the Nimitz Freeway started in 1949 and completed in 1952. The freeway made large tracts of industrially-zoned land accessible, and a number of industries requiring relatively large sites were attracted to the area.

Between 1954 and 1959, new industrial development in Zone II decreased, while Zones I and III showed gains. The rapid rise in land costs in Zone II have apparently made sites in the older industrial areas of Zone I more attractive, and have encouraged some industries seeking large sites to locate in Zone III, somewhat farther from Oakland and its seaport.

Completion of the Nimitz Freeway through Zone III to San Jose in 1958, and the attendant surge of new industrial growth in the zone between 1957 and 1959, attest to the importance of the new route in attracting industry to the area.

Development of new industry in Zone IV, which began in 1956, consists mainly of specialized atomic energy facilities sponsored by the Atomic Energy Commission. The accessibility of this site via the new U. S. 50 freeway was obviously considered in its selection. The freeway was completed in 1957 from its junction with the Nimitz Freeway to a point a few miles west of Livermore.

Industrial Expansion — The pattern of expenditures for industrial expansion was almost the opposite of that for new industry. Zone I, with its established industrial plant, accounted for about half of plant expansions during the first two time periods, but somewhat less in the years 1957-1959.

In Zone II, there was considerable plant expansion during the first period, due largely to immediate second-stage development of new industries. Some of this construction might properly be regarded as part of the initial stage of development.

During the third period, 1957-1959, when new construction had slowed markedly, a large amount of plant expansion was undertaken as new industries added to their production facilities. In Zone III, where new industries were arriving in increasing numbers in the third period, plant expansion was at a relatively low level. These relationships are consistent with the anticipated patterns of initial growth and subsequent maturing of new industrial parks.

In Zone IV, some major plant expansion occurred in the third period, but again, was so closely related to development of atomic energy facilities that no significant relation to highway development is apparent.

Impact of Freeway – To what extent is the new industrial growth in the Oakland area related to the development of the Nimitz Freeway? Would the $300 million industrial investment have come about in the last decade if the freeway had not been built? Undoubtedly much of this investment would have been made somewhere in the San Francisco-Oakland metropolitan area, and perhaps most of it would have located in Greater Oakland. The freeway appears, however, to have been a catalyst in the localization of industry, and in guiding its expansion.

Location of industrial establishments along the Nimitz Freeway in Zone II, shown in Figure 108, suggests that access to the freeway has been a paramount consideration in new industrial development.[4] Thus, the fact that each addi-

[4]Source: Kelley, John F., "Industry and Freeways," *California Highways and Public Works,* May-June, 1954. This map shows the location of industrial establishments in this corridor in early 1954, as set forth in an extensive study of industrial development by the California Division of Highways; the location of new plants built in the area since 1954 are depicted on an overlay.

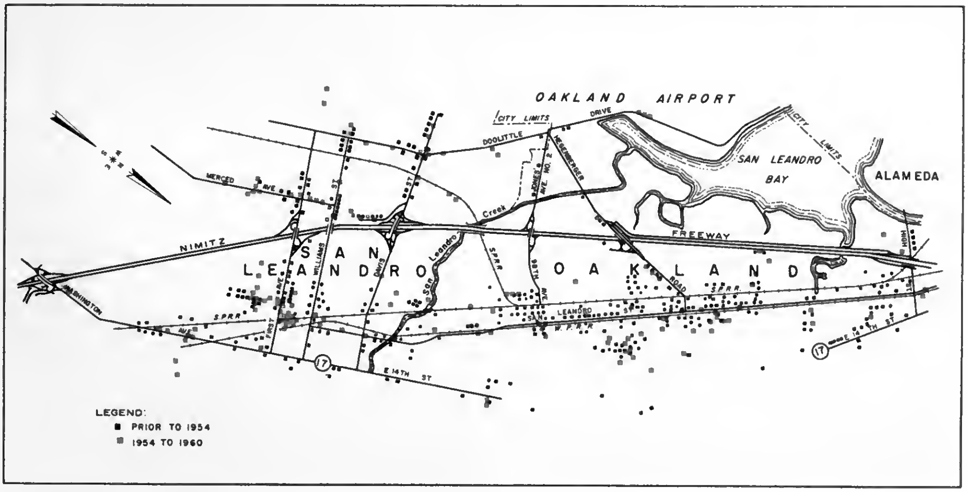

Figure 108

LOCATION OF NEW INDUSTRIAL DEVELOPMENTS ALONG NIMITZ FREEWAY

ALAMEDA COUNTY, CALIFORNIA

tion to the freeway system has seen an immediate, large expansion of industrial development in the areas best served by the freeway — in Zones II, III and IV, in that order — suggests that the new freeway has had a major bearing on decisions affecting selection of industrial sites.

Residential Growth — Trends in residential land values in Alameda County are shown in Figure 109, using 1949 as an index year. The market value of

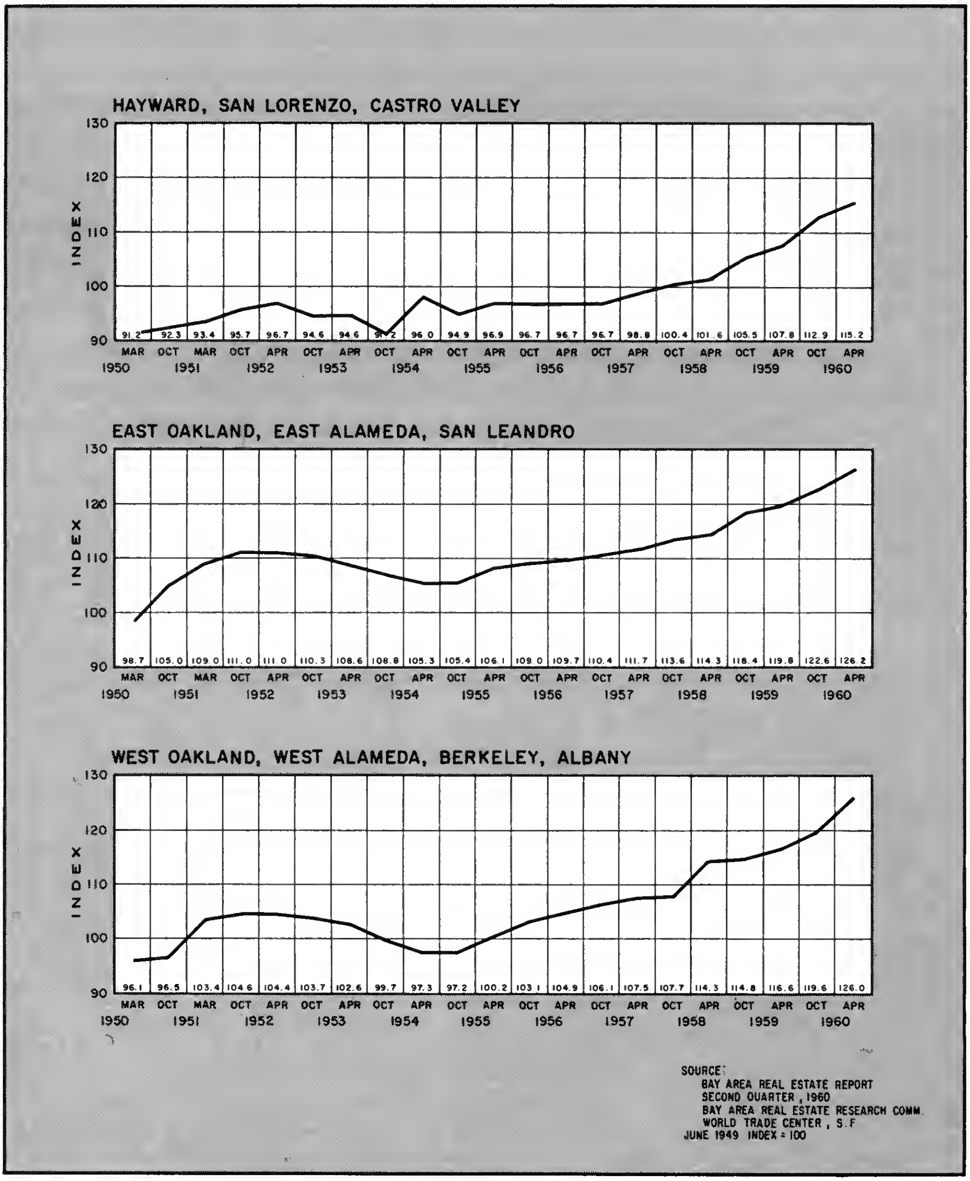

Figure 109
TREND OF RESIDENTIAL MARKET VALUE
ALAMEDA COUNTY, CALIFORNIA

residential land has increased about 25 per cent since 1949, much of which may be attributed to freeway development.

In all three areas within the county — West Oakland-Alameda, East Oakland-San Leandro, and Hayward-San Lorenzo — there were continued increases, except for declines between 1953 and 1955 as a result of a nationwide recession.[5] Increases in land value were extremely rapid after 1958.

Some declines in property values in the western Oakland-Berkeley area may have resulted from population losses in the incorporated areas. In eastern Oakland, land values rose sharply in 1950-51 when the Nimitz Freeway was being completed; however, after the highway was completed within the zone, residential land values stabilized at about 10 per cent over 1949 values. In the Hayward-Castro-Valley area, land values rose sharply coincident with completion of additional portions of the Nimitz Freeway, especially in 1958 when the freeway was completed to San Jose.

There is no doubt that residential growth in eastern Oakland and Hayward, (corresponding to Zones II and III), has been fostered by over-all population increases in the San Francisco Bay area and industrial development in the Nimitz corridor. Construction of the freeway has, nevertheless, contributed to new growth in the East Bay areas south of Oakland and has encouraged development of housing tracts readily accessible to principal interchanges along the route.

Summary — The Nimitz Freeway appears to have encouraged both residential and industrial development, and contributed to the economy of the area. Travel along the freeway has more than doubled in the last decade — these rapid increases are directly related to new urban development in the Oakland-San Jose corridor.

The Nimitz Freeway has become the backbone of the East Bay arterial system — and the axis of both residential and industrial development. It is evident that the freeway has substantially contributed to new growth. It has made East Bay areas accessible, whereas topography has deterred extended urbanization in other directions.

LOS ANGELES FREEWAYS

Special studies conducted in Los Angeles during 1960 along the Hollywood, San Bernardino and Santa Ana Freeways show how freeway availability and use relate to residential development.[6]

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[5]These areas correspond to Zones I, II and III, respectively.

[6]Source: Newville, J. R., *Freeways as a Factor in Reducing Friction of Space in the Los Angeles Area,* prepared for Seminar in Human Ecology, University of California, 1960.

The results of these studies are summarized in Table 57. In each of three sectors within the city and its environs, the areas of most rapid residential growth appear to have extended outward, as travel times were reduced by freeways. The study has shown that with each freeway extension, residential growth was at increasing distances from the CBD until freeway capacities were reached and time benefits were minimized. For example, the Santa Ana freeway reached capacity in 1956, and growth in Orange County, which it serves, decreased in relative growth in 1956 and 1957.

TABLE 57

GREATEST PROPORTIONS OF TOTAL RESIDENTIAL GROWTH IN SELECTED SECTORS

Los Angeles, California[1]

DISTANCE FROM CBD	*HOLLYWOOD FREEWAY* Opened to North Hollywood, 1954, Opened to Los Angeles City Line, 1960	*SAN BERNARDINO FREEWAY* 6 Miles Opened 1952, 10 Miles Opened 1954, Entire Freeway Opened 1956	*SANTA ANA FREEWAY* 8 Miles Opened 1953, Opened to Orange County 1954, Opened to Santa Ana, 1956
5-10 Miles	–	–	1940-1945
10-15 Miles	1940-1945	1940-1950 1952 1960	1946-1953
15-20 Miles	1946-1954	1951-1954 1953	1954-1960[2]
20-25 Miles	1955-1960	1955-1959	–
Over 25 Miles	–	–	–

[1]Source: Newville, J. R., *Freeways as a Factor in Reducing Friction of Space in the Los Angeles Area,* 1960.
[2]Over 15 miles.

Workers apparently choose to live in outlying areas within acceptable driving time from downtown via freeways. When peak-hour driving time increased, there was a tendency for workers to live in higher density, close-in areas; some redensification was shown to be underway in Los Angeles.

INTERSTATE ROUTE 85

Interstate Route 85 will extend from Petersburg, Va., to Montgomery, Ala. and roughly parallels U. S. 29. It connects Durham, Greensboro and Charlotte, N. C.; Spartanburg and Greenville, S. C.; Atlanta, Ga.; and Montgomery, Ala.

Special studies were made of the motorists using the 200-mile section of I-85 between Durham, N. C., and Greenville, S. C., shown in Figure 110, which bypasses or traverses the outer parts of Spartanburg, Gastonia, Charlotte, Salisbury, Lexington, and Greensboro. Considerable sections of roadway are complete between Spartanburg and Gastonia, around Charlotte and Salisbury, and between Greensboro and Durham. The remaining parts of the route are served by four-lane U. S. Route 29.

The I-85 studies were designed to evaluate the impact of a rural Interstate route on travel in a corridor flanked by a number of urban communities. More than 30,000 motorists were interviewed at 10 survey stations in the I-85 corridor. The interviews provided information on length, purpose, origin, and destination of trip, type of vehicle and other pertinent facts.

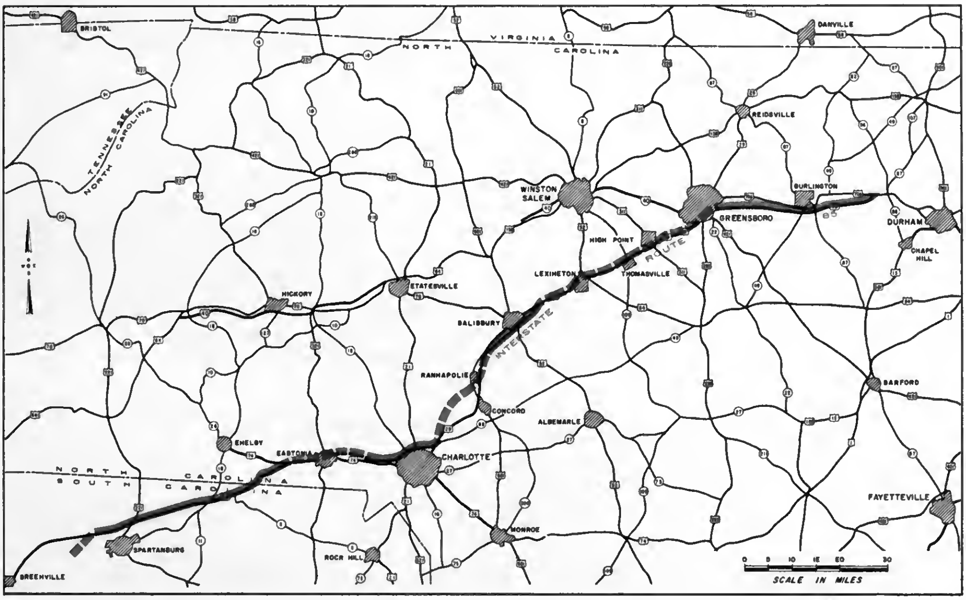

Figure 110
INTERSTATE ROUTE 85 AND RELATED HIGHWAYS
NORTH AND SOUTH CAROLINA

Traffic Volumes – Traffic volumes along the I-85 corridor are graphically depicted in Figure 111; corridor volumes reach peaks in urban areas, and have low points in between – a pattern characteristic of travel throughout the nation. The heaviest corridor volumes – about 28,000 cars per day – are in Charlotte; the lightest corridor flows – about 8,000 cars per day – are east of Burlington. More than half of all corridor travelers use I-85, except within urban areas.

Route volumes along I-85 generally range from 10,000 to 12,000 vehicles per day. They peak to 19,000 vehicles per day east of Gastonia where Routes I-85 and U. S. 74 coincide, and approximate 16,000 vehicles per day within Greensboro.

Most travel along the sections of I-85 studied is by cars that have one trip terminus in North Carolina. Through "interstate" traffic approximates 1,200 vehicles per day over most of the route, and is usually less than 10 per cent of the total volume. West of U. S. 74, and east of Greensboro, through traffic is considerably less.

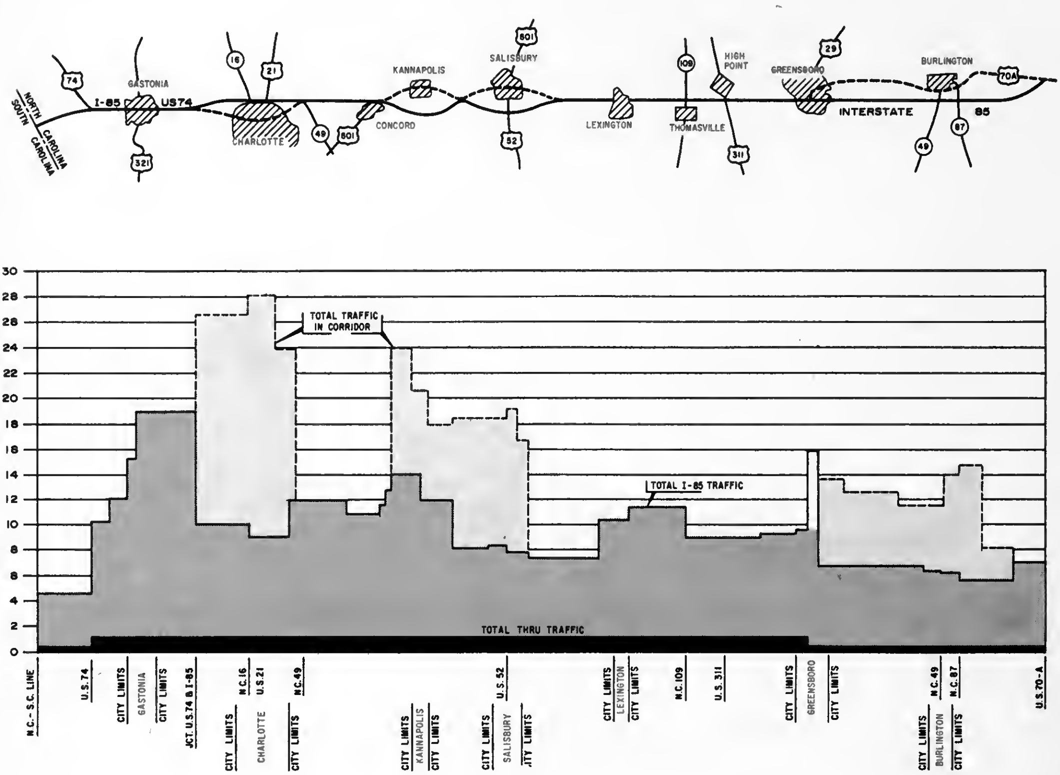

Figure 111
TRAFFIC VOLUMES ALONG INTERSTATE ROUTE 85 CORRIDOR IN NORTH CAROLINA

Travel Characteristics – Interviews of approximately 12,000 motorists at locations near Durham, Charlotte, and Gastonia afford further insight into the characteristics of I-85 travelers. About three fourths of the traffic along I-85 at the above location consists of passenger cars, and the remainder commercial vehicles. About 93 per cent of the passenger cars were standard American vehicles; the remaining seven per cent were smaller vehicles, about evenly divided between American compact cars and small foreign imports.

Passenger Cars – Characteristics of passenger car travel by type of vehicle are depicted in Figure 112. Studies of trip frequencies along I-85 (Figure 112a) indicate that over 40 per cent of the small-car drivers reported daily travel on the route, compared with about 30 per cent of the standard and compact car drivers. This is partly explained by drivers' trip purposes (Figure 112b) that indicate a higher proportion of small-car trips made to and from work – a motive that implies daily repetition.

There is relatively high use of the standard car for high-occupancy, social-recreational travel. Work trips averaged less than one and a half persons per car, while social-recreational trips averaged almost three persons per car.

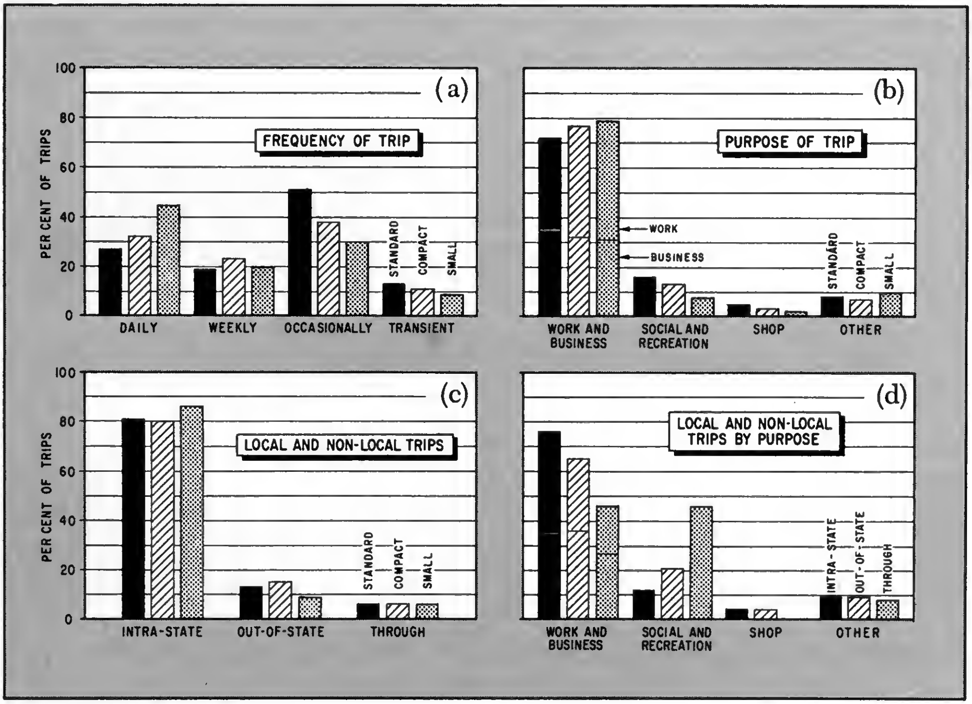

Figure 112
CHARACTERISTICS OF PASSENGER CAR TRAVEL ALONG
INTERSTATE ROUTE 85, NORTH CAROLINA

Thus, the compact cars assume a position, in trip frequency and purpose, intermediate between the extremes presented by the standard and the small cars; small vehicles are being driven for low-occupancy purposes.

Passenger car trips, by vehicle type, when separated into three classes according to general origin and destination (Figure 112c) indicate a predominance of local travel. Over 80 per cent of all driver trips recorded at the interview stations began *and* ended within the state where the interviews were made (intrastate); nearly 15 per cent more began *or* ended their trips within the state (out-of-state). Slightly more than five per cent were rated as "through" trips – with neither origin or destination in the state where interviews were made. Through trips accounted for almost exactly the same proportion of cars in each vehicle class and there were no significant differences between intrastate and out-of-state trips and vehicle size.

The variation of trip purposes by intrastate, out-of-state, and through vehicles (Figure 112d) indicate about two thirds of all intrastate travel was for business or work. (These purposes were combined because the terms were used interchangeably by some respondents.) About 65 per cent of out-of-state travel was in this purpose category, with principal emphasis on "business" travel. Less than half of the through trips were for work or business (most were for "business").

Social-recreational travel accounted for nearly half of all through trips, less than 25 per cent of out-of-state trips and only 12.5 per cent of local or intrastate traffic. If Saturday and Sunday travel is included, there would be a higher proportion of recreational trips in all trip-length categories.

Trucks – Characteristics of truck trips in the I-85 corridor are illustrated in Figure 113. Three distinct classes of commercial vehicles were denoted in the study: (a) panels and pickups which in rural areas frequently substitute for passenger cars; (b) two-axle trucks with dual tires on the rear axle; and (c) all large trucks, mostly tractor-trailer combinations. Of the truck trips in the I-85 corridor, 25 per cent were pickups and panels; 20 per cent were two-axle dual-tire trucks; and nearly 55 per cent were large, over-the-road types.

All types of trucks appear in the I-85 corridor with about the same frequency (Figure 113a). About one third use the same portion of route each day; another third use the route once or twice a week; most of the remainder appear on the route at infrequent intervals; a few are "transient" and are not involved in recurrent use of the route.

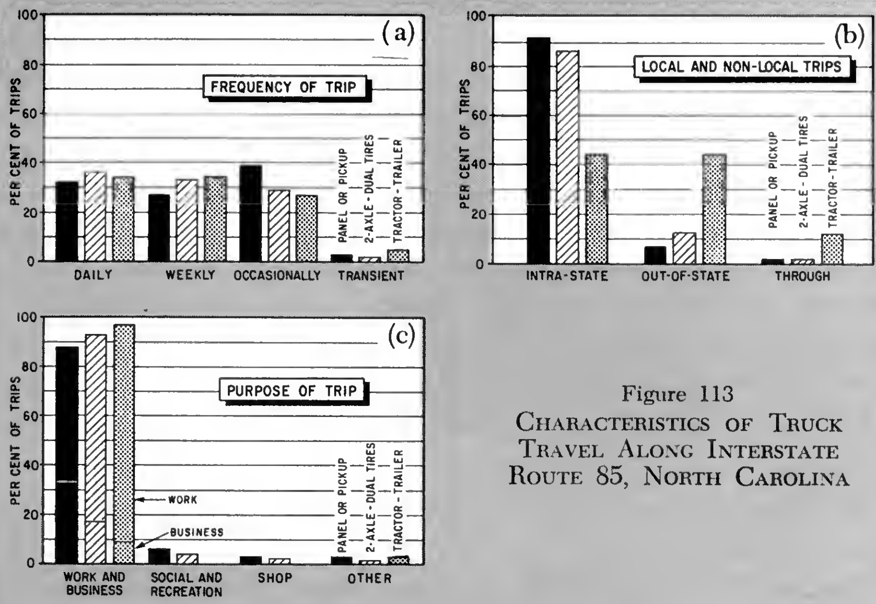

Figure 113
CHARACTERISTICS OF TRUCK TRAVEL ALONG INTERSTATE ROUTE 85, NORTH CAROLINA

Most of the smaller trucks (panel-pickup and two-axle with dual tires) remain within the state, whereas more than half of the large trucks originate out of state (Figure 113b). About 12 per cent of all large trucks are making through trips and have out-of-state origins and destinations.

"Work" is the principal purpose of travel for each class of truck (Figure 113c). Work trips predominate, although some of the smaller vehicles, especially pickups and panels, are used for shopping and recreation; about one third of the pickup-panel drivers indicated a "business" purpose which implies use of the vehicle as a passenger car rather than for load-carrying. Conversely, virtually all truck-trailers were engaged in transport of goods at the time of interview.

Trip Length – Most trips along Interstate 85 are short. Midway between urban centers (between Greenville and Spartanburg or between Charlotte and Concord), 70 to 75 per cent of all passenger-car trips are less than 25 miles long; between 15 and 20 per cent of all trips range from 25 to 100 miles; only eight to ten per cent of all cars make trips longer than 100 miles.

Between Greensboro and Durham, the volume of traffic on I-85 diminishes sharply, and long trips – over 100 miles – constitute less than five per cent of the total. This is because U. S. 29 diverges from I-85 at Greensboro and provides a more direct route to the north for through trips. However, completion of I-85 north from Durham to Petersburg, Virginia, will attract considerable through traffic volumes from U. S. 29.

Comparisons — The I-85 findings confirm travel characteristics of drivers in rural areas previously reported in other studies. Trip purposes of auto drivers agree, in general, with material collected for the Bureau of Public Roads in 13 states between 1952 and 1956. The Bureau study reported about 79 per cent of all trips for work or business purposes; about 14 per cent for social and recreational purposes, and seven per cent for miscellaneous purposes (not associated with work, shopping or family business). Work, shopping and business accounted for three fourths of I-85 travel, whereas about 16 per cent was for social-recreational travel and 8 per cent for miscellaneous reasons.

Differences between the two studies are attributed mainly to the larger proportion of long trips in the I-85 corridor — a major intercity route.

The urban influences on I-85 are apparent. Most intrastate trips have one or both ends in urban areas. This was forcefully indicated in an analysis of traffic across the boundaries of a three-county area, recently published by the North Carolina State Highway Commission.[7] Of more than 54,000 trips intercepted at the limits of the three-county area (Davidson, Guilford and Forsyth Counties), 88 per cent began or ended at urban places within the study area. Intercity travel within this area was found to follow a predictive interactance relationship.[8]

Summary and Implications — The I-85 studies clearly show that urban centers have a significant influence on traffic, even along a rural Interstate route. *Relatively few of the drivers on the route were traveling interstate;* most trips were relatively short, and had origins and destinations within the corridor studied.

The study also indicates that nearly all of the trips which begin and end in urban places in the I-85 corridor use the facility. Thus, it is likely that many trips followed indirect routings to use the new highway. This practice is consistent with the reported traffic generation experienced on other freeways and toll roads.

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[7]N. C. State Highway Commission, *Report on the Origin-Destination Traffic Survey at Five City Crescent Area*, Raleigh, N. C., November, 1959.

[8]Burch, J. S., *Traffic Interactance Between Cities*, January, 1961. The formula was quadratic as follows:

$$T = 0.04m^2 + 4.9m + 160$$

where:

T = number of 24-hour weekday Intercity Trips between City A and City B

$$m = \frac{\sqrt{\text{population A} \times \text{population B}}}{(\text{distance between A and B})^2}$$

HIGHWAYS AND TRAFFIC GENERATION

Good transportation facilities generate travel; conversely, the lack of facilities tends to suppress travel. Growths are especially apparent in rural or semi-rural areas. They result from intensified land use and elimination of travel barriers made possible by reduced driving times and improved accessibility.

Good road systems, particularly freeways, and automobile ownership are interrelated. For example, Houston and Los Angeles, where relatively extensive freeway systems are in operation, have high car ownership and use and reduced transit riding; the opposite has been true in Philadelphia.

While the extent of traffic generation resulting from highway improvements is difficult to measure precisely, studies made in recent years by state and federal road agencies have shed considerable light on this subject.

Traffic growths along two radial freeways, the Shirley Highway in the Washington, D. C., metropolitan area and the Gulf Freeway in the Houston, Galveston, Texas area are shown in Figure 114.[9] It is significant that in each

[9]Schmidt, R. E., and Campbell, M. E., *Highway Traffic Estimation,* Eno Foundation For Highway Traffic Control, Saugatuck, Conn.

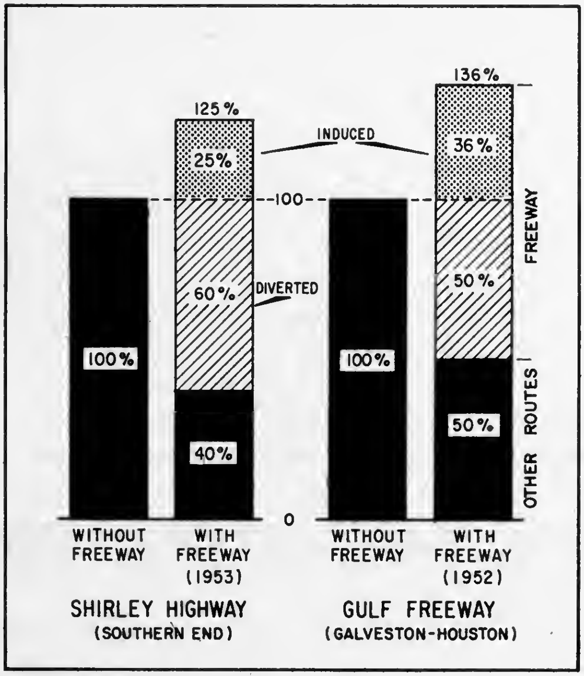


Figure 114
EFFECT OF FREEWAYS
ON
TOTAL CORRIDOR TRAVEL

case, there was at least 25 per cent more travel through the corridors than if the freeways did not exist. At the same time, the freeways afforded substantial relief to other highways in the same corridor of travel—arterial volumes were reduced by more than half. This relief is consistent with that in urban areas, and anticipated by the assignments to freeway systems in Chapter V.

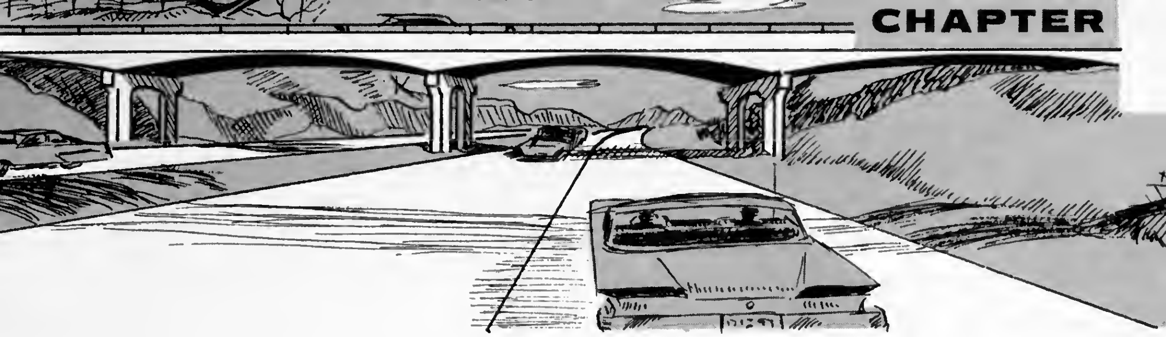
Other examples of traffic generation, cited in Table 58, indicate that "free" express highways have generated from 40 to 60 per cent of their traffic and "toll" express highways from 20 to 30 per cent. For example, the Merritt Parkway in Greenwich, Connecticut, has generated over 25 per cent more traffic than would be anticipated from normal growth.

TABLE 58

ILLUSTRATIVE EXAMPLES OF TRAFFIC GENERATION[1]

FREE ROADS	*PER CENT GENERATION*
Washington-Baltimore Parkway (Maryland near Washington)	63
Gulf Freeway (Texas)	50
Shirley Highway (Virginia, south end)	38
TOLL ROADS	*PER CENT GENERATION*
Denver-Boulder Turnpike (Colorado)	19
Merritt Parkway (Connecticut)	28
Wilbur Cross Parkway (Connecticut)	23
Maine Turnpike	29
Pennsylvania Turnpike (eastern extension)	32

[1]Source: Holmes, E. H., *The Influence of New and Improved Roads on the Distribution of Traffic,* U. S. Department of Commerce, Bureau of Public Roads, Washington, D. C., 1958.



DIRECT BENEFITS TO ROAD USERS

SUMMARY

THE National System of Interstate and Defense Highways will more than pay for itself in direct benefits to motorists, realized through lower operating costs, fewer accidents, and time saved. In addition, it will provide benefits of increased comfort, convenience, and capacity.

In 1960, operating and accident cost savings totaled 1.69 cents per vehicle mile in urban areas and 0.72 cents per rural vehicle mile. Time savings amounted to 2.66 cents per urban vehicle mile and 0.98 cents per vehicle mile in rural areas. These savings are for vehicles using freeways.

Direct savings to road users in fuel, maintenance and accident reduction will, by 1980, amount to about 2.12 cents per vehicle mile in urban areas and about 1.00 cents per vehicle mile in rural areas. Estimated 1980 time savings will approximate 2.92 cents per urban vehicle mile and 0.98 cents per rural vehicle mile.

The completed urban Interstate system will afford annual savings in operating and accident costs of approximately $4 billion by 1980; the rural Interstate should save about $1 billion per year. Thus, by 1980, the total operating cost savings from the entire Interstate system will exceed $5 billion annually; these annual motoring economies will equal about one-eighth of the total cost of the system.

Annual time savings by 1980 will amount to about four billion hours on the complete Interstate system, over three billion hours on urban sections, and over a half billion on rural sections of the completed Interstate system. If a monetary value were given it would exceed $6.5 billion.

Total savings attributed to all of these economies would approximate $12 billion per year for the entire Interstate system; over 9,000 lives would be saved annually. If the monetary values of time saved were also considered, the total 1980 motorist benefits accruing from the Interstate system would be equal to almost a third of the system's cost.

The aggregate net benefits, 1961-1980 resulting from completing the remaining portion of Interstate highways on schedule would approximate $42 billion in operating costs and $56 billion in time savings; a total of 75,000 lives would be saved. More than 80 per cent of these benefits would accrue in urban areas. Thus, the *net* savings in motor vehicle operating costs and accident reductions would more than pay for all sections of the Interstate system not built as of 1960.

A three-year delay in completing the Interstate system — from 1972 to 1975 — would amount to aggregate road-user penalties of about $10 billion, and would cost about 10,000 lives, prior to completion of the system (1961-1975).

Each mile of urban Interstate highway will average about five times the traffic carried by rural routes at two-and-a-half times the unit cost benefits. Thus, on a per mile basis, urban Interstate highways will, on the average, provide 12 times the benefits afforded by rural routes.

It is clear that substantial benefits will result from early completion of the Interstate Highway System, especially in urban areas. Particular emphasis should, therefore, be given to completing urban Interstate highways as soon as possible.

INADEQUATE roads penalize both the motorist and the community. The motor vehicle operator is adversely affected by increased operating and accident costs, loss of time, discomfort, and inconvenience. The community experiences economic losses through decreased land values and lower volumes of business. It has often been said that it is not a matter of being able to afford good roads, but rather a matter of being able *not* to afford them.

The economic consequences of traffic congestion and inadequate roads have long been recognized, although it is only recently that they have been assessed in monetary terms. For example, the economic losses in London had become apparent as early as 1635: "The greatest number of hackney coaches of late time seen and kept in London, Westminster and their suburbs, and the general and promiscuous use of coaches there, was not only a great disturbance to his Majesty . . . and others of place and degree in their passage through the streets; but the streets themselves were so pestered and the pavements so broken up, that the common passage is thereby hindered and more dangerous; and the prices of hay and provender, and other provisions of stable, thereby made exceedingly dear."[1]

This chapter evaluates the direct or measurable road-user benefits resulting specifically from construction of the Interstate highway system. It sets forth the penalties resulting from inadequate roads — greater operating costs, increased accidents, and loss of time; it relates unit cost differentials to anticipated future travel. In developing unit cost values, consideration has been given to the many studies and tests that have compared costs of operating motor vehicles on freeways with travel on conventional roads and streets.

Monetary savings in operating, time, and accident costs have been calculated for urban and rural Interstate highways. They have been related to vehicle miles of travel anticipated under alternate completion dates of the system to obtain aggregate cost savings for the entire nation.

Direct benefits to road users resulting from freeway construction have been reported widely. It was anticipated that the Maricopa County (Arizona) freeway system would provide annual savings to motorists of about $47 million by 1980.[2] The Schuylkill Expressway in Philadelphia would provide about $18 million total annual savings at current levels.[3] The California Interstate System would save approximately $8 billion over a 30-year period, more than twice the amount of the total interest and principal required to finance the system.[4] Savings to users of the Central Expressway in Dallas were reported to be sufficient to liquidate the original investment in 10 years.[5]

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[1]Brunner, Christopher, "Roads and Traffic Economic Aspects," *Traffic Engineering and Control,* July, 1960. A proclamation in London in 1635, quoted by R. M. C. Anderson in *Roads of England.*

[2]Wilbur Smith and Associates, *A Major Street and Highway Plan, Phoenix Urban Area, Maricopa County, Arizona, 1960.*

[3]Gardner, Evan H., *Urban Expressway Earnings — A Study of Portions of the Schuylkill Expressway — Part I,* Pennsylvania Department of Highways, Harrisburg, Pa., 1960.

[4]Moyer, Ralph, "User Benefits in California," *Journal of the Highway Division,* Proceedings Paper 875, American Society of Civil Engineers, 1958.

[5]Automotive Safety Foundation, *What Freeways Mean to Your City,* Washington, D. C., April, 1957.

BASIC FACTORS IN HIGHWAY OPERATION

The Interstate highway system will reduce those vehicle operating costs that are susceptible to change through highway improvements. It will directly affect the costs of fuel, oil, tires, and maintenance; it will also affect insurance charges by reducing the number of accidents. Registration levies, garage fees, and depreciation will be generally unaffected by highway conditions.

Cost of Operating a Car – To the American family, the automobile is a sizeable and important capital investment. As shown in Table 59, the cost of owning and operating a car approximates 10 cents per vehicle mile, or almost six cents per passenger mile, at an occupancy of 1.7 persons per car.[6]

[6]Cope, E. M., and Liston, L. L., *A Discussion of Gasoline Tax Rates and Gasoline Consumption,* U. S. Department of Commerce, Bureau of Public Roads, January, 1961.

TABLE 59

ESTIMATED COST OF OPERATING A MOTOR VEHICLE[1]

ITEM	*CENTS PER MILE*	*PER CENT OF TOTAL*
Costs Excluding Taxes		
Depreciation	2.54	26.0
Repairs, Maintenance	1.72	17.6
Replacement Tires and Tubes	.18	1.8
Accessories	.14	1.4
Gasoline (Except Tax)	1.45	14.9
Oil	.19	2.0
Insurance	1.29	13.2
Garaging, Parking, Tolls, etc.	1.08	11.1
Sub-Total	8.59	88.0
Taxes and Fees		
Gasoline	.70	7.2
Registration	.10	1.0
Titling and Property	.10	1.0
Oil	.01	0.1
Auto, Tires, Parts, etc.	.26	2.7
Sub-Total	1.17	12.0
TOTAL OPERATING COST	9.76	100.0

[1]Source: Cope, E. M., and Liston, L. L., *A Discussion of Gasoline Tax Rates and Gasoline Consumption.* U. S. Department of Commerce, Bureau of Public Roads, January, 1961. Estimated average costs for owning and operating a medium priced 4-door sedan, 10-year life, 100,000 miles, excluding interest.

These costs are usually subdivided into fixed costs, and variable costs. Fixed costs are related to vehicle ownership and are not materially affected by the use of the vehicle. They include depreciation, licenses, insurance, and some maintenance. Variable costs are related to the amount and type of vehicle use and include fuel, oil, tires, and most maintenance. Exclusive of depreciation, garaging, insurance, and license fees, (but including fuel taxes) the variable costs approximate 5.3 cents per vehicle mile or slightly over three cents per person-mile.

Studies of Operating Costs — Operating costs will vary according to roadway type, design, and location. They will be influenced by size, weight and operating characteristics of vehicles; frequency, length, amount, and distribution of grades; amount of curvature; speed as influenced by roadway location; design conditions, terrain, and traffic volumes; pavement surfaces; and length, time, and frequency of stops.[7]

Interstate highways will be designed to high standards and will thereby have lower operating costs. They eliminate stop-and-go driving; their grades are slight; they are well surfaced.

Bureau of Public Roads Studies — Studies of passenger car operation over rural freeways or turnpikes and major parallel alternate routes were conducted by the Bureau of Public Roads during 1951-1952. The studies showed that the freeways afford substantial time savings over parallel routes.[8] Fuel consumption was found to be generally higher on freeways than on parallel routes, except where the major highway was congested or had a greater rate of rise and fall. However, at comparable speeds, fuel consumption on freeways was less than that on parallel major highways.[9]

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[7]For example, the American Association of State Highway Officials in its *Road User Benefits Analyses for Highway Improvements,* Revised, 1959, showed an average differential of about two miles per gallon in fuel consumption between typical gravel roads and concrete roads in good condition; assumed a time-differential of three miles per hour between gravel surfaces and unpaved roads; and has indicated costs ranging from two cents to six cents per stop depending on time stopped and amount of slowdown. Oregon has found an average cost of about three cents per stop.

[8]Saal, Carl C., "Operating Characteristics of a Passenger Car on Selected Routes," *Public Roads,* Vol. 28, No. 9, U. S. Department of Commerce, Bureau of Public Roads, August, 1955.

Studies were made on the New Jersey Turnpike, the middle section of the Pennsylvania Turnpike, the Maine Turnpike, the western section of the Pennsylvania Turnpike, and the Shirley Memorial Highway in Virginia, all rural freeways constructed to approximately the same design standards with full access control, grade separations, and maximum grades of three per cent. The alternate routes were the commonly traveled roadways between the two termini — usually two and four-lane roads with varying widths, surface types, curvatures and gradients, and passing through local towns and communities.

[9]Fuel consumption was found to increase as speeds get higher; from 22.5 miles per gallon at 20 miles per hour to about 15 miles per gallon at 60 miles per hour.

The savings in travel time more than offset the cost of additional fuel consumption. Travel times on the rural freeways ranged between 43 and 73 per cent of the time required on the alternate routes, whereas fuel consumption on freeways varied from 96 to 108 per cent of that on arterial routes.

Turnpike Studies — Studies of motor vehicle operations on the Northern Indiana Toll Road and the New York Thruway, summarized in Table 60, show that trans-state turnpike travel saves time for all vehicles, as well as fuel for commercial vehicles.[10] Time savings over both toll-road routes approximated 0.4 minutes per mile of travel.

May Study — This study of vehicle operations on limited access highways, conducted in 1955, showed no substantial changes in speeds or fuel consumption on rural Interstate highways as compared with rural routes without control of access. Speeds on rural highways were found to average 47.4 miles per hour with full access control, and 44.9 miles per hour with no access control.[11] Speeds in urban areas were found to be 47.3 miles per hour where access is controlled, and 26.4 miles per hour where there is no access control.

The average time savings in minutes per vehicle mile on controlled access routes were found to be 0.07 rural, 0.32 suburban, and 1.00 urban, corresponding to average monetary savings of 0.2, 0.9, and 2.8 cents per vehicle mile, respectively.

Time Savings — Freeways provide substantial time savings. Measured by time, urban freeways can reduce distance by half by separating cross traffic through high-type designs, reducing volumes on surface streets, and providing direct trip linkages[12] to areas previously not tapped.

Illustrative Time Savings — In San Antonio, for example, freeway travel averages 39.7 miles per hour compared with 13.4 mile-per-hour speeds on parallel streets; in Boston, a three-mile trip on the Central Traffic Artery saves over 20 minutes; in Chicago, the Congress Expressway saves its users from five to twenty minutes on Loop-oriented trips; in Seattle, the Alaskan Way saves motorists about eight minutes per trip; and in Houston, the Gulf Freeway has saved over three million vehicle hours annually.[13]

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[10]Northern Indiana Toll Road Schedule; and Lee, Anita, "Turnpikes Made for Trucks," *Motor Truck News*, September, 1958.

[11]May, A. D., Jr., "Economics of Operation on Limited — Access Highways," *Vehicle Operation as Affected by Traffic Control and Highway Type*, Highway Research Board, Bulletin 107 (1955), p. 55.

[12]For example, the recently completed Northwest Expressway in Chicago traverses a gridiron street network diagonally, reducing both time and distance between areas served and the central business distict.

[13]Information compiled from *What Freeways Mean to Your City*, Automotive Safety Foundation, Washington, D. C.

Table 60

SAVINGS REPORTED FROM TURNPIKE TRAVEL[1]

	INDIANA, OHIO, PENNSYLVANIA AND NEW JERSEY TURNPIKES BETWEEN CHICAGO AND NEW YORK (Round Trip — 1674 Miles)		*NEW YORK THRUWAY BETWEEN ALBANY AND MASPETH, NEW YORK (One-way 329 Miles)*
	SAVINGS		
TYPE SAVINGS	*Passenger Cars*	*Trucks*	*Trucks*
Driving Time Saved	10 Hours - 34 Minutes	11 Hours - 17 Minutes	2 Hours - 15 Minutes
Speed Differential – Miles Per Hour	14.66 MPH (Faster)	8.2 MPH (Faster)	9.5 MPH (Faster)
Gasoline Consumption – Gallons (Saved)	——[2]	30.5 Gallons	9.9 Gallons
Gear Shifts Eliminated	834	2339	407
Brake Applications Eliminated	736	696	192
Traffic Stops Eliminated	241	185	92
Fuel Savings Per Vehicle Mile	——[2]	.017 Gallons	.030 Gallons
Time Savings Per Vehicle Mile	0.36 Minutes	0.38 Minutes	0.41 Minutes

[1]Source: Toll Schedule Indiana Toll Road; Lee, Anita, *Turnpikes Made for Trucks,* Motor Truck News, September, 1958.
[2]Not cited.

Table 61

SUMMARY OF TRAVEL TIMES IN NASHVILLE

1959[1]

ROAD SYSTEM	*WITHOUT INTERSTATE SYSTEM*			*WITH INTERSTATE SYSTEM*		
	Vehicle-Hours	*Vehicle-Miles*	*Per Cent of Total*	*Vehicle-Hours*	*Vehicle-Miles*	*Per Cent of Total*
Local	17,859	167,344	6.5	17,813	168,050	6.3
Arterial	84,282	2,421,811	93.5	55,923	1,639,830	62.2
Freeways	—	—	—	17,996	830,708	31.5
TOTAL	102,141	2,589,155	100.0	91,732	2,638,588	100.0
Index	1.00	1.00		0.90	1.02	

[1]Source: Origin-destination studies now underway. Intrazone trips are not indicated in the tabulation.

In Connecticut, speeds on the Merritt Parkway average about 50 miles per hour compared to an average of less than 30 miles per hour on the Boston Post Road; the 75-mile trip from New York City to New Haven saves about one hour and 20 minutes via the Connecticut and New York Parkways.[14]

Nashville – A summary of 1959 travel in Nashville, shown in Table 61, clearly indicates the time savings resulting from freeway operation.[15] Present travel on existing streets consumes a daily total of 102,141 vehicle-hours, at an average speed of about 25 m.p.h. and an average trip duration of about 9.5 minutes. An over-all reduction of about 10 per cent in total vehicle hours of travel would result from constructing the proposed 56-mile freeway system, despite a two-per-cent increase in total vehicle miles of travel. The over-all average speed would increase about 14 per cent (to almost 29 m.p.h. from the present 25 m.p.h.) and the average freeway user would save about four minutes per trip.

[14]Halsey, Maxwell, Editor, *A Study of the Economics of Automotive Transportation,* Bureau for Street Traffic Research, Yale University, Unpublished, 1949.

[15]In 1959, the 225-square-mile Nashville urbanized area had a population of 357,000, and 648,000 daily vehicular trips were reported within the study area of which about 151,000 (23 per cent) were assignable to freeways. Interzone trips totaled 540,000 and aggregated 2,589,155 vehicle miles daily – nearly five miles per trip. The proposed freeways would carry almost one third of the urban area's 1959 traffic and would reduce arterial street volumes accordingly whereas travel on local streets would remain relatively constant.

Values of Time Saved — It is generally recognized that time savings for commercial vehicles have a tangible monetary value. Similarly, passenger cars used for commercial purposes should have a monetary value assigned to their time saved, and evidence is also increasing for the placement of a monetary value on the time saved by all passenger cars.

Several indications support placing a monetary value on passenger car time saved; in all study cities a large proportion, usually about 50 per cent, of passenger car trips are for work or business.[15]

Time savings are used as a basis for assigning traffic to freeways; usually, the time difference between alternate routes represents a reliable assignment factor; more than one half of all freeway trips in the study cities showed a savings in time over trips via the alternate route.

Motorists are often willing to pay a toll to travel on turnpikes where the principal benefit is time saved: studies by the Bureau of Public Roads have shown that 80 per cent of the trips by passenger cars on the Maine and Pennsylvania Turnpikes accrue a time advantage.[16] Similar experiences are found along the Connecticut Turnpike which more than halves the driving time along the parallel route, U. S. 1.

Generally accepted time-cost values of $3.00 per hour for commercial vehicles and $1.35 per hour for passenger cars have been used in this study.

Accidents — The aggregate cost of highway accidents is determined by the number of accidents, the average accident severity, and the unit monetary value of the losses. The first two factors may be modified by changes in road conditions, whereas the third depends on the general level of the economy.

In a single year, more than 17.5 million U. S. drivers are involved in about 10 million motor vehicle accidents. In 1959, there were 37,800 deaths and 1.4 million injuries disabling beyond a day.

Since 1950, the total number of accidents has increased about 23 per cent from 8.3 to 10.2 million; and the number of fatal accidents has increased six per cent, from 32,300 to about 34,450. The fatality rate per hundred million motor vehicle miles has declined continually from 15.6 in 1933 to 5.4 in 1959, largely as a result of improved driver education, better roads, and increasing proportions of freeway travel in urban areas.

Accident Costs — The costs of motor vehicle accidents in the United States, have steadily increased from about $3.1 billion annually in 1950 to $6.2 billion

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[16]O'Flaherty, Daniel, "Pennsylvania Turnpike Analysis," *Public Roads,* Vol. 28, No. 10, U. S. Department of Commerce, Bureau of Public Roads, Oct., 1955, pp. 203-223.

in 1959, totaling over $45 billion in the 10-year period.[17] The increases reflect the inflationary trend experienced since the end of World War II and the 20 per cent increase of the total number of accidents since 1950.

Between 1950 and 1959, travel aggregated 5,800 billion vehicle miles. The average accident cost per vehicle mile amounted to 0.78 cents, increasing from 0.68 cents in 1950 to 0.89 cents in 1959.

Trends in accident costs per vehicle mile of travel have been projected to 1980 in Figure 115. The 1960 cost is estimated at 0.90 cents per vehicle mile; it is expected to increase to approximately 1.20 cents per vehicle mile by 1970, and 1.30 cents per vehicle mile by 1980.

Accident Cost Savings – Freeways have constantly been found to be safer than routes of lower design standards. For example, the average 1959 fatality rate on toll roads was 2.8 deaths per hundred million vehicle miles compared with 5.4 for all the nation's roads and streets. Thus, toll roads represent a saving of about 2.6 fatalities per hundred million vehicle miles of travel. They serve about 120 hundred million miles of travel annually, thereby saving over 300 lives each year.

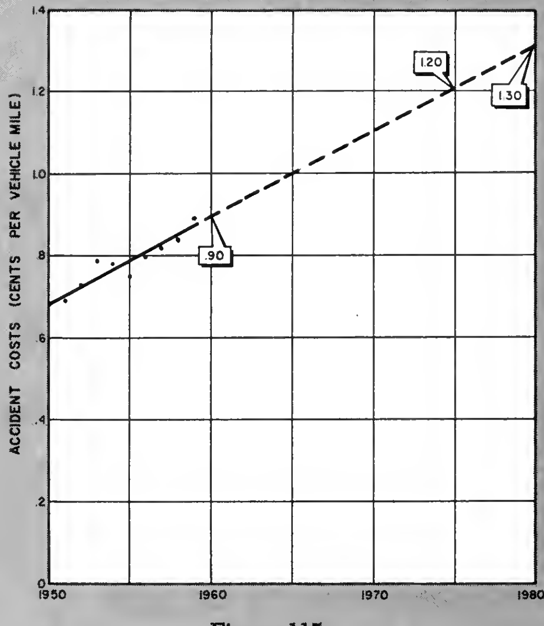

Figure 115
TRENDS IN ACCIDENT COSTS PER VEHICLE MILE

Comprehensive studies of accident frequency and fatality rates were conducted by the Bureau of Public Roads in 30 different states and involving about 27 billion vehicle miles of travel on 2,590 miles of highway.[18] Results of these studies, depicted in Figure 116, clearly show that control of access substantially reduces accidents and fatalities. Urban freeways are twice as safe as city streets in terms of fatalities, and about three times in terms of total accidents.

17National Safety Council, *Accident Facts*, yearly editions. Data report trends for United States. Accident costs include property damage caused by motor vehicle accidents, medical and hospital expenses, wages lost because of temporary disability, the present value of future wages lost because of permanent disability or death, and overhead cost of insurance. These are detailed in Table A-40, Appendix C.

18House Document No. 93, *The Federal Role in Highway Safety*, 86th Congress, 1st Session.

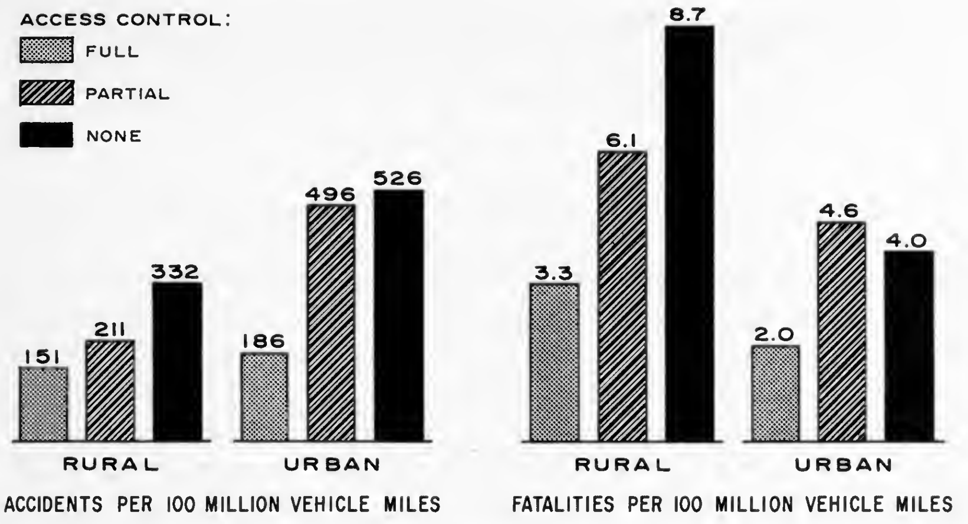

Figure 116
EFFECT OF ACCESS CONTROL ON ACCIDENTS AND FATALITIES

Urban roadways with full control of access have a fatality rate of two per hundred million vehicle miles compared with a fatality rate of four per hundred million vehicle miles where access is not controlled; rural limited-access facilities have a fatality rate of 3.3 per hundred million vehicle miles; with no control of access, the corresponding value is 8.7. Thus, as shown in Table 62, urban freeways save about two lives per hundred million vehicle miles, whereas rural freeways save over five lives per hundred million vehicle miles.

TABLE 62

FREEWAY FATALITY SAVINGS[1]

TYPE AREA	*FATALITIES PER HUNDRED MILLION VEHICLE MILES* — *No Access Control*	*FATALITIES PER HUNDRED MILLION VEHICLE MILES* — *Full Access Control*	*SAVINGS FROM FULL ACCESS CONTROL*
Urban	4.0	2.0	2.0
Rural	8.7	3.3	5.4

[1]Source: House Document No. 93, *The Federal Role in Highway Safety*, 86th Congress, 1st Session.

Comparative studies of freeway accidents during 1959 on the Congress, Calumet, and Edens Expressways in Cook County, Illinois, show an average fatality rate of 1.6 per hundred million vehicle miles, compared with the national average of 2.0 for all urban freeways.[19]

Comprehensive studies of accidents on arterials and expressways in the Chicago area found that 100,000 vehicles traveling on a mile of expressway daily will have 290 fewer property damage accidents per year and 98 fewer personal injury accidents than vehicles traveling the same distance on arterial streets.[20] Direct accident costs per year (1958) for travel on a mile of expressway with traffic volumes of 100,000 vehicles per day were found to be about $160,000 lower than costs for the same travel on an arterial system – a direct cost saving of 0.49 cents per vehicle mile. Accident rates appeared to increase with traffic volumes; they tended to be high near the central part of the city, and tended to decrease toward the city limits, perhaps reflecting the effects of traffic saturation near downtown.

In Massachusetts, extensive studies have developed detailed analyses of accident involvement, severity, and costs, as related to location, driver, and roadway type.[21] The average direct cost of all accidents was found to be 0.43 cents per vehicle mile with urban accidents costing 0.76 cents, and rural accidents 0.11 cents. Eighty-seven per cent of the direct costs resulted from accidents occurring in urban areas.

The relation between accident costs, traffic volumes and types of road, as found in Massachusetts studies are depicted in Figure 117. Mile for mile, controlled access highways accommodated the same volume of traffic as conventional arterials with a far lower accident cost. The yearly accident cost per mile of freeways varied linearly with traffic volumes, whereas the cost of accidents per mile of uncontrolled highways tended to increase more rapidly as volumes increase. The study showed a yearly saving in accident costs on the controlled-access roads of $18,000 per mile at a volume of 10,000 vehicles per

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[19]"Cook County Report on Expressway Accident Pattern," *Street Engineering*, September, 1960. See Table A-41, Appendix C.

[20]Hoch, Irving, *Accident Experience – Expressways vs. Arterials*, Chicago Area Transportation Study, 1959.

[21]Dunman, Robie, "The Economic Cost of Traffic Accidents in Relation to the Human Element," and Twombly, Bernard, B., "The Economic Cost of Traffic Accidents in Relation to the Highway System," in *Public Roads*, June, 1960, Volume 31, Number 2, U. S. Department of Commerce, Bureau of Public Roads, based on studies conducted in 1955 and 1958 by the Massachusetts Department of Public Works and the Massachusetts Registry of Motor Vehicles.

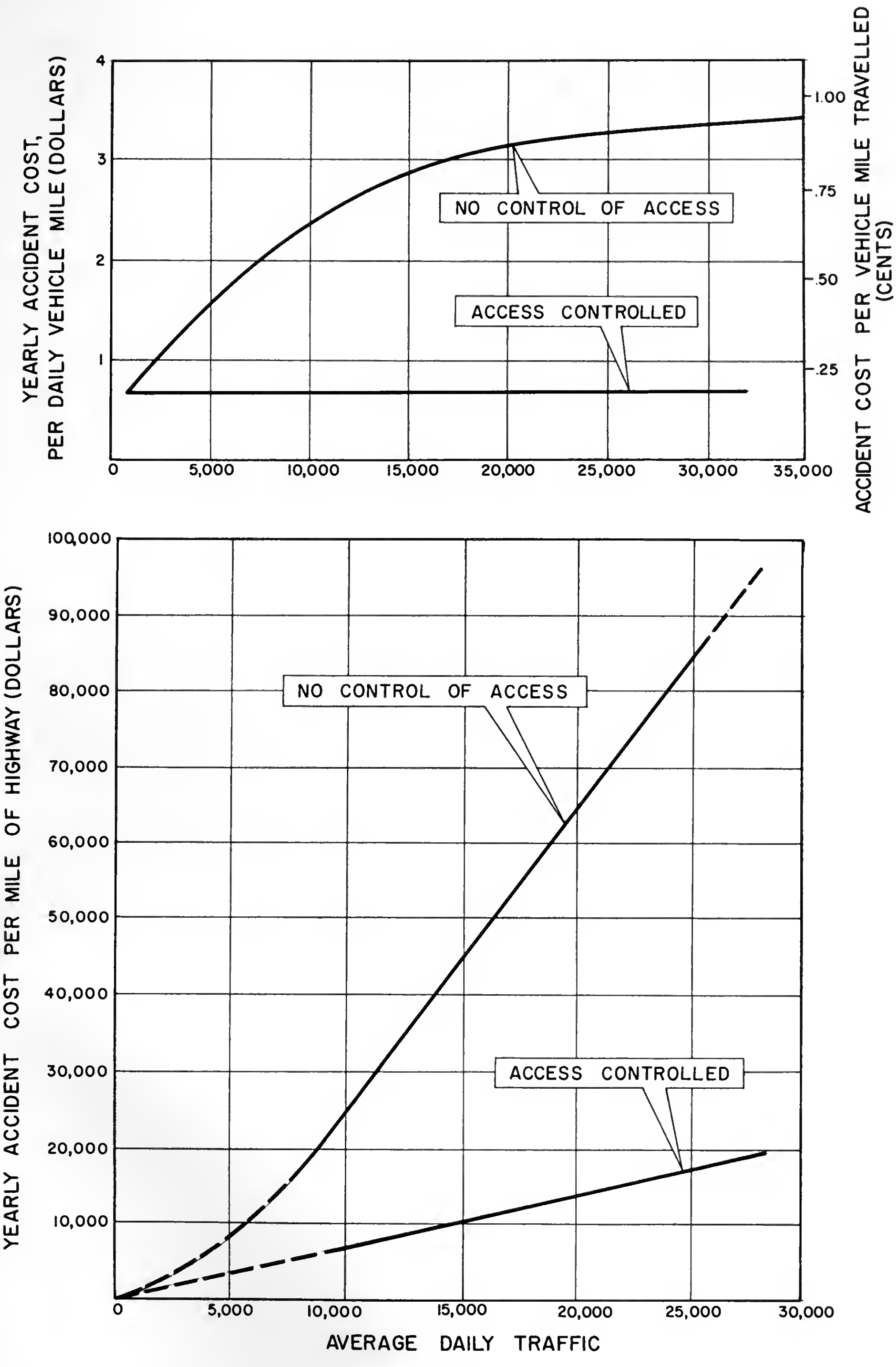

Figure 117
ACCIDENT COSTS RELATED TO
CONTROL OF ACCESS IN MASSACHUSETTS

day, and $68,000 at 25,000 per day. Annual savings in accident costs resulting from control of access and other features of freeway design ranged from 70 to 80 per cent. When volumes were over 15,000 cars per day, freeway accident savings amounted to 80 per cent of the accident costs.

Experiences in California corroborate the Massachusetts findings. California freeways were found to have about one fifth the accident rate and costs, as experienced on city streets.[22] They tend, therefore, to corroborate the experiences found in Massachusetts.

Suggested Accident Savings – Based on the preceding analyses, it has been assumed that accident costs on freeways will be about 20 per cent of those on city streets and rural highways – a saving of 80 per cent. At 1960 levels, the accident cost savings should, therefore, approximate 0.72 cents per vehicle mile; by 1975, these savings should be over 1.0 cent per vehicle mile.

FREEWAY COST SAVINGS

The savings in operating costs, accidents, and travel time resulting from freeway use have been summarized in Tables 63 and 64 for some of the more recent studies. It may be seen that the benefits on urban freeways resulting from improved operating and accident costs range from 1.13 to 2.50 cents per vehicle mile; when time is included for passenger and commercial vehicles, the savings approximate four cents per vehicle mile. Savings on rural freeways result mainly from time benefits and amount to almost one cent per vehicle mile.

Variables in Previous Studies – A 1951 study by Moyer estimated that freeways in California would save about four cents per mile,[23] 1.25 cents saved in fuel consumption, tire and brake wear; 1.25 cents per vehicle mile saved on accidents, and 1.50 cents saved per vehicle mile in time for commercial vehicles and all passenger car drivers paid to drive during working hours.[24]

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[22]Moyer, Ralph A., *Effect of Freeways and Expressways on Transportation Costs,* 1951, University of California; Winter, Hugo H., "Experiences in Los Angeles," Proceedings Paper 874, *Journal of the Highway Division,* American Society of Civil Engineers, 1958; Moyer, Ralph A., "User Benefits in California," Proceedings Paper 875, *Journal of the Highway Division,* American Society of Civil Engineers, 1958.

[23]Moyer, Ralph A., *Effect of Freeways and Expressways on Transportation Costs, 1951,* University of California.

[24]The accident cost saving was based on the finding that arteries in California have about double the 0.75 cent accident cost for all travel in the area, with freeways having about one fifth the accident rate experienced on city streets. Time costs, assuming 40-mile-per-hour travel on freeways, and 20 miles per hour on streets, were found to be 2.5 cents on all facilities, three cents per vehicle mile on city streets, and 1.5 cents per vehicle mile on freeways.

TABLE 63

FREEWAY COST SAVINGS IN URBAN AREAS[1]

ITEM	Moyer 1951	Detroit 1953	Los Angeles 1953	Auto Club of Southern California 1954	Moyer 1955
	SAVINGS IN CENTS PER VEHICLE MILE — STUDY				
Operating Costs	1.25	0.71	0.57[2]	0.53	0.88[3]
Accident Costs	1.25	0.76	0.56	—[4]	0.60
Sub-Total	2.50	1.47	1.13	0.53	1.48
Time Savings for Commercial and Passenger Vehicles[5]	1.50	2.25	3.03	3.66[6]	2.68[7]
TOTAL	4.00	3.72	4.16	4.19	4.16

[1]Sources: Compiled from Moyer, Ralph A., "Effect of Freeways and Expressways on Transportation Costs," 1951, University of California; Winter, Hugo H., "Experiences in Los Angeles," Proceedings Paper 874, *Journal of the Highway Division*, American Society of Civil Engineers, 1958; Moyer, Ralph A., "User Benefits in California," Proceedings Paper 875, *Journal of the Highway Division,* American Society of Civil Engineers, 1958. Engineering Department, Automobile Club of Southern California, *An Appraisal of Freeways versus Surface Streets in the Los Angeles Metropolitan Area,* August, 1954.

[2]Does not include commercial vehicle operating losses, per se.

[3]0.52¢/vehicle mile for passenger cars and 3.54¢/vehicle mile for trucks and buses.

[4]Not itemized.

[5]Time savings for commercial and passenger vehicles have been prorated to all traffic and then totaled.

[6]All vehicles at $1.20 per hour.

[7]12 per cent trucks at $3.00/hour, 3.18¢/vehicle mile; and 88 per cent cars at $1.35/hour, 2.61¢/vehicle mile.

A 1953 study of freeway benefits in the Los Angeles area shows freeways move three times as much traffic in one half the time with approximately one fifth the risk of an accident, and that the average freeway savings totaled 4.16 cents per mile, including 1.13 cents per vehicle mile savings in fuel, maintenance and accidents; 0.87 cents per vehicle mile time savings in commercial vehicles prorated to all traffic and 2.16 cents per vehicle mile for passenger car driver-time savings.[25]

[25]Winter, Hugo, "Experiences in Los Angeles," Proceedings Paper 874, *Journal of the Highway Division,* American Society of Civil Engineers, 1958.

TABLE 64

FREEWAY COST SAVINGS IN RURAL AREAS[1]

ITEM	CENTS PER VEHICLE MILE: Moyer 1955	Moyer Prorated to 20 Per Cent Trucks	May 1955
Operating Costs	– 0.66[2]	– 0.60[3]	No Change in Fuel Consumption
Accident Costs	0.60	0.60	
Sub-Total	– 0.06	0.00	
Time Savings for Commercial and Passenger Vehicles[4]	0.89	0.98	
TOTAL	0.83	0.98	

Sources: Moyer, Ralph A., "User Benefits in California," Proceedings Paper 875, *Journal of the Highway Division*, American Society of Civil Engineers, 1958; and May, A. D., Jr., "Economics of Operation on Limited-Access Highways," *Vehicle Operation as Affected by Traffic Control and Highway Type*, Highway Research Board, Bulletin 107 (1955), p. 55.

[1] 0.75¢ for passenger cars prorated to all traffic and 1.90¢ for commercial vehicles prorated to all traffic.

[2] 0.75¢ for passenger cars prorated to all traffic.

[3] 20 per cent commercial vehicles.

[4] Time savings for commercial and passenger vehicles have been prorated to all traffic and then totaled.

A more recent study in Los Angeles found an over-all saving of 4.16 cents per vehicle mile for all traffic using freeways: passenger cars, with time value saved 3.73 cents per vehicle mile; passenger cars without time value, 1.12 cents; trucks, 9.93 cents; and pickups, 4.66 cents.[26]

Test runs conducted by the Automobile Club of Southern California in 1954 showed savings of 0.531 cents per mile on gas and operating costs, and 3.663 cents per mile on time costs (at two cents per minute).[27]

[26] Aldrich, Lloyd, *A Study of Freeway System Benefits,* Report to the Los Angeles Board of Public Works, Los Angeles, California, September, 1954.

[27] Engineering Department, Automobile Club of Southern California, *An Appraisal of Freeways versus Surface Streets in the Los Angeles Metropolitan Area,* August, 1954. See Table A-42, Appendix C.

A study by Ralph Moyer in 1955, in which operating and time cost savings were calculated for both passenger and commercial vehicles, showed over-all savings of 4.16 cents per vehicle mile on urban freeways and 0.83 cents per mile on rural freeways, assuming 12 per cent commercial vehicles in traffic.[28] Urban vehicle operating and accident costs totaled 1.48 cents per vehicle mile, whereas no savings were reported in operating and accident costs on rural freeways.

Recommended Unit Cost Values – Anticipated unit road user cost savings that will accrue from use of Interstate highways and other freeways are graphically summarized in Figure 118. These unit savings, detailed in Tables 65 and 66 for urban and rural areas, respectively, are consistent with values currently in use. Cost values are indicated for both 1960 and 1975-1980 conditions.[29]

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[28]Moyer, Ralph A., "User Benefits in California," Proceedings Paper 875, *Journal of the Highway Division,* American Society of Civil Engineers, 1958. Urban vehicle operating cost savings were found to be 0.52 cents per vehicle mile for passenger cars; 3.54 cents for trucks and buses; and 0.88 cents for all vehicles. Accident cost savings of 0.6 cents per mile were based on the saving experienced on Los Angeles freeways and were 80 per cent of the total accident costs per vehicle mile found for all traffic in the Los Angeles area.

[29]In subsequent calculations of accumulative benefits for the 20-year period, interpolations were made between these years.

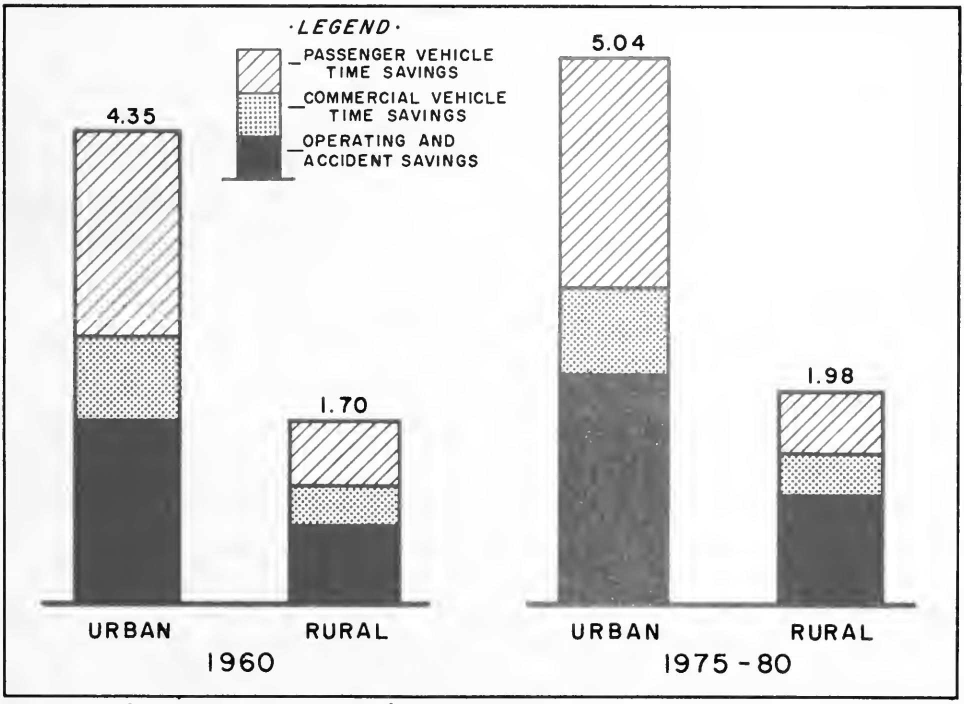

Figure 118
FREEWAY COST SAVINGS
(CENTS PER VEHICLE MILE)

Table 65

RECOMMENDED FREEWAY COST SAVINGS IN URBAN AREAS[1]

ITEM	*CENTS PER VEHICLE MILE*[2]	
	1960	*1975-1980*
Operating Costs	0.97	1.12[3]
Accident Costs	0.72[4]	1.00[5]
Sub-Total	1.69	2.12
Time Savings for Commercial and Passenger Vehicles[6]	2.66[7]	2.92[8]
TOTAL	4.35	5.04

[1]Source: Estimated from analyses of various cost studies.
[2]Assumes 15 per cent commercial vehicles.
[3]Adjusted to reflect 15 per cent increase in operating costs 1960 to 1975.
[4]0.8 of assumed 1960 accident cost of 0.90 cents per vehicle mile.
[5]Average savings 1975-1980.
[6]Time savings for commercial and passenger vehicles have been prorated to all traffic and then totaled.
[7]Assumes all vehicles save 1.0 minute per mile.
[8]Assumes all vehicles save 1.0 minute per mile.

Table 66

RECOMMENDED FREEWAY COST SAVINGS IN RURAL AREAS[1]

ITEM	*CENTS PER VEHICLE MILE*[2]	
	1960	*1975-1980*
Operating Costs	0.00	0.00
Accident Costs	0.72	1.00
Sub-Total	0.72	1.00
Time Savings for Commercial and Passenger Vehicles[3]	0.98[4]	0.98[4]
TOTAL	1.70	1.98

[1]Source: Estimated from analyses of various cost studies.
[2]Assumes 20 per cent commercial vehicles in rural traffic.
[3]Time savings for commercial and passenger vehicles have been prorated to all traffic and then totaled.
[4]Assumes all vehicles save 0.33 minutes per mile.

Time Savings – Freeway time savings will total 1.0 minute per mile in urban areas in 1960, and should increase to 1.1 minutes per mile by 1975-80. Freeway time savings in rural areas will average 0.33 minutes per mile.

Lives Saved – Freeways are expected to save two lives per hundred million vehicle miles in urban areas and 5.4 lives per hundred million vehicle miles in rural areas.

Cost Savings - 1960 – Direct savings to road users in fuel, maintenance, and accident costs in 1960 will amount to about 1.70 cents per vehicle mile in urban areas and about 0.72 cents per vehicle mile in rural areas.

Estimated 1960 time savings will approximate 2.66 cents per urban vehicle mile and 0.98 cents per rural vehicle mile. (These values are based on expected savings of one minute per urban vehicle mile and about a third of a minute per rural vehicle mile.) Thus, the total 1960 cost savings amount to 4.35 cents per urban vehicle mile and 1.70 cents per rural vehicle mile.

Cost Savings - 1975-1980 – In anticipating 1975-1980 cost savings, accident costs were projected in accordance with the previously cited trends. Some allowances were also made for increases in fuel and maintenance costs. No changes were made in the unit-time costs; future benefits resulting from time saved may, therefore, be somewhat conservative.

Direct savings to road users in operating costs will, by 1980, amount to about 2.12 cents per vehicle mile in urban areas and 1.00 cents per vehicle mile in rural areas. Estimated 1980 time savings will approximate 2.92 cents per urban vehicle mile and 0.60 cents per rural vehicle mile. Total 1980 savings will, therefore, approximate 5 cents per vehicle mile in urban areas and 2 cents per vehicle mile in rural areas.

DIRECT BENEFITS OF INTERSTATE HIGHWAYS

Unit cost-savings that accrue on express highways have been related to the anticipated future travel on the Interstate system. Total benefits arising from savings in operating costs and time have been computed. The results of these calculations are presented in Tables 67 through 72.

Over-all System Savings – By 1980, the completed urban Interstate system will afford annual savings in operating and accident costs of about $4.0 billion; the rural Interstate highways should save about one billion dollars. Thus, the total savings resulting from the entire Interstate system will exceed $5 billion annually. These motoring cost savings would equal the total cost of the system in about eight years.

As shown in Table 67, by 1980 the annual time savings will amount to 3.4 billion hours on urban sections and over half a billion hours on rural sections of the completed Interstate system. If a monetary value were given to these time savings, they would aggregate over $6.5 billion annually by 1980.

By 1980, the total annual savings from all of these economies would approximate $12 billion for the entire Interstate system. These total yearly motorist benefits would be equal to almost a third of the system's entire cost.

It is anticipated that the Interstate system will save over 9,500 lives annually by 1980. This is more than one fourth of the total annual loss of 38,000 lives on highways in the nation today.

Savings if System Were Complete in 1960 – The savings that would result today if the entire Interstate system were in operation are shown in Table 68. If the complete urban Interstate system were in operation *today,* it would afford an annual savings in operating and accident costs of $1.6 billion, and time benefits totaling almost $2.5 billion. The rural sections of the Interstate system would afford savings of $0.6 billion in operating and accident costs, and $0.8 billion in time saved. The total savings would be approximately $5.6 billion: $2.2 billion in operating costs and $3.4 billion in time. Over 3,600 lives would be saved annually.

TABLE 67

ANTICIPATED BENEFITS IN 1980 OF COMPLETED INTERSTATE SYSTEM[1]

ITEM	*LOCATION*		*TOTAL*
	Urban	*Rural*	
Miles of Annual Travel on Interstate System (Billions)	188.0	107.5	295.5
Operating Cost Savings (Billions of Dollars)	$ 4.0	$ 1.1	$ 5.1
Time Cost Savings (Billions of Dollars)	$ 5.5	$ 1.1	$ 6.6
Total Savings (Billions of Dollars)	$ 9.5	$ 2.2	$11.7
Hours Saved (Billions)	3.4	0.6	4.0
Lives Saved	3,760	5,805	9,565

[1]Source: Calculated from 1980 travel detailed in Appendix A, with Interstate system completed.

Table 68

ESTIMATED BENEFITS IN 1960 IF INTERSTATE SYSTEM HAD BEEN COMPLETED[1]

ITEM	LOCATION Urban	Rural	TOTAL
Miles of Annual Travel on Interstate System (Billions)	92.2	87.2	179.4
Operating Cost Savings (Billions of Dollars)	$ 1.6	$ 0.6	$ 2.2
Time Cost Savings (Billions of Dollars)	$ 2.5	$ 0.9	$ 3.4
Total Savings (Billions of Dollars)	$ 4.1	$ 1.5	$ 5.6
Hours Saved (Billions)	1.5	0.5	2.0
Lives Saved	1,844	4,709	6,553

[1]Source: Calculated from 1960 travel detailed in Appendix A, with Interstate system completed.

Savings Potential to Incompleted Portions – Approximately one third of the Interstate system is currently in operation. The benefits that would accrue from travel on the *existing* Interstate highways in 1980, assuming *no* additional construction (shown in Table 69) would total $3.6 billion; operating benefits would total $1.6 billion and time benefits $2.0 billion.

The 1980 *net* benefits that would accrue from completing the *remainder* of the system (summarized in Table 70) would amount to over $3.5 billion in operating costs savings and $4.6 billion in time cost savings, totaling $8.1 billion. Almost 6,000 lives would be saved annually.[30]

Accumulative Savings Resulting from Interstate System – The *net* benefits resulting from normal and stretched-out construction of the Interstate system are compared in Tables 71 and 72.

On-Schedule Construction Net Benefits – Construction of the remaining Interstate highways according to present schedules would result in their completion by 1972. The accumulative net benefits in time and operating cost savings between 1961 and 1980 resulting from this program are graphically depicted in

[30]Table 70 represents the difference between Table 67 and 69.

Table 69

ANTICIPATED BENEFITS IN 1980 OF EXISTING INTERSTATE HIGHWAYS[1]

(No Additional Interstate Construction After 1960)

ITEM	LOCATION Urban	Rural	TOTAL
Miles of Annual Travel on Interstate System (Billions)	52.0	48.4	100.4
Operating Cost Savings (Billions of Dollars)	$ 1.1	$ 0.5	$ 1.6
Time Cost Savings (Billions of Dollars)	$ 1.5	$ 0.5	$ 2.0
Total Savings (Billions of Dollars)	$ 2.6	$ 1.0	$ 3.6
Hours Saved (Billions)	1.0	0.3	1.3
Lives Saved	1,040	2,614	3,654

[1]Source: Calculated from 1960 travel detailed in Appendix A, assuming no additional Interstate construction after 1960.

Table 70

ANTICIPATED NET BENEFITS IN 1980 RESULTING FROM COMPLETION OF REMAINDER OF INTERSTATE SYSTEM[1]

ITEM	LOCATION Urban	Rural	TOTAL
Miles of Annual Travel on Interstate System (Billions)	136.0	59.1	95.1
Operating Cost Savings (Billions of Dollars)	$ 2.9	$ 0.6	$ 3.5
Time Cost Savings (Billions of Dollars)	$ 4.0	$ 0.6	$ 4.6
Total Savings (Billions of Dollars)	$ 6.9	$ 1.2	$ 8.1
Hours Saved (Billions)	2.4	0.3	2.7
Lives Saved	2,720	3,191	5,911

[1]Source: Calculated by subtracting Table 69 from Table 67. The table shows *net* benefits that would result from *additional* 1980 travel over the sections of Interstate system not yet available.

Figure 119 on a year-by-year basis and are also summarized in Figure 120. Within this 20-year period, urban operating and accident savings would total $34.2 billion and rural operating savings, $7.9 billion. Thus, the total savings in fuel consumption, maintenance, and accidents would aggregate $42.1 billion. These net savings would more than pay for completion of all sections of the Interstate system not built as of 1960.

The accumulated monetary value of time savings by passenger and commercial vehicles would amount to $48.2 billion in urban areas and $8.2 billion in rural areas, totaling $56.4 billion.

Thus, completion of the Interstate system by 1972 according to schedule will save the nation's motorists almost $100 billion in fewer accidents, greater operating economy, and time saved in the next 20 years. Eighty-four per cent of the aggregate benefits will accrue on urban sections of the Interstate system.

In addition, approximately 75,000 lives would be saved – an average of almost 4,000 per year. The aggregate savings in human lives represent about twice the present annual fatality toll.

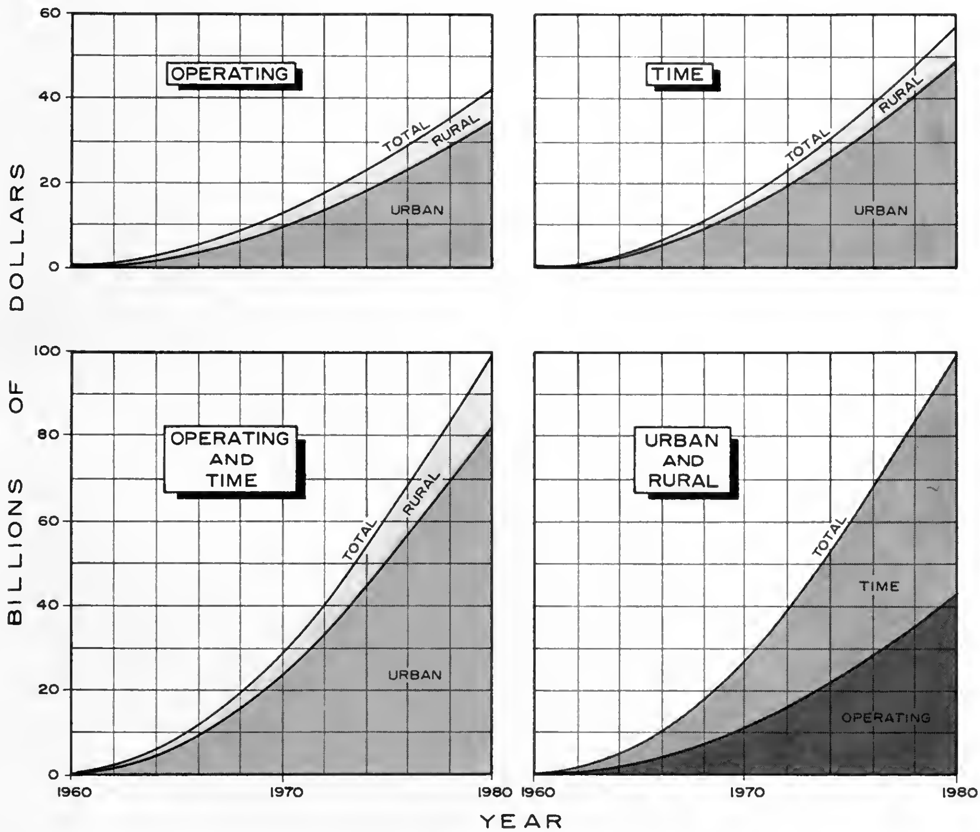

Figure 119
CUMULATIVE NET BENEFITS OF INTERSTATE HIGHWAY SYSTEM
1961 TO 1980
NORMAL CONSTRUCTION PROGRAM

TABLE 71

SUMMARY OF ACCUMULATED NET BENEFITS OF INTERSTATE HIGHWAY SYSTEM[1]

1961-1980

ASSUMED CONDITION	URBAN Billions of Dollars			RURAL Billions of Dollars			TOTAL Billions of Dollars		
	Operating Savings	*Time Savings*	*Total Savings*	*Operating Savings*	*Time Savings*	*Total Savings*	*Operating Savings*	*Time Savings*	*Total Savings*
1. All Needed Freeways Completed in 1960	$36.9	$52.5	$89.4	$10.1	$10.9	$21.0	$47.0	$63.4	$110.4
2. Only Interstate System Completed in 1960	39.8	56.7	96.5	9.8	10.6	20.4	49.6	67.3	116.9
3. On-Schedule Construction of Interstate System[2] (1972 Completion)	34.2	48.2	82.4	7.9	8.2	16.1	42.1	56.4	98.5
4. Interstate System Construction Stretched-Out to 1975[1]	31.3	44.1	75.4	6.7	6.8	13.5	38.0	50.9	88.9
5. Net Savings From On-Schedule Construction Compared With Stretch-Out (Col. 3 Minus Col. 4)	2.9	4.1	7.0	1.2	1.4	2.6	4.1	5.5	9.6

[1]Source: Calculations based on estimates of future travel, Appendix A.

[2]Assumes that *only* Interstate freeways would be completed by 1980; with *all* freeway needs complete by 1980, aggregate net savings on the Interstate System would be slightly lower.

Table 72

SUMMARY OF ACCUMULATED NET BENEFITS OF INTERSTATE HIGHWAY SYSTEM 1961 - 1980 — LIVES AND TIME SAVED[1]

ASSUMED CONDITION	Additional Net Vehicle Miles on System (Billions)			Net Hours Saved (Billions)			Net Lives Saved		
	Urban	*Rural*	*Total*	*Urban*	*Rural*	*Total*	*Urban*	*Rural*	*Total*
1. All Needed Freeways Completed in 1960	1,810.9	1,071.5	2,882.5	31.69	5.89	37.58	36,200	57,900	94,100
2. Only Interstate System Completed in 1960	1,954.0	1,038.7	2,992.7	34.20	5.71	39.91	39,100	56,100	95,200
3. On-Schedule Construction of Interstate System[2] (1972 Completion)	1,644.6	795.1	2,439.7	28.78	4.37	33.15	32,900	42,900	75,800
4. Interstate System Construction Stretched-out to 1975	1,496.8	658.5	2,155.3	26.19	3.62	29.81	29,900	35,600	65,500
5. Net Savings From On-Schedule Construction Compared With Stretch-out (Col. 3 Minus Col. 4)	14.78	13.66	28.44	2.59	0.75	3.34	3,000	7,300	10,300

[1]Source: Calculations based on estimates of future travel, Appendix A.

[2]Assumes that *only* Interstate freeways would be completed by 1980; with *all* freeway needs complete by 1980, aggregate net savings on Interstate System would be slightly lower.

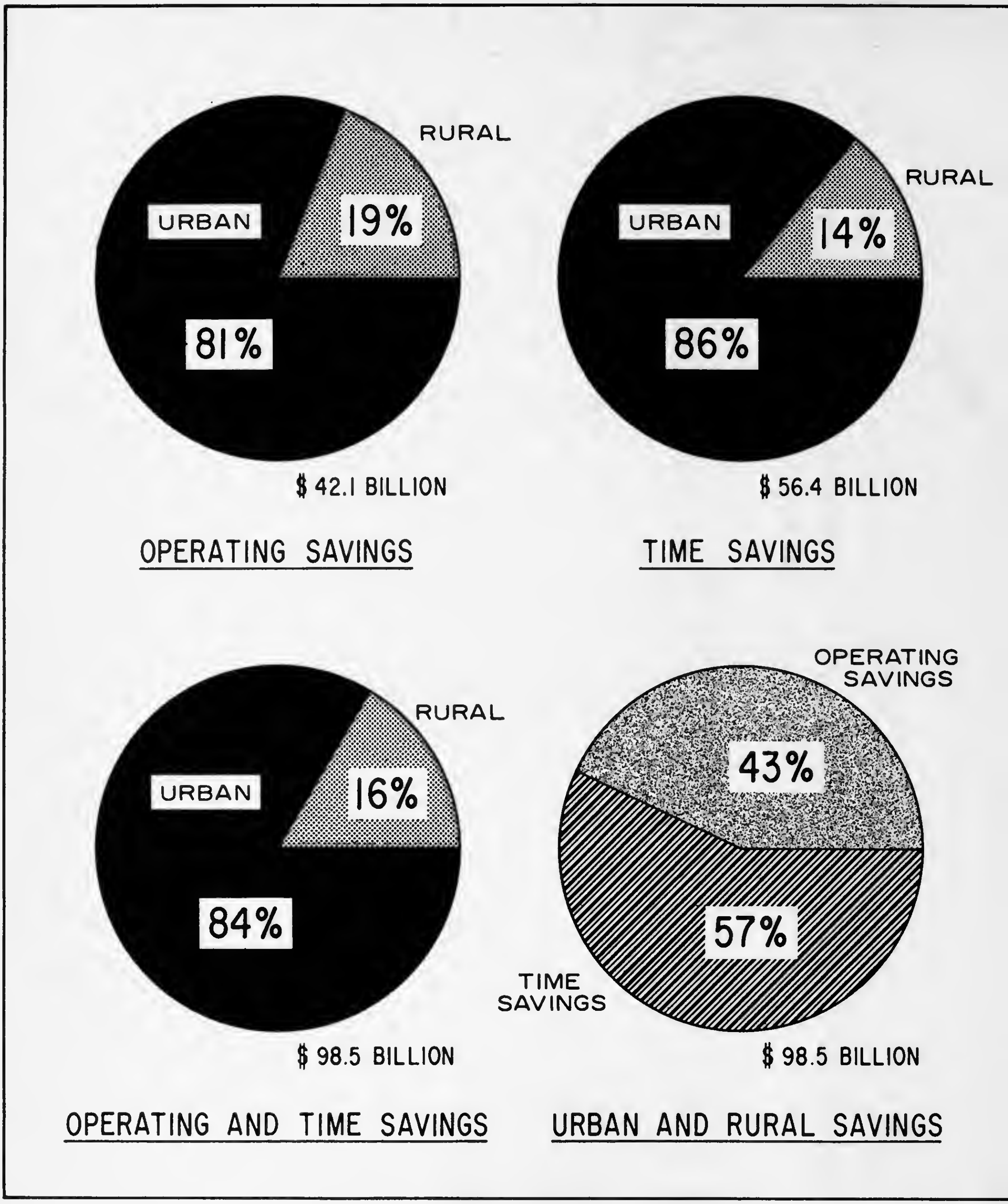

Figure 120
Summary of Cumulative Net Benefits of Interstate Highway System
1961 to 1980
Normal Construction Program

Effect of a Stretch-out – The aggregate benefits, with a three-year stretch-out from 1972 to 1975 in completion of Interstate highway construction, would be somewhat less. Accumulative 1961-1980 operating cost savings would likely amount to 31.3 billion dollars in urban areas and 6.7 billion dollars in rural areas, totaling about 38 billion dollars. The time savings would amount to approximately 44.1 billion dollars in urban areas and 6.8 billion in rural areas over the 20-year period. Total benefits would approximate 88.9 billion dollars. Approximately 65,000 lives would be saved.

Thus, there could be substantial motorist penalties from a three-year stretch-out in Interstate highway construction. Operating cost penalties resulting from this delay (i.e. gains accruing from on-schedule completion) would amount to approximately $4.1 billion between 1961 and completion of the system in 1975 ($2.9 billion urban and $1.2 billion rural). Time penalties would amount to approximately $4.1 billion urban and $1.4 billion rural.

The three-year stretch-out in completion of the Interstate system, from 1972 to 1975, would probably cost the nation's motorists approximately 10 billion dollars in motoring cost penalties. It is anticipated that 10,000 lives would be lost as a result of the three-year stretch-out.

Summary and Qualifications – These preceding analyses of road-user savings clearly indicate that the nation's motorists will enjoy substantial savings from Interstate highway construction. These savings, in the aggregate, will more than pay for the cost of construction of the system, especially in urban areas. They clearly show that the benefits accruing from urban Interstate highways will be so great that early completion of these segments is essential.

Each mile of urban Interstate highway will carry about five times the traffic with unit-cost benefits two and a half times as great as on rural Interstate highways. *On a per-mile basis, urban Interstate highways will on the average,* therefore, *provide 12 times the benefits that will be afforded by rural routes.* There can be no doubt that the urban routes will more than pay for themselves and are far more economical when measured in terms of their total utilization.

While the cost-saving analyses show in a generalized way the direct monetary benefits of Interstate highway construction, these benefits may be considered somewhat conservative, particularly on urban sections. Future advances in Interstate highway design (such as further elimination of roadside obstacles) may make freeways even safer than at present;[31] unreported accidents not re-

[31]Stonex, K. A. – *Scientific Design for Safer Motoring,* Presented at the Greenbrier Meeting, Detroit Section – Society of Automotive Engineers, September, 1960.

flected in accident cost values, will also be reduced; removal of traffic from key arterials will achieve a reduction in accidents greater than indicated, since accidents along arterials increase more than proportionately with increasing volumes. Without urban Interstate highways, arterial street congestion would usually intensify, thereby increasing operating and time costs; in addition, many sections of the Interstate system will afford savings in actual travel distances, and thereby multiply road-user benefits.

In the aggregate, these additional savings will tend to increase Interstate highway benefits beyond the reductions that may result from adverse travel distances and increased trip lengths.

GENERAL ROAD-USER BENEFITS

Interstate highways and other freeways also provide motorists with important intangible road-user benefits that further justify their construction. In addition to direct benefits to motorists in time saved, lower operating costs, and accident savings, freeways provide increased comfort and convenience; they often prove economical in terms of capacity gained.

Comfort and Convenience — Freeway travel is convenient, permitting continuous free-flow. While it is difficult to evaluate comfort and convenience in quantitative terms, they are important considerations. The convenience of fast, easy travel and the comfort of steady, conflict-free flow may relieve driver tension. These values are demonstrated by many motorists who drive greater distances, sometimes with little or no time saved, to gain the pleasures of relaxed freeway driving. The unprecedented use of many toll roads also indicates the values attached to comfort and convenience.

A freeway providing uninterrupted travel to a central business district renders a service to the motorist that may transcend values of direct operating cost savings. Downtown areas will benefit from the removal of non-productive through traffic from their streets, and from greater market potentials as measured by driving time.

Capacity Attained — Freeways provide greater capacity than can be attained by conventional street widenings and often minimize the need for disruptive street widenings. Freeways may cost less per unit of capacity gained. For example, widening of roads from two to four lanes in Phoenix cost up to $500 per unit of capacity gained, whereas freeways cost up to about $300 per unit of capacity gained. Cost-benefit ratios for heavily traveled freeways are often higher than for alternate arterial routes despite their greater construction costs.

CHAPTER 10

GENERAL BENEFITS of INTERSTATE HIGHWAYS

SUMMARY

MODERN highways have a far-reaching effect on the lives of everyone, whether or not an actual highway user. Directly and indirectly, they are beneficial to communities and individuals in making readily available materials and services essential to daily life. Unquestionably, they have effected revolutionary social and economic changes; they have a vital impact on contemporary living. Relative ease of travel has stimulated suburbanization and reoriented industrial and residential development, giving new freedom of movement to the worker, the shopper, the student.

The role of the Interstate system in the total highway plan is extremely important. As a basic avenue of communication traversing all sections of the country, it will contribute to the general welfare of the local community and the nation as a whole. It will stimulate commerce between principal centers of population and industry, facilitate the overland movement of military personnel and equipment, and encourage industrial expansion.

Within metropolitan areas, urban Interstate highways will improve mobility and increase job and residential opportunities. They will encourage orderly community development by delineating basic land uses and transportation patterns, and by facilitating the containment of specific land-use areas.

Interstate highways can sharply affect land use, land values, employment and commuting patterns, local government, taxes, schools and every other aspect of life within their zones of influence. They encourage and channel low-density development; they increase land values of remote areas by reducing driving times; they are catalysts to industrial location and expansion. Their shorter driving times make long-distance commuting attractive, thereby extending and reorienting the labor market. By making markets more accessible, they extend trading areas; by removing through traffic from shopping streets, they aid business sections of cities.

Higher property values resulting from new freeways increase tax returns to government, which, in effect, may reimburse taxpayers for original highway expenditures. For example, the gain in taxable property and retail business in the counties served by the Garden State Parkway is twice that of New Jersey's remaining 11 counties.

Interstate highways will bring the farmer closer to market, and will further extend the conveniences of urban life to the farm.

The economic and social advantages afforded by the Interstate system are also reflected in the public services rendered by all levels of government — federal, state, county and municipal. Public health, education, fire and police protection, public library and postal services are just a few of the many activities that benefit from good highways.

Interstate highways will increasingly broaden opportunities for cultural, religious and recreational activity. Increased mobility and accessibility will encourage and permit the extension of travel, reduce transportation costs, and thereby contribute to the national welfare.

THE economy and culture of a modern nation is heavily dependent upon the linkages provided through transportation and communication. National progress is geared to the effective movement of people and commodities between different parts of the country. Where communication is slow, difficult, and costly, development of the full economic potential of an area is delayed because it cannot meet competition of other areas. Reorientation of the economic structure of a nation follows each improvement in transportation that revises the internal competitive status of one region with another.

Modern highways are a basic component of the nation's communication system. Each year an increasing number of people and a growing flow of goods depend on highways for necessary day-to-day functions. The Interstate system of highways is the latest and most modern element in the national highway network.

This chapter summarizes some of the benefits provided by good roads to the national economy and welfare — it reiterates the significance of the Interstate system in stimulating commerce between principal centers of population and industry throughout the country, in encouraging the efficient location of industry, and in facilitating the overland mobility of military vehicles and personnel.

It shows how benefits will accrue to other than highway users through more intensive utilization of land, increases in property values, and more efficient governmental services.

The special research investigations have been augmented with a careful review of current studies of highway transportation benefits, and impacts; findings presented in Chapter VIII tend to verify those of other impact studies, although relatively little has been added to the many facts and responses already compiled. Accordingly, various impact studies have been reviewed briefly herein.[1]

LAND-USE BENEFITS

In Chapter VIII it was shown that the Wilbur Cross Highway in Connecticut and the Nimitz Freeway in California have stimulated residential and industrial development. Throughout the country experiences have been similar: freeways have encouraged land development, intensified land use, and strengthened communities' tax bases.

Freeways give a new mobility to labor, shoppers, and students, permitting them to travel twice as far, in the same travel time, as they could on conventional highways. Thus, they increase the economic range of attraction and distribution between industrial plants and their service areas. New land areas are placed into more productive uses. Merchants have realized that freeway bypasses have made local streets available for local shoppers; industry has learned that good highways make it possible to move large new plants into suburban and rural areas; workers have found that freeways enable them to get to jobs more quickly, easily, and safely.

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[1]U. S. Department of Commerce, *Third Progress Report of the Highway Cost Allocation Study,* House Document No. 91, 86th Congress, 1st session, 1959.

For example, in Los Angeles along the Santa Ana Freeway, in New Haven along the Connecticut Turnpike, and in St. Louis along the Daniel Boone Expressway, freeways have accelerated development.

Freeways Benefit Residential Development — Although freeways accelerate residential development, even more significant is the favorable attitude of nearby residents toward freeways.

The *Third Progress Report of the Highway Cost Allocation Study* has indicated that residents' satisfaction with their neighborhoods depends upon a number of factors, including social status, neighborhood amenities and highway accessibility; however, neighboring residents have generally regarded major highways as conveniences.[2] For example, in Westchester County, New York, two thirds of residents interviewed considered the highway a convenience; only one fifth found it a "nuisance."[3]

As distance of residence from the highway increases beyond the first 100-foot zone, approval of the road increases and disapproval declines; in one area approval of the road by residents increased from six per cent in the first 100-foot zones, to 83 per cent in the 300 to 400-foot zones, while disapprovals decreased from 23 to eight per cent. Most dissatisfaction of residents probably could be minimized or eliminated by effective integration of highways and subdivision designs.

Freeways Improve Land Values — Freeways favorably affect the value of land in their zones of influence. Land in suburban areas generally increases in value because it is usually more accessible and less expensive than alternate sites within the central city.

The findings of principal "impact" studies, summarized in Table 73, show that land use and land values are closely interrelated with the amount of influence depending on the type of land-use change resulting from freeway construction. A conversion from agriculture or vacant land to residential, commercial, or industrial uses — common along freeways — produces a high percentage increase in land values.

The area within the freeway's zone of influence, or "study area," increases far more rapidly in value than the "control" or adjoining area. Ratios of the percentage increases between the study and control areas were found to range from 0.7 to over 10; in most cases, the value of land adjacent to the freeways increased between 1.1 and 3.5 times as fast as land in other areas.

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[2]U. S. Department of Commerce, *Third Progress Report of the Highway Cost Allocation Study*, House Document No. 91, 86th Congress, 1st session, 1959.

[3]Westchester County Department of Planning, *Traffic Impact, A Study of the Effects of Selected Routes in Residential Living in Southern Westchester*, 1954.

Gulf Freeway – The changes that have taken place along the Gulf Freeway linking Houston and Galveston, Texas, clearly illustrate freeway impacts on land values. Construction on the 45-mile freeway began in 1946 and the road was progressively opened to traffic between 1948 and 1952.[4]

Studies conducted in 1951 and 1956 have shown that low-cost, run-down residential areas were replaced by more intensive uses, e.g., small businesses, light industries, and multi-unit apartments; restricted residential areas have remained stable.[5] Vacant land values have increased considerably, compared with similar properties in other parts of the city – many vacant tracts have been developed as industrial, commercial or residential sites. For example, in 1945-50, the value of land along the freeway increased 65 per cent more in dollar value than similar properties elsewhere in Houston served only by the standard street system.

Edsel Ford Freeway – Studies along the depressed Edsel Ford Freeway in Detroit also indicate that freeways have a beneficial effect on property.[6] Properties within 1,000 feet of the route – the extent of the freeway's influence – maintained or increased their value, while in the control area, values decreased.

The degree of freeway-induced change varied considerably between residential, commercial and industrial properties: Residential land-use changes were limited to movement of homes displaced by the freeway with losses up to 50 per cent of their value. However, commercial building activity increased over 300 per cent in value and properties increased over 100 per cent in value. Industrial land changes were slight and occurred through additions to existing plants; properties increased in value at the same rate as those in the control area, but reached levels one third higher.

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[4]Construction was begun in 1946; the first section was opened to traffic in 1948; six and one-half miles of the freeway were in operation in October, 1951; and the road to Galveston was completed in mid-1952, a distance of about 45 miles. Within this period, Houston has greatly expanded its area, population and economy.

[5]The original report, *A Study of Land Values and Land Use Along the Gulf Freeway in the City of Houston, Texas,* was prepared by L. V. Norris Engineering Company, for the Texas Highway Department and the Bureau of Public Roads. It was based on a study of land values, between 1939-1951. The final report was made by Norris & Elder in 1956, *A 15-year Study of Land Values and Land Use Along the Gulf Freeway, Houston, Texas,* and included all factual data from the 1951 report in addition to new material collected and analyzed for the period 1951-1956.

[6]Duke, Richard De Le Barre, "The Effects of a Depressed Expressway – A Detroit Case Study," *The Appraisal Journal,* published by the American Institute of Real Estate Brokers, October, 1959.

Table 73

CHANGES IN VALUE OF LAND NEAR SELECTED HIGHWAY FACILITIES

State	Place and facility	Time period	Unit of measure	Percentage of original value: Study area	Percentage of original value: Control area	Ratio of percentages, study area to control area
				Percent	*Percent*	
California[2]	Oakland and San Leandro—Eastshore Parkway.	1941-53	Assessed value	8,700	5,200	1.67
	Ventura Blvd. (U. S. Highway 101).	1951-55	Price per front foot	210	(3)	
	Fresno (U. S. Highway 99)	1946-49	Value per acre	(4)	(4)	
	Orange Avenue Freeway (U. S. Highway 99).	1946-49	do	438	(3)	
	Los Angeles-Santa Ana Freeway.	1949-54	Assessed value			
	A			168	154	1.09
	B			705	460	1.53
	C			412	390	1.06
Georgia[5]	Atlanta Expressway	1941-46 1952-56	Weighted average price per square foot.		234	
	East side:					
	Proximity band A			234	(3)	
	Proximity band B			207	(3)	
	Proximity band C			101	(3)	
	West side:					
	Proximity band A			260	(3)	
	Proximity band B			68	(3)	
	Proximity band C			76	(3)	
Illinois[6]	Edens Expressway	1940-57	Assessed value	(6)	(3)	
	Calumet-Kingery Expressway	1940-57	do	(6)	(3)	
Massachusetts[7]	Needham residential	1945-57	Sales value	231	247	0.94
	Lexington residential	1945-57	Assessed value	264	242	1.09
	Influenced band	1945-57	do	388		
	Rest of town	1945-57	do		239	
New York[8]	Bronx River Parkway	1910-32	do	1,278	493	2.59
	do	1939-51	do	254	219	1.16
	Shore Parkway	1939-53	do	176	119	1.48
	Henry Hudson Parkway	1935-53	do			
	Bronx study area			202	77	2.62
	Manhattan study area			105	92	1.14
	Grand Central Parkway	1925-53	do	2,138	601	3.56
	Queens	1925-53	do		332	
Texas	Gulf Freeway, Houston:[9]	1939-41 1954-56	Value per square foot.[10]			
	Proximity group 1			667		
	Proximity group 2			242		
	Proximity group 3				80	
	Proximity group 4				203	
	Dallas Expressway:[11]	1941-45 1951-55	Value per square foot.			
	Proximity band A[12]			723	240	3.01
	Proximity band B			223	223	1.00
	Proximity band C			285	227	1.26
	Interstate Highway System:[13]					
	Austin	1941-48	Average price per acre	460	389	1.18
		1954-57	Nonsubdivided land	622	322	1.93
	Temple	1941-48	Average price per acre	1,417	140	10.12
	Rockwall County	1944-48 1952-57	do			
	1st section, Highway 67, Dallas County line to Rockwall.			198	142	1.39
	2d section, Highway 67, Rockwall interchange to Royse City interchange.			99	142	0.70
	Both sections			151	142	1.06
	San Antonio Expressway[14]	1941-45 1952-56	Price per square foot.	(14)	(14)	
Virginia	Lexington Bypass[15 16]	1948-57	Value per square foot			
	Buena Vista				175	
	Greater Lexington (including suburbs).			183		
	Lexington, less Main St.				180	
	Main St.			243		

[1]Source: U. S. Department of Commerce, Bureau of Public Roads; also, *Third Progress Report of the Highway Cost Allocation Study.*

[2]California Department of Public Works, Division of Highways, *California Land Studies:* Kelley, John F., *Camarillo Study (Ventura Boulevard)*; Bangs, Robert L., *Fresno*, 1954. See Garrison, William L., and Marts, Marion E., *Influence of Highway Improvements on Urban Land; A Graphic Summary*, University of Washington, Seattle, 1958, sec. II, pp. 18, 21, 41, for data on Eastshore Freeway and Santa Ana Freeway.

[3]Not available.

[4]An analysis of 15 individual parcels vacant before construction of the Fresno Freeway indicated a value impact greater than twice on most parcels. Only 1 of these parcels had a larger gain before the freeway development than after that construction. In addition, 18 parcels of land adjacent to the Fresno Freeway and 23 parcels not abutting the freeway were analyzed. These were all the sales in the area. The Orange Ave. percentage gain is illustrative.

[5]Lemly, James H., *Expressway Influence on Land Use and Value, Atlanta 1941-56*, Georgia State College of Business Administration, Atlanta, 1958, Table A-2, p. 106.

[6]George W. Barton & Associates, *Highways and Their Meaning to Illinois Citizens*, Evanston, Ill., 1958, p. 22. Land values within various distances of the Edens Expressway and Calumet-Kingery Expressway were charted from Olcott's Bluebook of Land Values. Increases in the overall values were generally higher in the middle section through which the highways run. 1947 land-value increases along the Edens Expressway ranged from 2.3 to 5.8 times 1940 values, and those along the Calumet-Kingery Expressway ranged from 2.5 to 3.5 times 1940 values.

[7]Bone, A. J., et al., *Economic Impact Study of Massachusetts Route 128*, Massachusetts Institute of Technology, Cambridge, interim report, 1958.

[8]Garrison and Marts, op. cit., pp. 8-14.

[9]Norris & Elder, *A 15-Year Study of Land Values and Land Use Along the Gulf Freeway, Houston, Tex., 1956*, pp. 146-149.

[10]Value of improvements omitted after adjustment for construction cost changes. Table includes only land annexed to city before 1941; figures for land annexed since 1946 are even more striking. The proximity groups in the Houston study are defined as follows: Group 1 is the primary area immediately adjacent to the facility; group 2 is a secondary band on each side of group 1; group 3 consists of properties in the same quadrant as the freeway, with good roads and access to the freeway, but farther away; group 4 consists of 10 acres widely distributed over all areas of the city except the southeast quadrant, through which the Gulf Freeway passes. The effort was made to select properties as closely similar as practicable to areas in groups 1 and 2.

[11]Adkins, William G., *Effects of the Dallas Central Expressway on Land Values and Land Use*, Texas Transportation Institute, College Station, 1957, p. 24.

[12]Bands were designated by distance from the expressway for study areas; control areas were selected with similar characteristics but out of the influence of the expressway.

[13]Haning, C. L., et al., *Changes in Land Value and Land Use Along Three Sections of the Interstate Highway System of Texas*, Texas Transportation Institute, College Station, 1958, pp. 14, 17, 42, 58.

[14]Adkins, William G., *Economic Impact of San Antonio Expressway*, Texas Transportation Institute, College Station, 1958, p. 11. Value of improvements omitted after adjustment for construction cost changes. Study shows only the differences between percentage changes of control and study areas, amounting to 133 per cent.

[15]Virginia Council of Highway Investigation and Research, *The Influence of Limited Access Highway on Land Value and Land Use; The Lexington, Virginia, Bypass: Progress Report No. 1*, 1958, Appendix III.

[16]Value of improvements omitted.

Grand Central Parkway — In 1925, when the Grand Central Parkway was constructed in Queens, New York City, a three-block "influence area" was worth $4,359,970, whereas in 1953, the same area was worth $93,210,860; a similar area outside the zone of influence was worth $141,540,460 in 1925, and $850,806,405 in 1953, a percentage increase only one fourth as great.[7]

Other Studies — In Atlanta, Georgia, undeveloped land along a freeway route formerly costing $100 to $400 an acre subsequently sold for $1200 to $1400 an acre.[8] In Westchester County, New York, tax receipts for a 22-year period showed that properties within the influence area of the Bronx River Parkway increased $22 million more than the normal gain in tax receipts — or just about the entire cost of the highway project.[9] In Chicago, along the

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[7]House Document No. 91, *Third Progress Report of the Highway Cost Allocation Study, 1959*, 86th Congress, 1st Session.

[8]Lemly, J. H., *Expressway Influence on Land Use and Value, Atlanta, 1941-1956*, Georgia State College of Business Administration.

[9]Source: Automotive Safety Foundation in Cooperation with Federal Extension Service, U. S. Department of Agriculture, *Vehicles, Roads, People*.

Edens Expressway, land values increased from 2.3 to 5.8 times; along the Calumet-Kingery Expressway, increases ranged from 2.5 to 3.5 times. Bypasses at Kokomo and Lebanon, Indiana, increased land values 50 per cent in one year. Communities located along the route of Boston's circumferential freeway report property value increases as high as 700 per cent.[10]

In creating property values, a new highway facility generally increases the tax return to government, and in effect, reimburses the taxpayers for the original highway expenditure. For example, the gain in taxable property and retail business in the counties served by the Garden State Parkway is twice that of New Jersey's remaining 11 counties.

Industrial Development – Freeways are important factors in the selection of industrial locations: movement of people to the suburbs requires good highways for employee access; truck transportation provides most less-than-carload shipments.[11] Advertising benefits accrue as a result of proximity to highways, since often the name of the firm on the building as well as the plant itself is within sight of approaching motorists.

New York Thruway – Sites along the 538-mile route of the New York Thruway attracted more than $650 million worth of industrial, commercial and residential and distributive developments, primarily near thruway interchanges.[12]

Santa Ana Freeway – The Santa Ana Freeway in Los Angeles increased property values on the old industrial highway, now a freeway frontage road, from 12 to 243 per cent higher than increases in nearby comparable property not served directly by the freeway. Properties abutting the central third of the freeway section which sold for an average acre price of $7,800, rose to $25,000 after the freeway was built.[13]

Industrial property owners along frontage roads indicated that the freeway tends to increase values of adjoining property; is an asset from an advertising point of view; and is a convenience to employees and business associates. Specific proximity of a firm along a frontage road, in relation to freeway exits, or directly opposite the exit, was not as important as previously believed.

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[10] Automotive Safety Foundation, *What Freeways Mean to Your City*, Washington, D. C.

[11] Barker, William M., *The Thruways as an Industrial Location Factor.*

[12] New York State Thruway Authority, November 20, 1958.

[13] "Industry and Frontage Roads, Santa Ana Freeway, California," *California Highways and Public Works,* 1954.

Route 128 – On Route 128, near Boston, some 227 companies have built 17 industrial parks and $175 million worth of buildings to house 28,000 workers; in June, 1955, there were only 39 companies in operation with 14 others under construction.[14]

Detroit Freeway – The decision to locate a 5,000-employee automobile assembly plant and administrative office 23 miles northwest of downtown Detroit, Michigan, is another example of an industrial decision to relocate in an outlying area serviced by a freeway. It set into motion a series of associated land developments that is sharply changing land use, land values, employment and commuting patterns, local government, taxes, schools and every other aspect of life within a 20-mile radius of the plant. Land values increased from $300 per acre as farmland before the freeway, to about $1,500 per acre as undeveloped subdivision land.[15]

Other Freeways – In Denver, The Valley Freeway and its connecting links have stimulated industrial, commercial and housing properties; in Alameda County, the East Shore Freeway has had a similar effect. The Central Traffic Artery in downtown Boston has stimulated a $35 million apartment development, a $25 million office development, and an extensive office-building program.[16]

Freeways Benefit Business – Accessibility to markets, rather than exposure to traffic, per se, determines business potentials. Freeways increase mobility and extend and reorient trading areas by enabling customers to reach business sites quickly and easily; by separating through from local traffic, and by providing more street capacity for business-bound patrons. They lower transportation charges to the community.

The relief of street congestion and the increase in parking creates a fresh business atmosphere in core areas that have been expanded by improved roads, particularly freeways. Similarly, freeways have been a major factor in the location of regional shopping centers. Many centers have located in proximity to interchanges on high-type roadways because capacity provided by the inter-

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[14]Bone, A. J., and Wohl, M., "Economic Impact Study of Massachusetts Route 128," prepared by the Massachusetts Institute of Technology for the Bureau of Public Roads, Department of Commerce, and the Massachusetts Department of Public Works, 1958.

[15]"The Michigan Freeway Program," in the *Michigan Economic Record*, Vol. 2, No. 9, Michigan State University, October, 1960.

[16]Automotive Safety Foundation in conjunction with Federal Extension Service, U. S. Department of Agriculture, *Vehicles, Roads, People.*

changes makes such locations desirable, and because the freeways tap a wide area in terms of time and distance.[17]

Throughout the country, the studies show that businesses located on bypassed routes generally benefit; and that broad opportunities are afforded new developments adjacent to improved roads. Some of the more pertinent studies of the freeway impacts on business are summarized herein.

North Sacramento, California – Experiences in North Sacramento, California, clearly denote how development of a freeway bypass has benefited business. A 4.1-mile section of the North Sacramento Freeway, opened in 1941, diverted 18,000 through vehicles from a road formerly carrying 39,000 vehicles per day.[18] In the following two years, the total retail business increased 48.5 per cent; volumes of business per establishment gained 28 per cent, compared to an increase of less than 10 per cent in the county.

Other California Experiences – Similar effects of other bypasses on business in eight California cities are shown in Table 74. In almost every case,

[17]Typical centers include North Shore, Peabody, Massachusetts; South Shore, Braintree, Massachusetts; Roosevelt Field, Garden City, New York, Mid-Island, Hicksville, New York; Gulfgate, Houston, Texas; Westview, Baltimore, Maryland; Seven Corners, Washington, D. C.; Garden State Plaza, Paramus, New Jersey; Cross County, Yonkers, New York; and Blue Ridge, Kansas City, Missouri.

[18]Source: Young, W. Stanley, "North Sacramento," *California Highways and Public Works.*

TABLE 74

BUSINESS VOLUMES AFTER CONSTRUCTION OF BYPASS FREEWAYS[1]

CALIFORNIA CITIES	*YEAR BYPASS WAS CONSTRUCTED*	*POPULATION OF TOWN OR CITY*	*PER CENT CHANGE* Businesses	Eating Places	Service Stations	All Others
Templeton	1952-3	600	+24	−9	−2	+20
Folsom	1949	1,700	+36	+7	+5	−1
Imperial	1949	1,700	+21	+2	+3	+1
Anderson	1950	2,200	+21	+132	−31	+22
Auburn	1947	4,600	+74	+5	+21	0
Fairfield	1949	5,000	+109	+14	−12	+7
Escondido	1949	6,600	+67	+12	+26	+13
North Sacramento	1947	6,000	+224	+12	+26	+22

[1]Source: *California Highways and Public Works.*

general retail businesses and restaurants showed gains as a result of freeway construction; service stations showed gains in five cities and losses in three. While there have been individual cases of business loss because of traffic diversion, business has generally experienced substantial over-all gains in excess of those found in surrounding areas.

For example, in Fairfield, California, retail outlets on bypassed highways have been experiencing greater business from the increased patronage of local customers.[19] Removal of through traffic has provided an uncongested and easily accessible central business district, which, in turn, has deterred the building of new shopping centers elsewhere in the city to compete with downtown. The construction of new motels is significant evidence that proper approaches from the bypass are as important as traffic volumes in the environs of the site.

Similarly, in Camarillo, the relocation of U. S. Highway 101, via the Camarillo Freeway, did not decrease the value of property along the old highway.[20] Land sale prices increased from $50 per foot in 1951, when the route was adopted, to over $100 when the freeway was opened; actually, every business in the community showed a substantial increase.

Freeway frontage roads enable roadside businesses to flourish and benefit from the freeway without interfering with it. An analysis of 41 business establishments on frontage roads abutting the 9.5-mile Fresno-Fowler Freeway in California shows a 42.2 per cent increase in sales, comparing two years before and after opening of the freeway. Like establishments elsewhere in the county show a 5.1-per-cent increase.[21]

Oregon Experiences — Whereas the California impact studies almost universally have indicated favorable economic results following the opening of a bypass, similar studies in Oregon have shown a different picture in some areas.[22] This may be attributed to California's heavier highway traffic and greater growth rate; thus, possible losses from traffic diversion would tend to be offset by more rapid population growth in California than in Oregon.

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[19]"Four Years After," *California Highways and Public Works,* 1953.

[20]Kelly, John F., "Camarillo Study," *California Highways and Public Works,* September-October, 1955.

[21]Evans, Henry K., "Their Roads Buy Themselves," *Nation's Business,* November, 1954.

[22]*Economic Effects of Through Highways By-Passing Certain Oregon Communities,* Bureau of Business Research, University of Oregon, 1956.

Motels — Studies in California show that attractiveness, service, cleanliness, and managerial ability have more effect on motel operations than the absence or presence of a freeway.[23] These results were substantiated by a study in Tallahassee, Fla., which showed that the first visit of motel guests was influenced by proximity to a restaurant, attractiveness of the motel, convenience to the route of departure, roadside signs, and referral groups.[24] Although motels depend on interception of traffic, it is apparent that factors *other* than freeways also influence motel operations.

OVER-ALL PUBLIC BENEFITS

The Interstate highway system will benefit all citizens by helping to increase the efficiency of public services, extending economies to farm and industry, increasing job opportunities, and contributing to national defense. In evaluating these national benefits, it is necessary to look retrospectively at benefits accrued by the nation over the past several decades as a result of good roads, and to further extend these benefits because of the improved mobility afforded by the Interstate highway system.

"Public benefits" in the broadest sense refers to the favorable social and economic effects resulting from road improvements. Construed more narrowly, the term refers to the measurable effects that modern roads have on reducing cost of improving the quality of specific government services, including national defense.

As indicated in the *Third Progress Report of the Highway Cost Allocation Study,* "there exists a formidable array of direct and indirect benefits resulting from federal-aid highway improvement in addition to benefits resulting from actual use. Regardless of the label affixed to these kinds of benefits — whether they be identified as an extension of vehicular benefits, transferred benefits, or non-vehicular benefits — what seems significant is that there are real and extensive beneficiary groups other than highway users as such, that reap the advantages of highway improvements and that the total magnitude of these benefits is great."[25]

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[23]"North Sacramento Study," *California Highways and Public Works.*

[24]Haverkorn, T. N., "A Study of the Factors Affecting the Selection of a Particular Lodging Accommodation in Tallahassee" (Unpublished Master's Study, Department of Restaurant and Hotel Management, Florida State University). The study found business the primary travel motive for 92.2 per cent of the hotel guests and 18.6 per cent of the motel patrons. The automobile was the only mode of transportation for guests to the motels; however, over 25 per cent of the hotel guests did not arrive by a car. Approximately 30 per cent of the motel guests indicated that they had stayed at the same motel before, while the repeat business of the hotels amounted to 76 per cent. Persons stopping at a motel for the first time made advance reservations compared with 32 per cent of the hotel guests.

[25]House Document No. 91, *Third Progress Report of the Highway Cost Allocation Study,* 86th Congress, 1st Session, 1959.

For example, a review of the products hauled by trucks clearly indicates the reliance of the national economy on motor transportation. As shown in Figure 121, the vast majority of farm products and livestock are hauled by motor trucks, as are many mine products.[26]

The time savings resulting from Interstate highway construction will be reflected in lower transportation costs, and lower prices for truck-borne merchandise; consumers will also benefit from a greater choice of goods; workers will benefit by being able to choose jobs from a wider area.

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[26]Automobile Manufacturers Association, *Motor Truck Facts, 1960,* based on percentage of mine products hauled by truck, percentage of farm products hauled to leading markets, and percentage of livestock shipped to major markets.

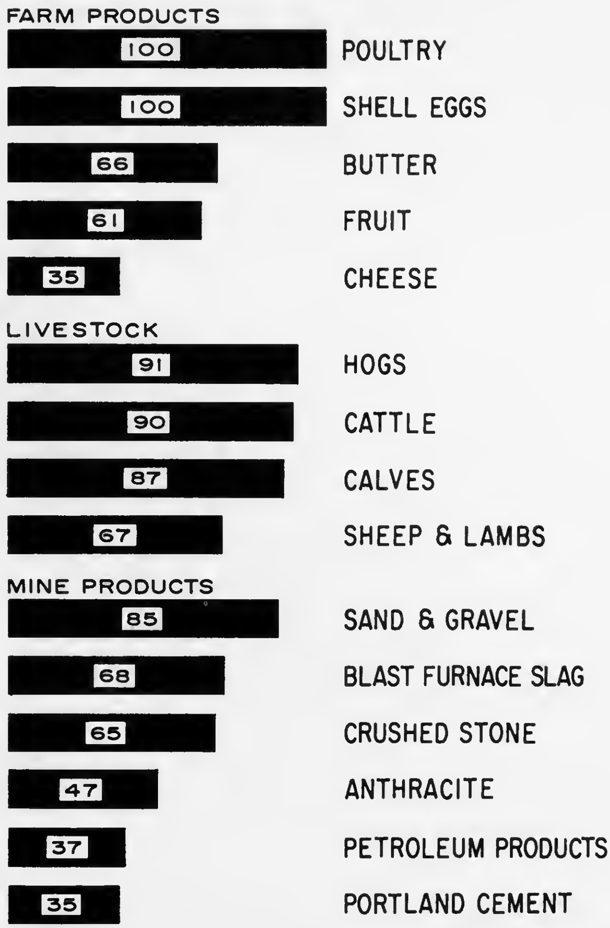

Figure 121
PRODUCTS HAULED BY TRUCK AS
PER CENT OF TOTAL DELIVERED

As shown in Chapter I, highway travel has kept pace with the expanding gross national product. Improved mobility has had significant bearing on this relationship between travel and economy. As impediments to travel diminish, the entire economy benefits.

Benefits to Farmers — Progressive improvement of the nation's highways has been instrumental in the transformation of agriculture to efficient, scientific bases. Good roads have brought the farmer closer to markets, and, in turn, have brought many of the products and conveniences of urban life to the farm. They tend to reduce damage to produce and livestock in transit, and make schools, markets and medical services readily accessible to farm homes. Interstate highways will undoubtedly extend these benefits.

Until the advent of the motor truck, farms not situated near a railroad produced few crops for outside markets. Truck transportation has subsequently figured substantially in doubling farm production and the $74 billion increase in farm property values since 1910.[27]

Approximately one of every 12 passenger cars and one of every four trucks is used on the farm; in 1960, an estimated 4.5 million farms owned 4.3 million autos, 3.1 million trucks and 4.8 million tractors. The use of these vehicles has substantially contributed to the productivity of American farms.

Recreational Travel — Recreational travel reflects the national level of prosperity, greater leisure time, and improved accessibility to civic and historic centers. More than 70 million Americans take vacations by car each year, averaging over 1,000 miles per trip, accounting for more than three fourths of all tourist travel, and spending over nine billion dollars. Each year, more than 20 million people visit National Parks in some six million cars.

Interstate highways will further increase accessibility to resort areas, making longer and more varied vacations possible. Vacations to new areas, as a result of good highways, will enrich the culture and heritage of the nation. The sum total of vastly expanding vacation experiences has an intrinsic value that is unmeasurable in monetary terms.

The Massachusetts Turnpike, for example, has increased the attractiveness of Cape Cod and the Berkshire Hills; in California, freeways have shortened the driving time between National parks and urban areas.

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[27]Automotive Safety Foundation in Cooperation with Federal Extension Service, U. S. Department of Agriculture, *Vehicles, Roads, People.*

[28]Department of Public Works, Division of Highways, *The California Freeway System,* September, 1958. The average trip length for social and recreational purposes in California was 15.5 miles; the average trip for vacations, over 200 miles.

Contributions to Over-all Economy — Highway transportation has become a major element of the nation's economy, generating more than 10 per cent of all gainful employment and accounting for about 14 per cent of the total gross national product. One of every six retail, wholesale, and service businesses is connected with motor vehicles. The proportions will increase in the future because of the development of Interstate highways and the increasing highway orientation of the populace.

Each $1 billion spent on highway construction equals approximately 102 million man-hours of employment on the site of construction and 126 million man-hours off the site — a total of 228 million man-hours of labor.

Social and Cultural Benefits — Interstate highways will increasingly widen opportunities for cultural, religious, and recreational activity. Entertainment facilities can be concentrated in focal points accessible via Interstate highways; larger church attendance will be made possible by good accessibility to members; and mobile chapels can be progressively extended into more remote areas. Interstate highways will permit faster delivery of newspapers to out-of-town communities.

Public Services — Higher standards of living, increased productivity, and social advances have created new demands for roads, educational and other services. These factors have developed together; and they have become increasingly reliant on highway transportation. Consequently, public services vital to contemporary living will tend to benefit from Interstate highway construction.

Public Education — No governmental service has been more profoundly affected by the advent of good roads than public education. One of the most tangible results is the increased percentage of the total school age population enrolled in schools and the average daily attendance. Although compulsory school attendance laws and other factors have contributed to the increases, improved transportation facilities have helped considerably. They have made possible reduced driving time, extended school bus service, and greater private car ownership. More and better all-weather roads have accelerated school consolidation, resulting in more effective and economical administration and instruction.

Eleven million pupils now ride to and from their daily classes in more than 165,000 school buses at an annual public expenditure approaching $400 million. Consolidation of schools made possible by school buses has eliminated 160,000 "one-teacher" schools during the past four decades and has, thereby, improved educational facilities.

Public Health — Good roads have made a substantial contribution to the vastly improved and broadened public health program. Over 221,000 doctors and 26,000 U. S. Public Health nurses regularly rely on the automobile in making their calls. The motor vehicle has made modern hospital service, frequent and widespread health inspections, and rapid delivery of vaccines and perishable laboratory specimens accessible to even remote areas.

Construction of Interstate highways will tend to increase the size and pattern of medical service areas. The scope and coverage of large centers will increase, consistent with the increasing specialization of medical services. Doctors will be able to see more patients per day; patients will be able to reach medical centers from an increasingly larger area and physicians will tend to concentrate in larger regional medical centers.

Postal Services — Interstate highways will help permit further improvements and efficiencies in the postal system, since the growth and development of postal service has continuously been associated with development of the nation's road network.

In 1900, there were about 1,250 rural free delivery routes, totaling about 29,000 miles and averaging 11 miles in length. In 1959, there were over 31,000 rural carriers, traveling on 1.7 million miles of route, and totaling over 500 million vehicle miles annually, with an average route length of 56 miles.

Police and Fire Protection Services — Modern transportation and communication facilities, permit police and fire personnel to provide efficient protection to large service areas. Protection of forest areas has been extended, with a resultant decline in the incidence and damage of forest fires attributable in great measure to good roads. In 1942, protection was afforded 76 per cent of all areas, whereas in 1958, 94 per cent of all forest lands were protected. In 1942, about nine per cent of all protected areas, and 20 per cent of all unprotected areas burned; in 1959, about 0.2 per cent of all protected areas, and five per cent of all unprotected areas were destroyed by fire.

Benefits to National Defense — The National System of Interstate and Defense Highways is vital to national defense for mobility of manpower, supplies, and weapons. Interstate highways are relatively invulnerable to attack, and could likely assist in evacuating people from cities and in transporting medical supplies and disaster personnel.

During periods of national emergency, highways have become extensions of production lines. For example, during World War II, 60 per cent of all outbound tonnages from defense plants was road-borne. Similarly, many raw materials and component parts were delivered by truck.

Impact of Delayed Construction — While it is difficult to evaluate the general benefits of the Interstate system to the national economy in precise quantitative terms, it is clear that these "non-user" benefits are substantial. Not only will the Interstate system provide relief to the nation's congested areas and link its principal centers of commerce and industry, but it will bring many immeasurable benefits to almost every facet of the nation's economy — and will help improve the public services so vital to contemporary living.

A cutback or slow-down of highway construction could limit national mobility. It would adversely affect national defense, reduce state highway department staffs, and depreciate national employment. It would engender basic diseconomies that would result from rising right-of-way and construction costs.

Rapid construction of the National System of Interstate and Defense Highways is, therefore, in the national interest.

APPENDICES

NDIX A

E MILES OF TRA

- 1975 - 1980[1]

ICLE MILES RSTATE SYSTEM (billions)		DIS GE ANNUAL VOLUMES PER MILE OF ROUTE (Thousands)				
		All Freeways		Interstate Freeways		
Urban	Rural	Urban	Rural	Total	Urban	Rural
36.0	42.9	17,252	5,778	8,305	17,955	5,778
92.2	87.2	13,760	2,607	4,376	13,761	2,542
92.0	90.2	13,860	3,764	4,444	13,731	2,630
40.7	43.9	19,617	5,944	8,905	19,614	5,912
128.3	82.3	17,160	2,905	5,774	17,163	2,838
148.0	100.5	17,608	3,125	6,061	17,619	3,083
141.0	101.5	16,765	4,214	5,915	16,785	3,113
44.4	45.2	21,357	6,122	9,432	21,398	6,088
161.3	104.2	18,238	3,278	6,476	18,225	3,241
151.0	105.4	17,034	4,350	6,254	17,062	3,278
52.0	48.4	25,043	6,511	1,057	25,060	6,519
188.0	107.5	19,615	3,456	7,207	19,583	3,424
172.0	108.8	17,875	4,497	6,849	17,916	3,465

APPENDIX B

DETAILS OF PRESENT AND PROPOSED RAPID TRANSIT FACILITIES

In this appendix, a brief description is presented for each of the principal rapid transit systems, present and proposed.

PRESENT SYSTEMS

New York City — The largest, most important and most extensive transit operation in the country is the New York City Transit Authority's rapid transit system, comprising about 236 miles of subway and elevated lines. In 1959, the system carried about 1.3 billion passengers, about 72 per cent of the number carried in 1954.

Continuous express service is operated on four of five Manhattan trunk lines and on principal lines in Brooklyn and Queens; additional peak-hour express service is operated in the Bronx, Brooklyn, and Queens. Express trains average from one to three miles between stops, whereas local trains have an average of three stops per mile.

Despite considerable renovation and modernization, obsolescence is evident on many key lines in terms of equipment, noise-level, alignment, station location, and design. Each of the three divisions (IRT, BMT, IND) was built separately, and good coordination between them is difficult to achieve; equipment, is not wholly interchangeable. Serious trunk line capacity deficiencies in Manhattan create peak-hour overcrowding; population dispersion, for example, has increased many demands for express service that cannot be provided because of inadequate track capacities.

Chicago — The Chicago Transit Authority's rapid transit system includes the North-South and West-Northwest L - subway routes, (each with two branches) and the Lake Street (West Side), Ravenswood, and Evanston elevated routes; however, about half of the 600,000 weekday riders use the North-South route. In the evening peak hour, about 183,000 out of 225,000 people in the Loop leave by public transportation, mainly rapid transit and commuter railroads; this would be an impossible volume to handle by private auto within the same time periods.

Between 1948 and 1958, seven branches of the rapid transit system serving suburban communities or low-traffic areas were discontinued and replaced by motor buses. Trip times on the system were reduced 20 to 30 per cent as a result of closing 54 stations and improving equipment; patronage stabilized, despite the reduced area served.

The system, focused on the Loop, serves the higher density areas in the city. It does not, however, have complete city-wide coverage, nor does it fully serve many of the rapidly growing sections of greater Chicago. It is not effectively integrated with the city's suburban railroad net.

Boston — The Metropolitan Transit Authority operates three rapid transit routes, a streetcar subway with six routes, and a suburban high-speed trolley route. About 90 per cent of the rush-hour movement to downtown Boston is by transit, largely on these facilities.

While there are great variations in the types of rapid transit equipment employed, the system is one of the best coordinated in the country. A high percentage of the 600,000 daily riders use both surface and rapid transit facilities.

The capacity of the system, however, is limited, particularly in the Tremont Street subway; express service was not provided prior to December, 1960; and over-all coverage is not extensive. Recent extensions to Revere Beach on the east, and to Newton Highlands on the west have added about 12 miles to the system.

In 1958, the Metropolitan Transit Authority extended its operation to Newton via the Highland Branch of the Boston and Albany Railroad; modernization of the 9.5 mile line cost $10 million.[1] Despite the lack of parallel expressways and general public acceptance of transit, the Highland Branch (like the entire MTA operation) had a first year operating deficit of about $338,000, which increased to about $804,000 when various fixed charges were added.

Philadelphia — Philadelphia's principal rapid transit routes include the Broad Street north-south route, and the Market Street-Frankford lines. A third route extends from downtown Philadelphia to Camden, with a spur northwesterly to Broad Street. The system is augmented by a short streetcar subway in Market Street and by an extensive network of electrified suburban lines of the Pennsylvania and Reading Railroads. The rapid transit and suburban railroads carry almost 700,000 persons daily.

The Philadelphia system serves the principal travel corridors within the city. It does not, however, cover many of the rapidly growing parts of the city, nor is it fully integrated with suburban railroads. There is no physical interconnection between the two principal subway routes, and equipment is not fully interchangeable. Opportunities for express service are limited to the multi-track Broad Street route.

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[1]Wolfe, Gregory B., *The New Highland Line in Boston,* presented at City Planning Division, American Society of Civil Engineers, Boston, October 14, 1960.

Cleveland — The Cleveland Transit System and the Shaker Heights rapid transit lines serve about 80,000 riders per weekday. The CTS, a high-platform, modern rapid line 15 miles long, was opened in 1955 and extended in 1958; it is located almost exclusively along railroad rights-of-way with 14 stations, spaced about 1.2 miles apart, and attains average speeds of 30 miles per hour. The Shaker Heights rapid transit connects the Cleveland Union Terminal with the suburban community of Shaker Heights via a six-mile line built on railroad rights-of-way; average express speed is about 25 miles per hour. Both facilities are more like commuter railroads than conventional rapid transit because of their light off-peak use.

The Cleveland rapid transit lines were developed with a minimum of capital costs. However, they skirt many high density areas and are, therefore, limited in their coverage; at present, they provide only one station within the central business district.

Toronto — The 4.6-mile Toronto subway under and along Yonge Street, the city's main north-south artery, is a combination subway and depressed open-cut facility. Since its opening in 1954, it has consistently carried about 250,000 people per day. It serves a high density area, and, like New York's subways, has stimulated land development along its route; both office buildings and apartments have been built northward along Yonge Street in a ribbon-like extension of the central business district. The major defects of the subway are its slow speed — somewhat under 20 miles per hour, and its limited coverage.

Los Angeles — The 20-mile Long Beach line of the Los Angeles Metropolitan Transit Authority (the last of the Pacific Electric passenger lines) operates essentially as interurban-rapid transit between the downtown areas of the two cities. It is located on a private right-of-way except for about three miles of street operation in Long Beach, and a mile in Los Angeles. Equipment on the line is old, stations are unattractive, and grade crossings are frequent; yet its 20 miles-per-hour speeds are comparable to those of many conventional rapid transit lines. Current rapid transit plans for the Los Angeles area include a route along this alignment.

CURRENT TRANSIT PLANNING

New York City is constructing a short $58 million link between the BMT and IND divisions in lower Manhattan, expected to open in 1962, and is improving maintenance and equipment on all lines. A plan was submitted by the Metropolitan Rapid Transit Commission for a new $400 million bi-state loop between New Jersey and New York. The Port of New York Authority, under recent criticism for its failure to enter the total urban transportation field and assume responsibility for all forms of transportation, has offered to purchase the Hudson and Manhattan Railroad.[2]

Chicago has completed a rail rapid transit system in the median strip on the Congress Street Expressway and is presently elevating a two-and-one-half-mile route at a cost of $4 million, jointly financed by the Chicago Transit Authority (CTA) and governmental agencies.[3] A $315 million 20-year program of rapid transit improvements and extensions to be financed from public funds has been proposed. The plans include extensions of rail rapid transit facilities, mainly in the medians of the Northwest and South expressways, special bus lanes in the Southwest expressway, general rapid transit improvements, and area-wide "park and ride" garages at strategic interchange points.

Philadelphia is planning extensions of its rapid transit lines to New Jersey and to the northeast, south, and southwest parts of the city to maintain present levels of transit use. The $160 million plan calls for an additional 10 miles of subway and six miles of underground trolley, within a four-year period, to be financed by city revenues rather than gas taxes. An extension of the Camden Bridge line into New Jersey, largely over three existing rights-of-way, would cost $89 million, serve 24 million passengers annually, and incur an annual operating loss of about $796,000. The Passenger Service Improvement Corporation, which manages "Operations Northwest and Northeast", is considering integrating the Pennsylvania and Reading commuter lines.

New Jersey has enacted legislation enabling the state to contract with railroad commuter lines to assure continuance of commuter transportation; an appropriation of $6 million was provided to underwrite subsidies for a one-year period.

Toronto is constructing its 10-mile, $200 million Bloor Street Subway which will link with the Yonge Street line. Cleveland has a plan for extending its new rail rapid system, as well as for adding a subway route through the heart of the downtown area.

In Boston, consideration is being given to a one-mile $21 million subway link paralleling Boylston Street to serve the new Prudential Center; to future improvement of the Scollay Square subway Station; and to possible extension of rail or bus rapid transit to the South Shore.

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[2]Chase, Edward T., "How to Rescue New York from Its Port Authority," *Harpers Magazine*, June, 1960.

[3]State of Illinois, $1 million; County of Cook, $100,000; Cook Park, $800,000; Chicago, $600,000; C. T. A.; Chicago and Northwestern Railroad is providing the right-of-way.

In San Francisco, where topography limits all transportation routes, a rail rapid transit system is being actively considered to serve the entire Bay area. The most comprehensive of the "grand plans", it calls for 100 miles of interurban rapid transit route, 32 miles of right-of-way acquisition for future extension, and 63 stations at a capital cost of about $1 billion, exclusive of rolling stock. A 3.6 mile underwater tube will be financed through revenue bonds bought with surplus automobile tolls from the Bay Bridge.

A 74.9 mile network of rubber-tired trains has been proposed for Los Angeles, at a cost of $529,700,000, including four lines radiating from downtown. Over 40 per cent of the system would follow existing or former Pacific Electric interurban lines.

The $175 million all-bus rapid transit plan recommended for St. Louis is part of a coordinated total transportation system, and is, in many respects, a prototype of future rapid transit in medium-to-large sized cities. It includes express bus operation over an 86-mile system, 42 miles on grade-separated roadways exclusively for transit buses, and 44 route miles on the outer sections of present or proposed expressways. An elevated downtown bus serves as a focal point for six radial routes augmented by one north-south crosstown route. Over 9,000 parking spaces are recommended at 29 proposed rapid transit stations. The system provides adequate capacity for the maximum anticipated 1980 morning peak-hour loadings of 35,000 persons, of which about 7,200 are on the busiest line.

A plan for the Atlanta area calls for development of a 15.9-mile rapid transit line with nine stations, using existing railroad rights-of-way to the maximum extent possible. Construction costs of the rapid transit system were estimated at $59 million, and patronage at 37,500 passengers per day.

A recent plan to develop a monorail between downtown New Orleans and the Moisant International Airport was reviewed by the city and considered unfeasible and contrary to public interest. The Department of Utilities for the City of New Orleans, in reviewing the recommended plan, expressed serious concern regarding the plan's economic feasibility, problems of route alignment, and overstatement of patronage.

The "balanced" transportation plan for the Washington, D. C. area includes a 329-mile network of freeways and parkways; eight express bus routes totaling 66 miles of (one-way) route, four rail rapid transit routes radiating from downtown and totaling 34 miles of double track (half in subway and half in freeway median strips), 22,000 new all-day spaces, and 27,000 short-time spaces in downtown and related fringe parking areas.

APPENDIX C

SUPPLEMENTARY TABULATIONS

TABLE A-1

RURAL AND URBAN POPULATION IN THE UNITED STATES 1900-1960[1]

YEAR	URBAN	RURAL	PER CENT URBAN	PER CENT RURAL	TOTAL
1900	30,159,921	45,834,654	39.7	60.3	75,994,575
1910	41,998,932	49,973,334	45.7	54.3	91,972,266
1920	54,157,973	51,552,647	51.2	48.8	105,710,620
1930	68,954,823	53,820,223	56.2	43.8	122,775,046
1940	74,423,702	57,245,573	56.5	43.5	131,669,275
1950[2]	88,927,464	61,769,897	59.0	41.0	150,697,361
1950[3]	96,467,686	54,229,675	64.0	36.0	150,697,361
1956	103,631,000	60,677,000	63.1	36.9	164,308,000
1959[4]	118,352,000	60,428,000	66.2	33.8	178,780,000
1960[5]	120,000,000	59,500,000	67.1	32.9	179,500,000

[1]Source: U. S. Department of Commerce, Bureau of the Census.

[2]Old census definition of rural and urban is used for consistency.

[3]New census definition.

[4]Total population estimated by Bureau of the Census as of November, 1959. Per cent urban and rural estimated by *Sales Management* as of January 1, 1959.

[5]Total population from preliminary census.

TABLE A-2

GROWTH OF CENTRAL CITIES AND RINGS OF STANDARD METROPOLITAN AREAS (SMA'S)

1900-1956[1]

CENSUS YEAR	NO. OF SMA's	PER CENT OF U. S. POPULATION			PER CENT INCREASE DURING PRECEDING DECADE			PER CENT OF TOTAL U. S. POPULATION GROWTH CLAIMED BY SMA'S DURING PRECEDING DECADE		TOTAL U.S. POPULATION
		Total Metropolitan Areas	Central Cities	Rings	Total Metropolitan Areas	Central Cities	Rings	Central Cities	Rings	
All SMA's										
1956	168	58.6	31.3	27.3	14.8	4.7	29.3	15.6	69.1	164,308,000
All SMA's										
1950[2]	162	56.8	32.8	24.0	21.8	13.9	34.7	31.6	49.0	150,697,361
Principal SMA's										
1950	147	56.1	32.3	23.8	21.8	13.7	34.8	30.7	48.6	150,697,361
1940	125	51.4	31.6	19.5	8.3	5.1	13.8	22.8	34.9	131,669,275
1930	115	49.8	31.8	18.0	27.0	23.3	34.2	43.3	32.9	122,775,046
1920	94	43.7	28.9	14.8	25.2	26.7	22.4	46.8	20.8	105,710,620
1910	71	37.7	25.0	12.7	32.6	35.3	27.6	37.4	15.7	91,972,266
1900	52	31.9	21.2	10.7	—	—	—	—	—	75,994,575

[1]Sources: Bogue, Donald J., *The Growth of Standard Metropolitan Areas: 1900-50*, December, 1953; U. S. Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States, 1958.*

[2]168 areas have been combined into 162.

Table A-3

METROPOLITAN AREAS OF THE UNITED STATES – 1950[1]

POPULATION CLASS	*NUMBER OF METRO-POLITAN AREAS*	*MILLIONS OF PEOPLE*	*PER CENT OF U. S. TOTAL*	*CUMU-LATIVE PER CENT*
3,000,000 and over	5	29.4	19.5	19.5
1,000,000 - 2,999,000	9	15.5	10.3	29.8
500,000 - 999,000	23	14.5	9.6	39.4
250,000 - 499,000	41	13.9	9.2	48.6
100,000 - 249,000	69	11.0	7.3	55.9
Under 100,000	15	1.0	0.7	56.6
Total	162[2]	85.3	56.6	

[1]Source: Bogue, Donald J., *Population Growth in Standard Metropolitan Areas, 1900-1950,* 1953, p. 23.

[2]According to the classification of the U. S. Bureau of the Census, there were 168 metropolitan areas in 1950 with a total population of 84,500,000. The above table consolidates several of these, resulting in a total of 162 metropolitan areas.

Table A-4

POPULATION INSIDE AND OUTSIDE URBANIZED AND STANDARD METROPOLITAN AREAS 1950[1]

LOCATION	*INSIDE STANDARD METROPOLITAN AREAS*		*OUTSIDE STANDARD METROPOLITAN AREAS*		*TOTAL POPULATION*	
	Number	*Per Cent*	*Number*	*Per Cent*	*Number*	*Per Cent*
Inside Urbanized Areas	68,989,014	45.8	260,134[2]	0.2	69,249,148	46.0
Outside Urbanized Areas	15,511,663[3]	10.3	65,936,547	43.7	81,448,213	54.0
TOTAL	84,500,680	56.1	66,196,681	43.9	150,697,361	100.0

[1]Source: U. S. Department of Commerce, Bureau of the Census, *U. S. Census of Population, 1950.*

[2]Includes population (141,291) of two urbanized areas which are entirely outside of standard metropolitan areas.

[3]Includes population (1,732,845) of 18 standard metropolitan areas containing no urbanized areas.

Table A-5

POPULATIONS INSIDE AND OUTSIDE CENTRAL CITIES – 1950[1]

LOCATION	*URBANIZED AREAS*		*STANDARD METROPOLITAN AREAS*	
	Number	*Per Cent*	*Number*	*Per Cent*
Central Cities	48,377,240	69.8	49,412,792	58.5
Outside Central Cities	20,871,908	30.2	35,087,888	41.5
Total	69,249,148	100.0	84,500,680	100.0

[1]Source: U. S. Department of Commerce, Bureau of the Census, *U. S. Census of Population, 1950.*

TABLE A-6

THE TIMING OF URBAN GROWTH AND DECENTRALIZATION IN THE UNITED STATES FOR 99 METROPOLITAN AREAS WITH CENTRAL CITIES OF 100,000 OR MORE INHABITANTS[1]

CENSUS YEAR WHEN CENTRAL CITY FIRST REACHED 50,000	DECADES IN WHICH DECENTRALIZATION BEGAN 1850's	1860's	1870's	1880's	1890's	1900's	1910's	1920's	1930's	1940's	CONTINUED CENTRALI-ZATION	TOTAL NUMBER OF AREAS
1800	1	—	—	—	—	—	—	—	—	—	—	1
1810	—	—	—	—	—	1	—	—	—	—	—	1
1820	—	—	—	—	1	—	—	—	—	—	—	1
1830	—	—	—	1	—	—	—	—	—	—	—	1
1840	—	—	—	—	—	—	—	1	—	—	—	1
1850	—	—	1	1	1	—	—	—	—	—	—	3
1860	—	—	1	—	—	4	—	1	—	—	—	6
1870	—	—	1	—	—	2	1	3	—	—	—	7
1880	—	—	—	—	—	—	1	5	1	—	—	7
1890	—	—	—	—	1	2	4	7	3	—	—	17
1900	—	—	—	—	1	1	5	3	3	—	—	13
1910	—	—	—	—	—	—	2	4	12	—	—	18
1920	—	—	—	—	—	—	—	2	11	—	—	13
1930	—	—	—	—	—	—	—	1	2	—	4	7
1940	—	—	—	—	—	—	—	—	—	1	1	2
1950	—	—	—	—	—	—	—	1	—	—	—	1
Total Number Areas	1	—	3	2	4	10	13	28	32	1	5	99

[1]Source: Schnore, Leo F., "The Timing of Metropolitan Decentralization," *Journal of the American Institute of Planners,* Volume XXV, No. 4, November, 1959.

Table A-7

CIVILIAN POPULATION OF THE UNITED STATES 1950-1956[1]

TYPE OF AREA	POPULATION IN THOUSANDS April 1950	Per Cent of Total	March 1956	Per Cent of Total	Per Cent Increase 1950-1956
Total United States	149,634	100.0	164,308	100.0	9.8
Standard Metropolitan Areas[2]	83,801	56.0	96,235	58.6	14.8
Central Cities	49,138	32.8	51,428	31.3	4.7
Outside Central Cities	34,663	23.2	44,807	27.3	29.3
Urban	23,712	15.9	27,750	16.9	17.0
Rural	10,951	7.3	17,057	10.4	55.8
Other Territory	65,833	44.0	68,073	41.4	3.4
Urban	23,067	15.4	24,453	14.9	6.0
Rural	42,766	28.6	43,620	26.5	2.0

[1]Source: Civilian population as given in U. S. Department of Commerce, Bureau of the Census, *Current Population Reports*, p. 20, No. 71, also: *Statistical Abstracts of the United States, 1958.*

[2]168 Standard Metropolitan Areas.

Table A-8

COMPARISON OF RESIDENTIAL DENSITY AT SELECTED DISTANCES FROM THE CENTER IN THREE METROPOLITAN AREAS[1]

DISTANCE FROM CENTER IN MILES	DENSITY: PEOPLE PER SQUARE MILE — Philadelphia (1940) Actual	Philadelphia (1940) Index	St. Louis (1940) Actual	St. Louis (1940) Index	Houston (1940) Actual	Houston (1940) Index
2	32,000	1.00	31,000	1.00	9,600	1.00
5	10,000	0.31	8,700	0.28	3,250	0.34
10	2,030	0.06	1,580	0.05	133	0.01

[1]Source: Row, Arthur, and Jurkat, Ernest, "The Economic Forces Shaping Land-Use Patterns," *the Journal of the American Institute of Planners*, Vol. XXV, No. 2, May, 1959.

Table A-9

NEW SHOPPING CENTERS REPORTED IN THE UNITED STATES 1947-1960[1]

YEAR	*NUMBER*	*TOTAL SQ. FT. AREA*	*SQ. FT. AREA IN REGIONAL CENTERS*	*SQ. FT. AREA IN OTHER CENTERS*
1947	8	736,000	0	736,000
1948	11	1,330,000	0	1,330,000
1949	22	3,210,000	500,000	2,710,000
1950	27	4,044,000	1,300,000	2,744,000
1951	44	6,085,000	1,750,000	4,335,000
1952	39	7,909,000	3,978,000	3,931,000
1953	54	6,252,000	1,125,000	5,127,000
1954	96	15,568,000	4,022,000	11,546,000
1955	104	16,228,000	3,989,000	12,239,000
1956	156	30,805,000	13,757,000	17,048,000
1957	188	30,606,000	9,625,000	20,981,000
1958	186	28,031,000	5,630,000	22,401,000
1959	206	31,754,000	7,178,000	24,576,000
1960	140	28,542,000	9,110,000	19,432,000
TOTAL 1947-1960	1,281	211,100,000	61,964,000	149,136,000

[1]Source: Compiled by Hoyt, Homer, in "The Status of Shopping Centers in the United States," *Urban Land*, Vol. 19, No. 5, Urban Land Institute, October, 1960. Tabulations based in part on information in *Directory of Shopping Centers in the United States and Canada, 1961 Edition*, National Research Bureau, Inc., Chicago, Illinois.

Table A-10

RETAIL TRADE IN SELECTED STANDARD METROPOLITAN AREAS AND COMPONENT PARTS 1948 AND 1954[1]

METROPOLITAN AREA	*STORES*		*SALES (000)*		*PER CENT OF TOTAL*				*PER CENT CHANGE 1948 TO 1954*	
					STORES		*SALES*			
	1948	*1954*	*1948*	*1954*	*1948*	*1954*	*1948*	*1954*	*Stores*	*Sales*
Total Metropolitan Areas for										
Twenty-four Cities	544,319	527,265	$48,015,045	$63,468,570	100.0	100.0	100.0	100.0	— 3.1	+32.2
Central Business Districts	41,680	38,858	9,469,067	9,516,112	7.7	7.4	20.0	15.0	— 6.8	+ 0.9
Cities	327,378	306,507	31,003,264	37,431,404	60.1	58.1	64.6	59.0	— 6.4	+20.7
Balance of Area	216,941	220,358	17,011,681	26,037,165	39.9	41.9	35.4	41.0	+ 1.6	+53.1
New York Metropolitan Area	161,695	148,693	12,308,614	15,433,091	100.0	100.0	100.0	100.0	— 8.0	+25.4
Central Business District	10,554	10,801	2,083,058	2,185,107	6.5	7.3	16.9	14.2	+ 2.3	+ 4.9
New York	98,183	87,210	7,820,109	8,796,790	60.7	58.7	63.5	57.0	—11.2	+12.5
Balance of Area	63,512	61,483	4,488,505	6,636,301	39.3	41.3	36.5	43.0	— 3.2	+47.9
Chicago Metropolitan Area	59,401	54,632	4,398,944	6,898,919	100.0	100.0	100.0	100.0	— 8.5	+27.8
Central Business District	2,507	2,292	753,508	714,784	4.2	4.2	14.0	10.4	— 8.5	— 5.1
Chicago	41,493	35,918	3,798,125	4,444,333	69.9	65.8	70.3	64.4	—13.4	+17.0
Balance of Area	17,908	18,714	1,600,819	2,454,586	30.2	34.3	29.7	35.6	+ 4.5	+53.3
Los Angeles Metropolitan Area	46,999	48,461	4,587,689	6,903,325	100.0	100.0	100.0	100.0	+ 3.1	+50.5
Central Business District	1,972	1,610	451,009	421,003	4.2	3.3	9.8	6.1	—18.4	— 6.7
Los Angeles	22,122	22,120	2,272,112	3,103,047	47.1	45.6	49.5	45.0	— 0.1	+36.6
Balance of Area	24,877	26,341	2,315,577	3,800,278	52.9	54.4	50.5	55.0	+ 5.9	+64.1
Philadelphia Metropolitan Area	42,410	41,033	3,109,188	4,060,514	100.0	100.0	100.0	100.0	— 3.2	+30.6
Central Business District	3,073	2,768	650,964	604,324	7.3	6.8	20.9	14.9	— 9.9	— 7.2

Detroit Metropolitan Area	27,263	27,732	2,946,668	4,106,958	100.0	100.0	100.0	100.0	+ 1.7	+39.4
Central Business District	1,382	1,318	456,005	405,465	5.1	4.8	15.1	9.9	— 4.6	—11.1
Detroit	17,665	17,016	2,034,415	2,474,001	64.8	61.4	69.0	60.2	— 3.4	+21.6
Balance of Area	9,598	10,716	912,253	1,632,957	35.2	38.6	31.0	39.8	+11.6	+79.0
Boston Metropolitan Area	23,358	22,917	2,114,082	2,855,379	100.0	100.0	100.0	100.0	— 1.9	+35.1
Central Business District	1,754	1,698	422,850	434,376	7.5	7.4	20.0	15.2	— 3.2	+ 2.7
Boston	9,414	8,720	1,008,408	1,236,160	40.3	38.1	47.7	43.3	— 7.4	+22.6
Balance of Area	13,944	14,197	1,105,574	1,619,219	59.7	61.9	52.3	56.7	+ 1.8	+46.5
Dallas Metropolitan Area	5,694	6,819	648,665	1,030,850	100.0	100.0	100.0	100.0	+19.8	+58.9
Central Business District	578	539	169,631	166,719	10.2	7.9	26.2	16.2	— 6.7	— 1.7
Dallas	4,506	5,562	572,123	894,838	79.1	81.6	88.2	86.8	+23.4	+56.4
Balance of Area	624	454	39,229	55,354	12.3	18.4	11.8	13.2	— 2.6	+77.7
Louisville Metropolitan Area	5,429	5,324	502,695	707,802	100.0	100.0	100.0	100.0	— 1.9	+40.8
Central Business District	1,181	1,026	193,979	233,060	21.8	19.3	38.6	32.9	—13.1	+15.0
Louisville	3,867	3,902	397,309	543,588	71.2	73.3	79.0	76.8	+ 0.9	+36.8
Balance of Area	1,562	1,422	105,386	164,214	28.8	26.7	21.0	23.2	— 0.9	+55.8
Denver Metropolitan Area	5,177	5,700	554,940	847,353	100.0	100.0	100.0	100.0	+10.1	+52.7
Central Business District	1,009	845	177,517	183,462	19.5	14.8	31.9	21.7	—16.6	+ 3.3
Denver	4,040	4,212	472,645	659,036	78.0	73.9	85.2	77.8	+ 4.3	+39.4
Balance of Area	1,137	1,488	82,295	188,317	22.0	26.1	14.8	22.2	+30.6	+128.8
Birmingham Metropolitan Area	4,742	4,500	432,994	523,714	100.0	100.0	100.0	100.0	— 5.1	+21.0
Central Business District	687	627	157,931	161,034	14.5	14.0	36.5	30.7	+ 0.4	+ 2.0
Birmingham	2,882	2,892	334,247	415,377	60.8	64.3	77.2	79.3	+ 0.4	+24.3
Balance of Area	359	258	14,668	25,697	7.8	35.7	22.8	20.7	—13.6	+ 9.7
Indianapolis Metropolitan Area	5,069	4,831	592,282	794,270	100.0	100.0	100.0	100.0	— 4.7	+34.1
Central Business District	1,181	977	265,216	293,085	23.3	20.2	44.8	36.9	—17.3	+10.5
Indianapolis	4,445	4,377	553,053	738,916	87.7	90.6	93.4	93.0	— 1.5	+33.5
Balance of Area	624	454	39,229	55,354	12.3	9.4	6.6	7.0	—27.2	+41.1

[1]Source: McMillan, Samuel C., *Changing Position of Retail Trade in Central Business Districts*, Traffic Quarterly, July, 1957.

Table A-11

MILEAGE OF EXISTING ROADS AND STREETS[1]

TYPE OF ROADWAY	*MILES*	*PER CENT*
Primary State Highways	434,357	12.5
Secondary State Highways	242,091	6.9
County, Town, and Township Roads	2,345,082	67.4
Municipal Streets	342,724	9.9
State Park, Forest and Other Roads	10,745	0.3
National Park, Forest, Reservation and Other Federal Roads	100,826	2.9
Toll Facilities Not Included in Other Systems	2,962	0.1
Total Mileage	3,478,787	100.0

[1]Source: U. S. Department of Commerce, Bureau of Public Roads, *Highway Statistics, 1958.* Data as of December 31, 1958.

TABLE A-12

MOTOR VEHICLE REGISTRATIONS, TRAVEL AND GROSS NATIONAL PRODUCT — 1921-1959[1]

YEAR	TOTAL VEHICLES REGISTERED (Millions)	TOTAL MOTOR TRAVEL (Vehicle-Miles, Billions)	GROSS NATIONAL PRODUCT (Constant 1947 Dollars, Billions)[2]	INDEX (1940 = 1.00)		
				Regis-trations	Travel	GNP
1921	10.49	55.0	95.3	32	18	56
1922	12.27	67.7	110.6	38	22	64
1923	15.10	85.0	123.8	47	28	72
1924	17.61	104.8	123.5	54	35	72
1925	20.07	122.3	134.4	62	40	78
1926	22.20	140.7	141.8	68	47	83
1927	23.30	158.5	141.7	72	52	83
1928	24.69	172.9	142.7	76	57	83
1929	26.70	197.7	149.3	82	65	87
1930	26.75	206.3	135.2	82	68	79
1931	26.09	216.2	126.6	80	72	74
1932	24.39	200.5	107.6	75	66	63
1933	24.16	200.6	103.7	74	66	60
1934	25.26	215.6	113.4	78	71	66
1935	26.55	228.6	127.8	82	76	74
1936	28.51	252.1	142.5	88	83	83
1937	30.06	270.1	153.5	93	89	89
1938	29.81	271.2	145.9	92	90	85
1939	31.01	285.4	157.5	96	94	92
1940	32.45	302.2	171.6	100	100	100

[1]Source: U. S. Department of Commerce, Bureau of Public Roads, Office of Business Economics.

[2]Constant dollars are in 1947 prices.

TABLE A-12 — *Continued*

MOTOR VEHICLE REGISTRATIONS, TRAVEL AND GROSS NATIONAL PRODUCT — 1921-1959[1]

YEAR	TOTAL VEHICLES REGISTERED (Millions)	TOTAL MOTOR TRAVEL (Vehicle-Miles, Billions)	GROSS NATIONAL PRODUCT (Constant 1947 Dollars, Billions)[2]	INDEX (1940 = 1.00)		
				Registrations	Travel	GNP
1941	34.89	333.6	198.2	108	110	116
1942	33.00	268.2	223.6	102	89	130
1943	30.89	208.2	248.9	95	69	145
1944	30.48	212.7	268.2	94	70	156
1945	31.04	250.2	263.1	96	83	153
1946	34.37	340.9	233.8	106	113	136
1947	37.84	370.9	232.2	117	123	135
1948	41.09	398.0	243.9	127	132	142
1949	44.69	424.5	241.5	138	140	141
1950	49.16	458.2	264.7	151	152	154
1951	51.91	491.1	282.9	160	163	165
1952	53.27	513.6	293.7	164	170	171
1953	56.28	544.4	305.3	173	180	178
1954	58.59	560.9	301.3	181	186	176
1955	62.76	603.4	322.8	193	200	188
1956	65.18	627.8	332.0	201	208	193
1957	67.16	647.0	339.0	207	214	198
1958	68.33	664.7	331.3	211	220	193
1959	70.45	696.0	NA[3]	217	230	NA[3]

[1]Source: Department of Commerce, Bureau of Public Roads, Office of Business Economics.
[2]Constant dollars are in 1947 prices.
[3]NA — Not Available.

TABLE A-13

ESTIMATE OF MOTOR VEHICLE TRAVEL — 1956-1958[1]

ITEM	MILLION VEHICLE MILES[2] 1956	1957	1958
Passenger Cars (including taxicabs):			
Rural travel	275,686	275,034	281,253
Urban travel	231,452	254,371	263,620
Total	507,138	529,405	544,873
Buses:			
Commercial buses:			
Rural travel	1,417	1,098	1,060
Urban travel	1,854	1,943	1,854
Total	3,271	3,041	2,914
School and non-revenue buses:			
Rural travel	1,184	1,103	1,141
Urban travel	150	249	255
Total	1,334	1,352	1,396
All buses:			
Rural travel	2,601	2,201	2,201
Urban travel	2,004	2,192	2,109
Total	4,605	4,393	4,310
All passenger vehicles:			
Rural travel	278,287	277,235	283,454
Urban travel	233,456	256,563	265,729
Total	511,743	533,798	549,183
Trucks and combinations:			
Rural travel	74,092	73,070	74,130
Urban travel	42,008	40,136	41,340
Total	116,100	113,206	115,470
All motor vehicles:			
Rural travel	352,379	350,305	357,584
Urban travel	275,464	296,699	307,069
Total	627,843	647,004	664,653

[1]Source: U. S. Department of Commerce, Bureau of Public Roads, *Highway Statistics, 1958.*
[2]Similar data for the years 1936-1955 are published in *Highway Statistics to 1955.*

TABLE A-14

ESTIMATED DOMESTIC PASSENGER-MILES — 1958 AND 1959[1]

(Billions of Passenger Miles)

MODE OF TRAVEL	1958 Miles	1958 Per Cent	1959 Miles	1959 Per Cent	PER CENT INCREASE 1958 to 1959
Automobiles	656.0	90.1	670.0	89.8	2.1
Railroads	25.3	3.4	29.0	3.9	14.9
Airlines	23.3	3.2	22.1	3.0	−5.1
Intercity Bus	24.0	3.3	24.0	3.3	0.0
Total Passenger-Miles	728.6	100.0	745.1	100.0	2.3

[1]Source: Chamber of Commerce of the United States, *Transport Review and Outlook,* year ending 1959.

TABLE A-15

HOME-BASED TRIPS IN STUDY AREAS, BY MODE OF TRAVEL[1]

	HOME-BASED TRIPS AS PER CENT OF ALL TRIPS							
	All Modes		*Auto Drivers*		*Auto Passengers*		*Transit*	
URBAN AREA	*Unlinked*	*Linked*	*Unlinked*	*Linked*	*Unlinked*	*Linked*	*Unlinked*	*Linked*
Chicago, Ill.[2,3]	----	86.8	----	83.0	----	88.5	----	94.0
Detroit, Mich.	79.4	*87.0*	74.0	*84.0*	82.2	*90.0*	91.0	*95.0*
Washington, D. C.	83.8	91.6	79.3	88.2	86.5	93.0	89.8	95.5
Pittsburgh, Pa.[3]	----	87.0	----	83.0	----	87.0	----	96.3
St. Louis, Mo.	81.0	91.3	76.0	86.8	85.0	95.0	91.4	97.0
Houston, Tex.	81.2	*91.0*	76.0	*87.0*	85.4	*95.0*	93.3	*97.0*
Kansas City, Mo.	77.2	88.2	71.7	82.9	83.4	94.1	90.6	97.3
Phoenix, Ariz.	74.8	85.3	69.0	*80.0*	83.2	*94.0*	96.7	*99.0*
Nashville, Tenn.	75.8	*85.5*	69.5	*80.0*	83.3	*94.0*	92.7	*97.0*
Fort Lauderdale, Fla.	77.5	*86.5*	75.4	*83.6*	81.2	*93.0*	90.3	*97.0*
Charlotte, N. C.	73.8	83.9	66.6	77.0	85.0	93.7	93.1	96.3
Reno, Nev.	77.6	*86.5*	75.2	*85.0*	81.1	*93.0*	96.0	*98.0*

[1]Source: Origin-destination studies in each area.

[2]Chicago and Detroit data for home-based trips computed at twice the volume of trips "to home" in each category.

[3]Chicago and Pittsburgh data represent only "linked" trips. The number of non-home-based trips is reduced in the linking process. Auto driver stops that are incidental to the main trip purpose have been eliminated. Thus, stops to pick up or let out passengers who belong to a "commuter club" have been eliminated, linking the driver's home and ultimate destination directly. The linking process will eliminate 5 to 10 per cent of the driver trips — all of them of the "non-home-based" variety. Auto passengers and transit riders (and some auto drivers) who change from one mode to another have been reported making two trips. When these are linked, the result may be identified as predominantly a transit trip, or essentially a passenger trip. In either case, non-home-based trips are eliminated in this process. Home-based trips thus become a higher proportion of the linked trips than of the original, unlinked data.

Figures for linked trips in italics are estimates, whereas other figures were compiled.

Table A-16

TRIPS TO AND FROM "EAT MEAL" IN STUDY AREAS WITH OTHER TERMINUS AT NON-HOME PURPOSE[1]

(Auto Drivers Only)

URBAN AREA	*TOTAL NON-HOME TRIPS (Unlinked)*	*NON-HOME TO OR FROM EAT MEAL*	*PER CENT FOR EAT MEAL*
Washington	265,000	20,000[2]	8
Pittsburgh	193,689	26,378	14
St. Louis	327,000	28,300	9
Houston	248,000	37,300	15
Kansas City	315,500	34,000	11
Phoenix	33,000	8,000	24
Fort Lauderdale	58,630	8,360	14
Charlotte	95,000	19,100	20
Reno	20,037	5,955	29

[1]Source: Origin-destination studies in each area.

[2]Approximate "Eat Meal" and "Medical-Dental" trip purposes were combined in the 1955 Washington Survey.

Table A-17

HOME-BASED TRIPS PER HOUSEHOLD BY PURPOSE IN STUDY AREAS[1]

URBAN AREA	NO. DWELLINGS (Thousands)	HOME-BASED TRIPS PER DWELLING UNIT						
		Work	*Business*	*Shop*	*Social-Recreation*	*School*	*Other*	*TOTAL*
Chicago	1,667.0	1.93	0.50	0.98	1.17	0.20	0.39	5.17
Detroit	896.0	1.94	0.40	0.65	0.94	0.29	0.45	4.67
Washington	520.0	1.82	0.41	0.60	0.53	0.40	0.47	4.23
Pittsburgh	452.0	1.58	0.91	0.63	0.58	0.51	----[2]	4.21
St. Louis	409.0	1.85	0.39	0.85	1.05	0.31	0.45	4.90
Houston	273.0	1.83	0.49	0.95	1.03	0.59	0.62	5.51
Kansas City	280.0	1.72	0.45	0.88	1.17	0.31	0.61	5.14
Phoenix	132.0	1.20	0.49	0.94	0.95	0.55	0.63	4.76
Nashville	109.0	1.66	0.47	0.92	1.31	0.41	0.71	5.48
Fort Lauderdale	98.2	0.79	0.43	0.68	0.64	0.03	0.25	2.82
Charlotte	59.0	1.79	0.45	0.87	1.32	0.36	0.77	5.56
Reno	19.8	1.42	0.62	0.89	1.28	0.03	0.64	4.88
Average (Unweighted)		1.63	0.50	0.82	1.00	0.33	0.50	4.78

[1]Source: Origin-destination studies in each area.

[2]Distributed to other categories.

TABLE A-18

WORK TRIPS BY RESIDENTS OF STUDY AREAS[1]
(ALL TRIPS TO WORK)

URBAN AREA	CARS OWNED (Thousands)	WORK TRIPS Total	WORK TRIPS Drivers and Passengers	AVERAGE PERSONS IN CAR	DRIVER TRIPS PER CAR	PER CENT OF TRIPS Drivers and Passengers	PER CENT OF TRIPS Transit
Chicago	1,342.0	2,033,000	1,369,000	1.21	0.84	67.4	32.6
Detroit	846.0	1,237,385	974,445	1.22	0.94	78.8	21.2
Washington	398.0	614,733	427,849	1.43	0.75	69.7	30.3
Pittsburgh	393.0	459,931	353,045	1.22	0.74	76.8	23.2
St. Louis	367.0	516,054	412,044	1.25	0.90	79.9	20.1
Houston	256.0	350,009	288,770	1.29	0.87	82.5	17.5
Kansas City	258.0	384,805	356,291	1.25	1.04	92.6	7.4
Phoenix	139.0	153,718	147,695	1.16	0.92	96.2	3.8
Nashville	107.0	150,393	134,376	1.31	0.96	89.5	10.5
Fort Lauderdale	77.6	61,300	59,200	1.20	0.64	96.5	3.5
Charlotte	61.8	97,070	86,697	1.22	1.15	89.5	10.5
Reno	22.7	21,084	20,534	1.24	0.73	97.3	2.7
Average (Unweighted)				1.25	0.87	84.7	15.3

[1]Source: Origin-destination studies in each area.

TABLE A-19

BUSINESS AND SHOPPING TRIPS BY RESIDENTS OF STUDY AREAS[1]
(ALL TRIPS TO BUSINESS AND SHOP)

URBAN AREA	CARS OWNED (Thousands)	SHOPPING AND BUSINESS TRIPS		AVERAGE PERSONS IN CAR	DRIVER TRIPS PER CAR	PER CENT OF TRIPS	
		Total	Drivers and Passengers			Drivers and Passengers	Transit
Chicago	1,342.0	1,780,000	1,449,000	1.59	0.68	81.5	18.5
Detroit	846.0	791,705	702,725	1.41	0.59	88.7	11.3
Washington	398.0	388,337	322,084	1.55	0.52	82.9	17.1
Pittsburgh	393.0	480,146	427,518	1.45	0.75	89.0	11.0
St. Louis	367.0	409,055	366,279	1.60	0.62	89.5	10.5
Houston	256.0	318,049	296,273	1.46	0.79	93.2	6.8
Kansas City	258.0	310,326	293,370	1.48	0.77	94.6	5.4
Phoenix	139.0	163,228	160,097	1.39	0.83	98.0	2.0
Nashville	107.0	133,553	128,025	1.41	0.85	96.0	4.0
Fort Lauderdale	77.6	91,090	90,360	1.46	0.79	99.3	0.7
Charlotte	61.8	73,117	70,033	1.30	0.87	95.8	4.2
Reno	22.7	26,895	26,457	1.48	0.78	98.4	1.6
Average (Unweighted)				1.41	0.71	92.2	7.8

[1]Source: Origin-destination studies in each area.

TABLE A-20

SOCIAL-RECREATIONAL TRIPS BY RESIDENTS OF STUDY AREAS[1]
(ALL TRIPS TO SOCIAL-RECREATIONAL)

URBAN AREA	CARS OWNED (Thousands)	SOCIAL-RECREATIONAL TRIPS		AVERAGE PERSONS IN CAR	DRIVER TRIPS PER CAR	PER CENT OF TRIPS	
		Total	Drivers and Passengers			Drivers and Passengers	Transit
Chicago	1,342.0	1,265,000	1,094,000	2.08	0.39	86.5	13.5
Detroit	846.0	636,675	594,790	2.40	0.29	93.4	6.6
Washington	398.0	185,512	163,887	2.25	0.18	88.3	11.7
Pittsburgh	393.0	173,476	161,326	2.08	0.20	93.0	7.0
St. Louis	367.0	303,593	281,020	2.30	0.33	92.6	7.4
Houston	256.0	199,808	191,181	2.31	0.32	95.6	4.4
Kansas City	258.0	241,366	233,733	2.54	0.36	96.8	3.2
Phoenix	139.0	93,885	92,932	2.19	0.31	99.0	1.0
Nashville	107.0	106,581	103,697	2.36	0.41	97.3	2.7
Fort Lauderdale	77.6	45,900	45,490	2.31	0.25	99.0	1.0
Charlotte	61.8	56,624	55,274	2.17	0.41	97.5	2.5
Reno	22.7	17,763	17,527	2.27	0.34	98.7	1.3
Average (Unweighted)				2.18	0.30	94.8	5.2

[1]Source: Origin-destination studies in each area.

TABLE A-21

TRAVEL MODES TO OFFICE BUILDINGS IN HOUSTON, TEXAS - 1959[1]

1. CENTRAL BUSINESS DISTRICT LOCATION

PERSON	TRAVEL MODE											
	Drove Personal Car		Drove Company Car		Passengers in Car		Bus		Walked and Other		Total	
	Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent
Male	745	50	193	13	438	30	90	6	20	1	1,486	100.0
Female	422	41	3	----	505	49	94	9	13	1	1,037	100.0
Total	1,167	47	196	8	943	37	184	7	33	1	2,523	100.0

2. LOCATION—ABOUT FOUR MILES SOUTHWEST OF DOWNTOWN

(Prudential and Fannin State Bank Buildings)

PERSON	TRAVEL MODE											
	Drove Personal Car		Drove Company Car		Passengers in Car		Bus		Walked and Other		Total	
	Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent
Male	85	56	33	22	32	22	1	----	1	----	152	100.0
Female	143	58	2	1	96	39	2	1	4	1	247	100.0
Total	228	57	35	9	128	32	3	1	5	1	399	100.0

[1]Source: City of Houston.

TABLE A-22

CHANGES IN ANNUAL TRANS-HUDSON PASSENGER MOVEMENTS BY MODES OF TRAVEL - 1948-1958[1]

YEAR	*MILLIONS OF PASSENGERS* All Modes	In Autos	In Buses	Ferry Pedestrians	In Railroads
1948	266.6	80.7	60.1	8.3	117.5
1958	276.8	136.4	76.9	1.4	62.1
Changes 1948-58					
Millions	+10.2	+55.7	+16.8	— 6.9	—55.4
Per Cent	+ 3.8	+69.0	+28.0	—83.1	—47.1

TYPE TRAVEL	*Total Travel By All Modes 1958*	*CHANGES IN MILLIONS* By All Modes	In Autos	In Buses	As Ferry Pedestrians	By Railroads
1. All Days	276.8	+10.2	+55.7	+16.8	—6.9	—55.4
2. Weekends (NY and NJ Residents)	86.2	+ 9.1	+21.1	+ 2.6	—2.2	—12.4
3. NY Residents to and from NJ	55.0	+10.1	+15.6	+ 2.6	—0.8	— 7.3
4. NJ Residents to and from Non-CBD	31.7	+ 8.8	+10.5	+ 1.2	—0.4	— 2.5
5. NJ Residents to and from Manhattan CBD	103.9	—17.8	+ 8.5	+10.4	—3.5	—33.2
6. In off hours	45.8	— 3.6	+ 4.7	+ 4.9	—1.1	—12.1
7. In rush hours	58.1	—14.2	+ 3.8	+ 5.5	—2.4	—21.1

[1]Source: Cherniack, Nathan, "Passenger Data for Urban Transportation Planning," *Journal of the Highway Division,* Proceedings of the American Society of Civil Engineers, December, 1959.

TABLE A-23

DAILY TRIPS TO SAN FRANCISCO CENTRAL BUSINESS DISTRICT 1912-1954[1]

YEAR	*FINANCIAL DISTRICT* Total People Entering	Per Cent By Car	Per Cent By Transit
1912	299,966	17.4	82.6
1926	332,356	30.0	70.0
1937	326,857	41.2	58.8
1947[2]	382,203	39.2	60.8
1954[2]	400,000	51.0	49.0

YEAR	*METROPOLITAN TRAFFIC DISTRICT* Total People Entering	Per Cent By Car	Per Cent By Transit
1947	535,286	50.6	49.4
1954[2]	540,552	60.1	39.9

[1]Source: San Francisco City Planning Commission.
[2]Estimate by Planning Commission.

TABLE A-24

TRENDS IN RAILROAD COMMUTATION – 1922-55[1]

YEAR	PASSENGERS (thousands)	PASSENGER-MILES (millions)	REVENUE: CENTS PER PASSENGER-MILE
1922	429,446	6,132	1.10
1923	446,538	6,401	1.09
1924	438,773	6,407	1.10
1925	446,766	6,592	1.11
1926	445,936	6,605	1.13
1927	445,171	6,650	1.11
1928	442,484	6,626	1.11
1929	457,617	6,898	1.11
1930	438,688	6,669	1.09
1931	386,349	6,018	1.06
1932	315,462	4,986	1.07
1933	271,984	4,308	1.08
1934	262,825	4,163	1.09
1935	259,099	4,112	1.09
1936	259,199	4,191	1.06
1937	245,824	4,116	1.01
1938	227,412	3,933	1.01
1939	231,126	4,012	1.02
1940	229,266	3,997	1.01
1941	232,456	4,088	1.01
1942	286,225	4,917	1.07
1943	312,246	5,261	1.07
1944	317,918	5,344	1.07
1945	322,734	5,418	1.08
1946	340,670	5,857	1.08
1947	344,604	6,008	1.12
1948	332,196	5,855	1.30
1949	308,512	5,478	1.43
1950	227,102	4,985	1.58
1951	269,464	4,870	1.71
1952	260,463	4,755	1.87
1953	255,829	4,757	1.95
1954	249,069	4,739	2.03
1955	247,759	4,776	2.12
1956	247,061	4,841	2.20
1957	249,142	4,901	2.37
1958	239,067	4,776	2.59
1959	221,407	4,529	2.75

[1]Source: The Association of American Railroads, *Statistics of Class I Railways of the United States.*

TABLE A-25

SUMMARY OF TRANSIT TRENDS[1]

YEAR	TOTAL VEHICLES	TOTAL VEHICLE MILES (millions)	TOTAL PASSENGERS CARRIED (millions)	RIDES PER CAPITA
1924	NA[2]	NA	16,301	271
1925	NA	NA	16,651	270
1926	86,166	2,669.7	17,234	274
1927	88,336	2,753.0	17,201	267
1928	88,292	2,748.0	16,989	257
1929	88,120	2,762.4	16,985	252
1930	86,263	2,707.0	15,567	226
1931	83,683	2,549.0	13,924	200
1932	80,403	2,363.0	12,025	172
1933	78,634	2,259.0	11,327	160
1934	76,759	2,312.0	12,038	169
1935	74,844	2,327.0	12,226	171
1936	76,039	2,433.0	13,146	182
1937	74,367	2,505.0	13,246	182
1938	73,137	2,434.0	12,645	173
1939	75,156	2,470.0	12,837	174
1940	75,464	2,596.0	13,098	176
1941	79,999	2,676.4	14,085	188
1942	86,893	3,047.7	18,000	239
1943	88,106	3,262.4	22,000	291
1944	89,160	3,284.5	23,017	309
1945	89,758	3,253.8	23,254	312[3]
1946	89,845	3,304.3	23,372[3]	282
1947	91,782[3]	3,342.4[3]	22,540[3]	269
1948	90,507	3,311.1	21,368	252
1949	88,129	3,183.6	19,008	219
1950	86,310	3,007.6	17,246	195
1951	85,335	2,913.4	16,125	180
1952	82,336	2,814.5	15,119	167
1953	78,875	2,695.5	13,902	153
1954	76,198	2,548.8	12,392	135
1955	73,089	2,447.5	11,529	124
1956	70,373	2,366.6	10,941	117
1957	68,971	2,289.5	10,389	111
1958	67,149	2,201.0	9,732	104
1959	65,780	2,158.9	9,557	102

[1]Source: American Transit Association.
[2]NA — Not Available.
[3]Peak year.

Table A-26

CHANGES IN TRANSIT PATRONAGE[1]

PERIOD	RAPID TRANSIT	SURFACE TRANSIT POPULATION GROUP: 500,000 and Over	250,000 to 500,000	100,000 to 250,000	50,000 to 100,000	Less Than 50,000	Suburban and Other	ALL
1925-1930	+13.0	— 8.3	— 18.8	— 5.0	— 12.4	— 14.4	— 2.6	— 6.5
1930-1935	—12.6	—17.5	— 23.2	— 28.6	— 34.6	— 31.0	— 35.8	—21.5
1935-1940	+ 6.5	+ 4.9	+ 16.8	+ 17.7	+ 35.2	+ 58.0	— 34.6	+ 7.1
1940-1945	+13.3	+56.9	+113.9	+122.1	+172.0	+207.3	+135.0	+77.5
1945-1950	—16.1	—23.8	— 31.6	— 31.1	— 28.1	— 18.5	— 33.3	—25.8
1950-1955	—17.4	—32.2	— 35.6	— 39.7	— 39.7	— 49.1	— 33.3	—33.1
1955-1959	— 2.3	—13.5	— 26.1	— 27.9	— 26.2	— 33.4	— 19.9	—17.1
1925-1959	—19.3	—44.3	— 49.3	— 46.9	— 32.7	— 20.7	— 65.8	—42.6

[1]Source: American Transit Association.

Table A-27

RAPID TRANSIT TRENDS[1]

(1940 = 100.0)

YEAR	NEW YORK CITY	CHICAGO	PHILADELPHIA
1940	100.0[2]	100.0[2]	100.0
1941	99.9	102.1	107.6
1942	103.5	107.7	124.5
1943	105.8	113.9	144.2
1944	103.7	122.1	139.5
1945	105.9	127.2	148.0
1946	112.1	127.6	154.8
1947	109.9	117.8	140.8
1948	103.7	111.2	131.8
1949	93.4	98.8	118.4
1950	90.0	89.4	119.8
1951	86.9	91.2	110.0
1952	84.3	91.1	107.1
1953	81.1	90.3	99.9
1954	75.6	89.9	95.2
1955	73.9	91.3	89.4
1956	74.0	93.5	87.0
1957	72.6	90.8	82.8
1958	71.8	86.6	80.9
1959	72.1	91.6	77.7

[1]Source: American Transit Association.

[2]In 1940, New York City had about 1,843 million riders; Chicago, 123 million; and Philadelphia, 94 million.

TABLE A-28

RAPID TRANSIT TRACK IN UNITED STATES — 1940-1959[1]

Miles of First Main Track and Total Miles of Single Track in Rapid Transit Service

YEAR	NEW YORK CITY TRANSIT SYSTEM		CHICAGO TRANSIT AUTHORITY		PHILA-DELPHIA TRANSPOR-TATION CO.		METRO. TRANSIT AUTHORITY (BOSTON)[3]		CLEVELAND TRANSIT SYSTEM		HUDSON AND MANHATTAN		TOTAL	
	Line	*Route*	*Line*	*Route*	*Line*	*Route*	*Line*	*Route*	*Line*	*Route*	*Line*	*Route*	*Line*	*Route*
1940	247.03	860.00	82.15	231.50	26.43	74.93	23.32	57.20			8.47	18.04	387.40	1,241.67
1941	247.03	860.00	82.15	231.50	26.43	74.93	23.32	57.20			8.47	18.04	387.40	1,241.67
1942	240.70	844.32	82.15	231.50	26.43	74.93	21.04	52.65			8.47	18.04	378.79	1,221.44
1943	240.10	844.32	86.98	241.56	26.43	74.93	21.04	52.50			8.47	18.04	383.02	1,231.35
1944	236.91	835.17	86.98	241.56	26.43	74.93	21.04	52.42			8.47	18.04	379.83	1,222.12
1945	236.89	835.13	86.98	241.56	26.43	74.93	21.04	52.42			8.47	18.04	379.81	1,222.08
1946	239.27	839.21	86.98	241.45	26.43	74.93	21.04	52.42			8.47	18.04	382.19	1,226.05
1947	239.27	839.21	86.98	241.39	26.43	74.93	21.04	52.33			8.47	18.04	382.19	1,225.90
1948	241.56	848.52	82.07	230.61	26.43	74.93	21.04	52.33			8.47	18.04	379.57	1,224.43
1949	242.06	855.09	82.07	230.61	26.43	74.91	21.04	52.33			8.47	18.04	380.07	1,230.98
1950	239.07	846.75	82.10	230.90	26.43	74.92	21.04	52.33			8.47	18.04	377.11	1,222.94
1951	237.07	844.89	77.80	227.10	26.43	74.92	21.04	52.31			8.47	18.04	370.81	1,217.26
1952	236.59	842.98	77.80	225.40	26.43	75.15	23.54	61.37			8.47	18.04	372.83	1,222.94
1953	236.59	842.98	78.00	226.46	27.50	77.15	23.54	61.19			8.47	18.04	374.10	1,225.82
1954	236.59	842.16	71.99	216.79	27.50	77.15	25.06	64.30			8.47	18.04	369.61	1,218.44
1955	228.71	817.66	72.89	212.52	28.12[2]	78.39	25.06	64.32	13.16	30.23	8.47	18.04	376.41	1,221.16
1956	237.74	840.95	73.40	214.38	30.37[2]	82.90	25.06	64.32	13.16	30.23	8.47	18.04	388.20	1,250.81
1957	237.41	842.45	69.28	206.94	30.37[2]	82.90	25.06	64.32	13.16	30.23	8.47	18.04	383.75	1,244.88
1958	236.70	841.17	68.23	204.65	29.82[2]	81.80	25.06	64.32	14.92	33.80	8.47	18.04	383.20	1,243.78
1959	236.70	836.86	68.23	204.96	32.23[2]	86.60	25.06	64.32	14.92	33.84	8.47	18.04	385.61	1,244.62

[1]Source: American Transit Association.

[2]Estimate.

[3]Rapid Transit Only. Excludes Newton Highlands Branch and related surface-subway routes.

TABLE A-29

SUMMARY OF TURNSTILE PASSENGER COUNTS CLEVELAND TRANSIT SYSTEM[1]

DATE	LOCATION				
	East Side	*West Side*	*Subtotal East and West Sides*	*Cleveland Union Terminal Public Square Station*	*Rapid Transit System Total*
Mar. 17, 1955, to Dec. 31, 1955	3,495,051	1,434,377	4,929,428	3,156,405	8,085,833
1956	4,964,599	4,275,619	9,240,218	5,492,945	14,733,163
1957	5,231,925	4,720,555	9,952,480	5,788,864	15,741,344
1958	4,976,208	4,830,444	9,806,652	5,742,329	15,548,981
1959	5,312,824	6,087,960	11,400,784	6,421,362	17,822,146
First Six Months, 1960	2,644,637	3,167,211	5,811,848	3,229,157	9,041,005
First Six Months, 1959	2,631,937	3,003,666	5,635,603	3,108,411	8,744,014
Increase or Decrease	12,700	163,545	176,245	120,746	296,991
Per Cent Change	+0.48	+5.44	+3.13	+3.88	+3.83

[1]Source: Cleveland Transit System.

TABLE A-30

DISTRIBUTION OF CONSUMER EXPENDITURES FOR TRANSPORTATION[1]

TYPE OF TRANSPORTATION	*YEAR*					
	1909	*1919*	*1929*	*1940*	*1950*	*1954*
All Transportation	100.0	100.0	100.0	100.0	100.0	100.0
Per Cent Private	47.4	71.5	78.3	82.2	86.9	87.9
Per Cent Local Public Carrier	33.3	16.8	14.7	12.7	8.9	8.0
Per Cent Intercity Public Carrier	19.3	11.7	7.0	5.1	4.2	4.1

[1]Source: J. Frederic Dewhurst and Associates, *America's Needs and Resources*, Twentieth Century Fund (1955) p. 971; U. S. Department of Commerce, *National Income*, A Supplement to the *Survey of Current Business* (1954) p. 207; *Survey of Current Business* (July, 1955), p. 19.

TABLE A-31

TRANSIT RIDING IN SELECTED CITIES – 1959[1]

City	*Population of Area Served By Transit (1959)*	*Total Area Served By Transit (Sq. Miles)*	*Area of Central City (Sq. Miles)*	*Transit Rides Per Capita Per Year (1959)*
Chicago	3,757,000	213	208	145.3[2]
Philadelphia	2,805,000	414	127	119.1
Detroit	2,158,326	182	140	65.1
Boston	1,520,516	114	45	132.4[2]
Pittsburgh	1,266,956	265	55	63.3
Minneapolis	1,250,000	198	59	51.8
St. Louis	1,200,000	130	60	81.8
Milwaukee	1,004,000	127	91	105.6
Buffalo	777,066	79	43	79.4
Kansas City	750,000	98	81	49.6
Atlanta	750,000	175	100	74.3
Cincinnati	673,500	109	76	69.7
New Orleans	597,000	58	199[3]	180.5
Seattle	580,000	88	88	76.5
Memphis	500,000	91	91	69.9
Providence	500,000	244	19	55.9
Indianapolis	475,000	61	61	55.3
Rochester	462,756	100	37	70.3
Akron	350,000	70	54	32.7
Harrisburg	137,044	30	12	66.0
ALL TRANSIT RIDING				102

[1]Source: American Transit Association.
[2]Includes surface and rapid transit.
[3]Actual populated area conforms with transit service area.

TABLE A-32

PERSON TRIPS LEAVING PHILADELPHIA CENTRAL BUSINESS DISTRICT SPRING WEEKDAY, 1955[1]

	PEAK HOUR (5:00-6:00 PM)			*OTHER 23 HOURS*			*TOTAL DAY – 24 HOURS*	
MODE OF TRANSPORTATION	*No. of Trips*	*Percentage of Peak Total By Each Mode*	*Percentage of Each Mode's Daily Total*	*No. of Trips*	*Percentage of Peak Total By All Modes*	*Percentage of Each Mode's Daily Total*	*No. of Trips*	*Percentage of Daily Total By All Modes*
Transit and Rail	126,592	71.5	23.6	411,108	45.7	76.4	537,700	50.0
PTC Surface	35,556	20.1	16.5	180,444	20.0	83.5	216,000	20.1
Rapid Transit	62,589	35.3	25.5	183,111	20.4	74.5	245,700	22.8
Suburban Rail	21,912	12.4	44.5	27,288	3.0	55.5	49,200	4.6
Interstate Bus	6,535	3.7	24.4	20,265	2.3	75.6	26,800	2.5
Auto, Taxi, Truck	45,066	25.5	9.4	435,234	48.4	90.6	480,300	44.6
Auto and Taxi	42,521	24.1	9.7	394,479	43.9	90.3	437,000	40.6
Truck	2,545	1.4	5.9	40,755	4.5	94.1	43,300	4.0
Pedestrian	5,244	3.0	9.0	52,756	5.9	91.0	58,000	5.4
Total	176,902	100.0	16.4	899,098	100.0	83.6	1,047,000	100.0

[1]Source: Philadelphia Urban Traffic and Transportation. Adapted from Owen, Wilfred, *The Metropolitan Transportation Problem,* The Brookings Institution, Washington, D. C., 1956.

TABLE A-33

SUMMARY OF PRINCIPAL RAIL RAPID TRANSIT OPERATIONS[1]

CITY	MILES OF LINE (Approximate)	NUMBER OF CARS (Approximate)	NUMBER OF STATIONS (Approximate)	PRINCIPAL ROUTES	TYPE SERVICE
New York City	237	6,600	486	5 Manhattan Trunk Lines 2 East-West Lines to Brooklyn[2] 1 East-West Line to Queens[4] 1 Crosstown Line (Queens-Brooklyn)	Express and Local
Chicago	68	1,216	137	2 North-South Routes 1 West-Northwest Route 1 West Route	Express; Skipstop; Local
Philadelphia	32	541	61	1 North-South (Broad St.) 1 East-West (Market St.) 1 Trans-River to Camden (1 Street Car Subway)	Express; Skipstop; Local Surface Cars
Boston	43[4]	650[4]	62[4]	1 Cambridge-Dorchester 1 Forest Hills-Everett 1 East Boston Tunnel 1 Tremont Surface Car Subway (Newton Highlands)	Local, Some Rush-Hour Express Service, Surface Cars
Cleveland[4]	28	143	14[5]	1 CTS Route 1 Shaker Heights Route	Local, Some Rush Hour Express Service
Toronto	4.6	140	12	1 (Yonge Street)	Local

[1]Source: Compiled from data obtained from American Transit Association; Gottfeld, Gunther, *Rapid Transit in Six Metropolitan Areas*, U. S. Government Printing Office, November, 1959, and special field investigations.
[2]Exclusive of Manhattan Trunk Lines.
[3]Includes both CTS and Shaker Heights systems.
[4]Includes rapid transit portions of surface subway routes, including 25 surface subway stations, 325 surface subway PCC cars.
[5]CTS only.

Table A-34

CAR OWNERSHIP OF TRANSIT USERS

Capitol Region — Hartford, Connecticut

September, 1960[1]

ROUTE *Description*	*CARS AVAILABLE FOR USE BY FAMILY – PER CENT DISTRIBUTION* None	One	Two	Three+	Total
Connecticut Company					
West Hartford-Unionville	43	48	8	1	100
Park Street-Main Street	50	43	6	1	100
Windsor-Rainbow-Campfield	32	48	17	3	100
Franklin Ave.-Blue Hills	40	50	9	1	100
Wethersfield	49	41	9	1	100
Manchester	32	50	16	2	100
Rockville	30	58	11	1	100
Arrow Line Incorporated					
Avon-Canton	30	70	0.0	0.0	100
Silver Lane Lines					
Manchester	22	62	14	2	100
TOTAL — All Lines	39	49	10	2	100

[1]Source: Wilbur Smith and Associates, *Mass Transportation in the Capitol Region, 1960.*

TABLE A-35

COST-INCOME SUMMARY — PLANNED RAPID TRANSIT SYSTEMS[1]

ITEM	SYSTEM								
	St. Louis, Missouri (1980)	San Francisco, (1980) 123 Mi.[2]	California (1980) 100 Mi.[3]	Los Angeles, California	Washington, D. C. (1980) Rail	Washington, D. C. (1980) Bus	Total	Philadelphia-New Jersey Extension (1958-1962)	Atlanta (1970)
Gross Revenue	$17,744,840	$35,100,000	$47,074,000	Not Available	Not Itemized	Not Itemized	$53,690,000	$6,825,000[5]	$3,800,000
Operating Expense	12,467,140	22,994,000	23,522,000	Not Available	20,650,000	17,900,000	38,500,000	2,700,000	1,530,000
Gross Income	5,277,700	12,106,000	23,552,000	Not Available	Not Itemized	Not Itemized	15,140,000	4,125,000[5]	2,370,000
Av. Annual Debt Service (30 years at 5 per cent)[4]	11,383,900	53,252,000	77,800,600	$34,575,100	30,955,000	5,739,500	36,694,500	4,538,000[6] 5,789,500	3,838,009
Reserve (or Deficiency)	(6,106,200)	(42,146,000)	(52,248,600)	Not Available	Not Itemized	Not Itemized	(21,554,500)	(1,251,500)	(1,468,009)

[1]Sources: Compiled from published transportation studies for each area —
a. W. C. Gilman and Company, *St. Louis Metropolitan Area Transportation Study*, 1957-70-80; 1959.
b. Parsons, Brinckerhoff, Hall and Macdonald, *Regional Rapid Transit — A Report to the San Francisco Bay Area Rapid Transit Commission*, 1953-1955.
c. San Francisco Bay Area Rapid Transit District, *Plans of Routes, Rights-of-Way, Terminals, Stations, Yards, and Related Facilities and Improvements*, August 11, 1960.
d. Daniel, Mann, Johnson, and Mendenhall, *Los Angeles Metropolitan Transit Authority Rapid Transit Program*, June, 1960.
e. DeLeuw, Cather, and Company, *Civil Engineering Report, Mass Transportation Survey, National Capital Region*, 1958.
f. Philadelphia Urban Traffic and Transportation Board, based on report submitted by Louis T. Klauder and Associates, March, 1959.
g. *"Rapid-Atlanta,"* as reported in *Passenger Transport*, August, 1960.

[2]1954 Report.

[3]June, 1960, Report.

[4]Assumed in Washington Study. (Note 40-year period at 5 per cent was assumed in St. Louis Report.)

[5]1958 Level.

[6]1962 Level.

TABLE A-36

COST PASSENGER RELATIONSHIPS – PLANNED RAPID TRANSIT SYSTEMS (1980)[1]

ITEM	SYSTEM: St. Louis Missouri	San Francisco, California: 1954 Plan[4]	San Francisco, California: 1960 Plan	Los Angeles, California	New Jersey Extension[7]	Atlanta, Georgia[8]	Washington, D. C.: Rail	Washington, D. C.: Bus	Washington, D. C.: Total
Type System	Bus-way	Rail	Rail	Rail	Rail	Rail	Rail	Bus	Total
Miles	42[9]	123	100	74	28	16	34.4	66.4	100.8
Capital Cost	$175,000,000	$818,630,000	$1,195,994,000	$529,700,000	$89,000,000	$59,000,000	$475,860,000	$88,230,000	$564,090,000
Capital Cost/Mile	4,166,670	6,655,530	11,959,940	7,062,670	3,178,570	3,680,000	13,833,000	1,328,700	5,596,100
Av. Annual Debt Service (30 years at 5 per cent)	11,383,900	52,252,000	77,800,600	34,575,100	5,789,500	3,838,000	30,955,000	5,739,000	36,694,500
Annual Operating Cost	12,467,140	22,994,000	23,522,000	Not Available	2,700,000	1,530,000	20,650,000	17,900,000	38,550,000
Total Annual Cost	$ 23,851,040	$ 76,246,000	$ 101,322,600	Not Available	$ 8,489,500	$ 5,368,000	$ 51,605,000	$23,639,500	$ 75,244,500
Total Annual Cost/Mile	$ 567,881	$ 619,000	$ 1,013,230	Not Available	$ 303,200	$ 336,000	$ 1,501,450	$ 356,020	$ 746,470
Daily Passengers	265,200	Not Available	426,800	Not Available	81,300	37,500	418,000	342,000	760,000
Passengers (Per Year)	75,582,000[2] 78,060,000[3]	Not Available	128,040,000	Not Available	24,390,000	11,250,000	125,400,000	102,600,000	228,000,000
Annual Cost/Passenger	$ 0.316	Not Available	$ 0.791	Not Available	$ 0.349	$ 0.503	$ 0.412	$ 0.230	$ 0.330
Annual Passenger Miles[3]	405,540,750[2] 426,629,000	429,840,000[4]	1,638,400,000[3]		121,946,000[3] 187,919,500[3]	56,250,000[3]	975,335,700[3]	608,520,000[3]	1,583,855,700[3]
Annual Cost/Pass. Mile	$ 0.059[2] 0.056[3]	$ 0.053	$ 0.062		$ 0.070[5] $ 0.046[6]	$ 0.095	$ 0.053	$ 0.039	$ 0.048

[1]Source: Compiled from published transportation studies for each area. All plans based on 1980 values except as noted.
[2]285 days.
[3]300 days.
[4]1971 level – annual value.
[5]On extension only.
[6]From downtown Philadelphia.
[7]1958 level.
[8]1970 level.
[9]Also 44 miles over freeways.

Table A-37

CAPITAL COSTS AND RELATED DATA – ALTERNATE TRANSPORTATION SYSTEMS NATIONAL CAPITAL REGION[1]

TYPE FACILITY	*ESTIMATED CAPITAL COST – (Thousands of Dollars)* *Plan I Auto-Dominant*	*Plan II All-Bus*	*Plan III All-Rail*	*Plan IV Recommended*
Highway Facilities				
Freeways	$1,870,450	$1,401,400	$1,401,400	$1,401,400
Parkways	299,050	220,150	220,150	220,150
Major Streets	201,650	181,450	181,450	181,450
	$2,371,150	$1,803,000	$1,803,000	$1,803,000
Parking Facilities				
Outer Transit Stations	$ ----	$ 20,800	$ 20,800	$ 20,800
Intermediate Stations	----	16,800	16,800	16,800
Sector Zero (Downtown)	236,000	119,000	119,000	119,000
	$ 236,000	$ 156,600	$ 156,600	$ 156,600
Total Highway and Parking Facilities	$2,607,150	$1,959,600	$1,959,600	$1,959,600
Express Bus Facilities				
Special Bus Roadways	$ ----	$ 57,100	$ ----	$ ----
Outer Terminals and Freeway Stations[2]	----	31,050	----	30,600
Shops and Garages	----	13,500	----	8,650[3]
Rolling Stock (Buses)	----	45,000	----	28,750[3]
		$ 146,650		$ 68,000
Rail Rapid Transit				
Subways	$ ----	$ ----	$ 561,700	$ 313,150
Open Construction	----	----	176,550	85,050
Outer Terminals	----	----	8,500	3,950
Yards and Shops	----	----	20,000	12,250
Rolling Stock (3-Car Units)	----	----	$ 72,000	$ 44,100
			$ 838,750	$ 458,500
Total Transit Facilities	$ ----	$ 146,650	$ 838,750	$ 526,500
Total System Cost	$2,607,150	$2,106,250	$2,798,350	$2,486,100

TABLE A-37 — *Continued*

CAPITAL COSTS AND RELATED DATA – ALTERNATE TRANSPORTATION SYSTEMS NATIONAL CAPITAL REGION

	PHYSICAL FEATURES			
TYPE FACILITY	*Plan I Auto-Dominant*	*Plan II All-Bus*	*Plan III All-Rail*	*Plan IV Recom-mended*
Highway Facilities				
Route-Miles of Freeways and Parkways	344	326	326	326
Factor	100	95	95	95
Lane-Miles of Freeways and Parkways	2,032	1,775	1,775	1,775
Factor	100	87	87	87
Net Additional Parking Spaces Needed				
Outer Transit Stations	----	20,800	20,800	20,800
Intermediate Stations	----	11,200	11,200	11,200
Sector Zero (Downtown)	85,000	48,500	48,500	48,500
Total	85,000	80,500	80,500	80,500
Factor	100	95	95	95
Transit Facilities				
Express Bus				
Number of Routes	----	11	----	8
Route-Miles[4]	----	103.8	----	66.4
Buses Required	----	1,800	----	980
Rail Rapid Transit				
Number of Routes	----	----	9	4
Route-Miles[4]	----	----		
Subway	----	----	32.4	14.3
Open-to-the-Sky	----	----	44.8	20.1
Three-Car Units Required	----	----	400	245

[1]Source: DeLeuw, Cather, and Company, *Civil Engineering Report, Mass Transportation Survey, National Capital Region, 1958.*

[2]Excluding parking facilities.

[3]More buses would be required in 1965 than in 1980, since rail rapid transit would replace some of the express bus routes during this period. As buses purchased prior to 1965 became worn out, therefore, they would not all be replaced. The depreciation funds represented by such excess buses would presumably be invested in rail rapid transit cars. Garages and bus shops, which would have a longer life than the buses, should be so designed that they could be partially converted for use in servicing the rail cars or used by the expanding fleet of local buses.

[4]Includes duplication where two or more routes operate on same street or right-of-way.

TABLE A-38

COMPARATIVE TRAVEL FACTORS TRANSIT AND HIGHWAYS (Peak Hours)

A. *Basic Assumptions*[1]

TYPE TRAVEL	*HIGH DENSITY URBAN AREAS*	*OTHER URBAN AREAS*
Speeds		
1. Arterial	15 mph	20 mph
2. Freeway	30 mph - 36 mph	36 - 40 mph
3. Surface Transit	10 mph	10 mph
4. Rapid Transit		
a. Conventional	20 mph	—
b. Improved	30 mph	30 mph
c. Optimum	—	36 mph
Waiting Times (½ Headway)		
1. Surface Transit	3 min.	4 min.
2. Rapid Transit	2 min.	3 min.
Walking Distances		
3. To Surface Transit	3 min.	5 min.
4. To Rapid Transit	4 min.	5 min.
5. To Destination from		
a. Parking Area	6-7 min.	3 min.
b. Surface Transit	1 min.	1 min.
c. Rapid Transit	2 min.	2 min.
Connecting Travel Times		
1. Surface to Rapid	7 min.	10 min.
2. Auto to Rapid	5 min.	6 min.
3. Auto to Freeway	4 min.	6 min.

B. *Summary of Time Losses*

CONDITION	*HIGH DENSITY URBAN AREAS*					*OTHER URBAN AREAS*				
	Initial Walk	*Waiting Time*	*Conn. Ride*	*Destination Walk*	*Total*	*Initial Walk*	*Waiting Time*	*Conn.*[2] *Ride*	*Destination Walk*	*Total*
Arterials Only	—	—	—	6	6	—	—	—	3	3
Arterials and Freeways	—	—	5	7	12	—	—	6	3	9
Surface Transit Only	3	3	—	1	7	5	4	—	1	10
Rapid Transit Only	4	2	—	2	8	5	3	—	2	10
Surface and Rapid Transit	3	5	7	2	17	4	7	10	2	23
Auto and Rapid Transit	—	2	5	2	9	—	3	6	2	11

[1]Source: Calculations represent basic assumptions for Figure 61.

[2]To rapid transit or freeway.

TABLE A-39

ORIGINS OF NORTHBOUND PASSENGER CARS ON NIMITZ FREEWAY SOUTH OF SAN LEANDRO[1]

South City Limits – Typical 1960 Day
(12 Hours)

ZONE IN WHICH CAR IS GARAGED Location	*Number*[2]	*NO. OF CARS*	*POPULATION 1960*	*CARS PER THOUSAND PEOPLE*
Piedmont	122	46	10,973	4.2
Oakland - North	106,109-111 115-117,123	455	48,040	9.5
Oakland - CBD	107,112-114 118-121, 125-127	1,160	95,100	11.6
Oakland - Central	130-134 136-142	1,255	105,120	11.9
Alameda	124,128-129 135	1,689	53,606	31.5
Alameda - Penn.	143-144	10	----	----
Oakland - Nimitz	145-146	1,043	74,000	14.1
Oakland - S. E.	147-149	407	38,800	10.5
San Leandro	150-153	734	77,700	9.4
Areas South of San Leandro	210-215	1,019	34,200	29.8
	220	2,970	25,600	115.0
	225,275	743	35,600	20.9
	230	752	12,700	58.2
	235-250	37	1,600	23.1
	240,255	1,668	16,300	102.4
	245,260	758	13,200	57.5
	265,270	883	11,900	74.2
	276,281	583	12,500	46.6
	280	71	1,000	71.0
	310	----	100	----
	315,321	533	6,700	79.5
	320	108	2,300	47.0
	322-455	3,387	45,100	75.1
	510-520 530-542 550-560 571,525-528	101	6,520	15.5
	543-545 565-566	15	20,000	0.8
TOTAL		21,097	874,557	

[1]Sources: Field study by Wilbur Smith and Associates, August, 1960.
[2]Zones based on Wilbur Smith and Associates, *Alameda County Highway Master Plan, 1959.*

Table A-40

COST OF MOTOR VEHICLE ACCIDENTS
UNITED STATES
1950 and 1959[1]

YEAR	DIRECT COSTS			INDIRECT COSTS	TOTAL COSTS
	Property Damage	*Wage Losses*	*Medical Expense*	*Cost of Insurance*	
1950	$1,250,000,000	$ 950,000,000	$ 50,000,000	$ 850,000,000	$3,100,000,000
1959	$2,100,000,000	$1,600,000,000	$150,000,000	$2,350,000,000	$6,200,000,000

[1]Source: *Accident Facts*, Yearly Editions, National Safety Council.

Table A-41

COOK COUNTY EXPRESSWAY ACCIDENT RATES – 1959[1]

FACILITY	*PER HUNDRED MILLION VEHICLE MILES*	
	Fatality Rate	*Accident Rate*
Calumet Expressway	0.72	73.09
Edens Expressway	0.96	8.45
Congress	2.51	180.64
Composite	1.60	125.20
Toll Roads - 1959	2.80	101.30
All Limited Access Roads	2.00	186.00

[1]Source: "Cook County Report on Expressway Accident Pattern," *Street Engineering*, September, 1960.

Table A-42

TEST RUNS ON FREEWAYS AND SURFACE STREETS

LOS ANGELES, CALIFORNIA[1]

ITEM	*VIA FREEWAYS*	*VIA SURFACE STREETS*	*SAVING*
Date	6/2/54	6/3/54	----
Start	9:30 A.M.	9:30 A.M.	----
Car	Ford No. 8	Ford No. 8	----
Distance	133.3 miles	123.8 miles	
Time	165 minutes	380 minutes	215 minutes
Gas Used	6.88 gallons	8.57 gallons	1.69 gallons
Miles/Gallon	19.38	14.44	4.94
Average Speed	48.473	19.547	29.926
Number of Signalized Intersections	0	578	578
Average Signals/Mile	0	4.67	4.67
No. of Stops Made	0	298	298
Average Stops/Mile	0	2.41	2.41
Operation Cost/Mile			
Gasoline	1.545¢	2.076¢	.531¢
Time at 2¢/Minute	2.476¢	6.139¢	3.663¢
	4.021¢	8.215¢	4.194¢

[1] Source: Automobile Club of Southern California, Engineering Department, *An Appraisal of Freeways versus Surface Streets in the Los Angeles Metropolitan Area,* August, 1954.

APPENDIX D

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