CHICAGO AREA TRANSPORTATION STUDY

volume one

COVER DESIGN

A preliminary run on the Cartographatron (see Chapter IV and Appendix) produced this pattern of dots representing the origins of trips made in the Chicago area on an average weekday. The data are incomplete, but the outline of the lake shore, the suburban developments, and the greater numbers of trip origins at the Loop are clearly visible.

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CHICAGO AREA TRANSPORTATION STUDY

FINAL REPORT
In Three Parts

Volume I
Survey Findings

DECEMBER 1959

STUDY CONDUCTED UNDER THE SPONSORSHIP OF

STATE OF ILLINOIS

William G. Stratton
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Acknowledgments

No task as comprehensive as the one reported on here could be accomplished without extensive contacts with, and help from, the people, business firms and governmental agencies of metropolitan Chicago. It is impossible, therefore, to make a complete listing of the many who contributed time and effort. In spite of this difficulty, acknowledgment must be made to particular people and agencies for special assistance, even though the list is incomplete.

The support of the heads of government is of great significance. This was provided by personal appearances and by the continued interest and support of Governor William G. Stratton; President of the Cook County Board of Commissioners, Daniel Ryan and the Mayor of Chicago, Richard J. Daley.

In addition, technical assistance above and beyond financial support was provided by the Department of Public Works, the Department of Streets and Sanitation and the Department of City Planning of the City of Chicago. Similar support came from the Cook County Highway Department and the personnel of the State Division of Highways — particularly those in Districts Ten (Cook County) and One, (Du Page and other western counties). Invaluable assistance was afforded too, by personnel from the Regional and Division Offices of the U. S. Bureau of Public Roads with particular help from the Washington Office.

Many hours of time, sifting of records and cooperation of every kind were provided by the Chicago Transit Authority. Facts on bus and railroad routing, scheduling and usage, in suburban areas, could not have been obtained without the willing cooperation of the bus and railroad companies.

The Chicago Central Area Committee, the personnel of the Chicago Association of Commerce, and the Chicago Community Inventory were among the many civic groups providing special information or data. The Chicago Motor Club has been especially helpful in public relations work and in general support of this Study.

Special thanks go to the Commonwealth Edison Company and the Public Service Company for making available, for this civic purpose, detailed records of meter locations. These records were of singular help in insuring a complete and accurate sample of all dwelling places for collection of home interviews. Sampling of truck and taxi owners was made possible by registration lists furnished by the Illinois Secretary of State.

The more than 360 employees of the Study deserve mention for their very loyal and thorough craftsmanship in interviewing, in coding and in processing several million pieces of information, and also in the other tasks necessary for a complete and accurate report.

Finally—warm thanks to the public citizenry of this community for answering detailed questionnaires—and to the truck and taxi operators and drivers for ready cooperation in furnishing all requested information.

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CHICAGO AND THE MIDWEST

MAP 1

Chapter I.
INTRODUCTION

THE PROBLEM

Within the built up area of the metropolis which includes Chicago and its adjacent suburbs there were 5.2 million persons living, working, shopping and carrying out their daily activities in 1956. On an average weekday, these people made 10.2 million one-way journeys—2.4 million via mass transportation and 7.8 million via passenger cars and taxis. All this travel is a measurable expression of the normal daily life of this area.

In the same area there were 1.6 million registered vehicles—1.46 million passenger cars and about 140 thousand commercial vehicles. On an average weekday they made 5,900,000 one-way journeys and traveled in excess of 36,000,000 miles.

In making all these trips within the limited spaces of the city and suburbs there is natural competition for use of highways and mass transportation facilities. People are bound to get in one another's way. Virtually all travelers are thereby made aware of the "traffic problem"—one of the chronic problems of urban places.

This traffic problem within the Chicago region is scaled by numbers which run into the millions. These measures of travel are large, as they must necessarily be for one of the world's largest centers, but each year they increase. Annually, some 100,000 persons are being added and some 20 square miles of formerly vacant land used up. Each year additional travel requirements are thrust on the limited space of the metropolis and its facilities are further pressured by the movements required in the daily life of its people.

Public agencies concerned with these problems are constructing new facilities steadily, making changes in existing facilities and working hard to meet the ever-enlarging travel demands. New expressways, subways and other travel facilities are among the largest public works in the history of the region. Construction on highways alone is currently at a rate in excess of 100 million dollars a year. In the next twenty-five years more than two and one-half billion dollars will be spent on construction and improvement of public facilities for travel. The problem faced by all responsible public officials is how to locate, build and pay for the new facilities so as to meet the travel needs of the present and future people and businesses of the region.

A metropolitan region of this size is so large, so complex and so delicately balanced in the many activities of its people and institutions that simple comprehension or understanding is hard and predictions are particularly difficult to make. Will the construction of one expressway severely disturb the patterns of growth and travel? How can it be certain (or as certain as possible) that the location of a particular improvement is the best of alternate choices, and that such a structure will fit in properly with the other works planned for five, ten and twenty-five years hence? Questions of this kind are the antecedents to the establishment of the Chicago Area Transportation Study.

The task of the Study is to analyze the present travel behavior, to forecast what the future requirements of the metropolitan region will be and, on the basis of this information, to devise a long range plan for needed highways and for mass transportation facilities.

With long range goals expressed in specific plans, the multitude of continuing decisions by public and even private agencies are coordinated towards a common target. Each seemingly independent civic problem, such as whether to close streets in redevelopment areas, when and where to supply more parking, or whether to make zoning changes, can be made more consistently in the public interest with detailed long range objectives as common background. Such plans are particularly necessary as a means of coordinating and programming the work of the several governmental agencies concerned with building new transportation facilities and managing the operations of existing ones.

OBJECTIVES

For plans to be purposeful and acceptable they must be designed to achieve an objective. What, then, is the dominant objective of a transportation facilities plan? It is to reduce travel frictions by the construction of new facilities so that people and vehicles of this metropolitan community can move about within the area as rapidly as possible, in a manner consistent with limitations of cost and safety. Since travel is productive—so productive, in fact, that no community could exist without it—concentration on rapid, yet safe and economical transportation systems is concentration on the circulation system which, in large measure, is the foundation of the community's strength.

But even the single objective of rapid movement within the limits of economy and safety must be tempered by additional conditions or restraints. Needs for transportation facilities compete with other possible community improvements, such as water supply, schools, parks and housing. Therefore, competitive requirements for other expenditures will place limitations on the extent of the community's ability to maximize the stated objective. Finally, of course, it must be recognized that the location of transportation facilities has much to do with the patterns of land development. The promotion of more desirable arrangements of land is an important objective, not only to secure better qualities of residential living and business productivity but, also, through land use controls, to preserve the efficiency of new transportation facilities.

In order to weigh possible courses of action in the light of all these considerations, the consequences of alternate possible decisions must be appraised. For example, if a rapid transit line were built along Cicero Avenue, would its passenger load cover operating costs? If expressways were built in densely settled areas, would car ownership increase and mass transit riding habits change? To answer such questions, the planner must be able to estimate changes in the urban area and to measure the probable consequences of the changes upon travel habits and facility usage. The Study's planning processes have been designed to permit this to be done.

Once prepared, a transportation plan does not necessarily stay fixed but is subject to periodic revision. The processes of review and appraisal against objectives (which may be modified from time to time by public decisions) are as essential as the plan itself. Thus, there are two major goals of this Study: the preparation of a plan and the careful design of information to be supplied for use in the regular processes of re-examination and updating. The plan, however, comes first because day-to-day decisions can only be fitted together to reach an objective if that objective is detailed by a known and agreed upon plan.

In summary, the Study has two goals—first, to prepare a transportation facilities plan and second, to provide the basic understanding and facts needed for continuing review and appraisal of the plan by responsible public officials. The plan, to be purposeful and to represent the needs of people, must have an objective. Stated formally, this is to maximize the ease of travel within the urban region, subject to the constraints of limited income, related effects on land use and development patterns, and a most probable estimate of future size and character of the region.

ABOUT THE STUDY

The Chicago Area Transportation Study was established late in 1955 by the City of Chicago, the County of Cook and the State of Illinois, acting in cooperation with the United States Bureau of Public Roads. The Study is financed jointly by these four governments and acts in an advisory capacity to them. Actual operation is as a segment of the Division of Highways of the State of Illinois with all personnel as State employees. Since these governments finance and build most of the new transportation facilities in the Chicago area, their adoption of a single plan will provide the basis for a unified transportation development program for the area.

The Study's Policy Committee, representing the four sponsoring governments, has consistently recognized that mass transportation is an integral part of the total transportation system in the Chicago area. As a result, surveys have been conducted so that travel of persons by both public and private transportation within the area has been recorded and projections will be made of the future loads on mass transportation routes, as well as on the road network. Thus, the basis for planning a coordinated intra-metropolitan transportation system has been set.

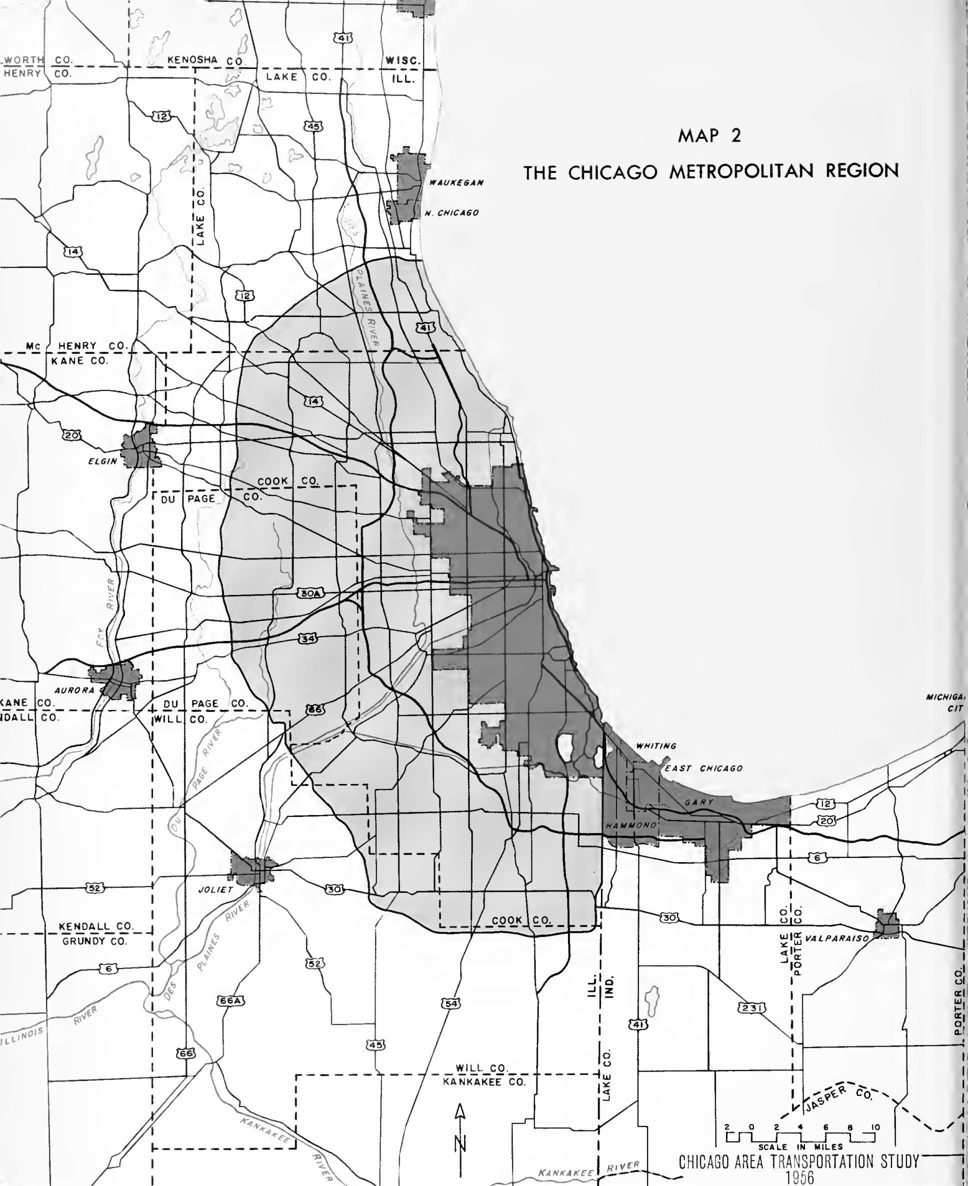
The sponsoring agencies have also set up a continuing agency charged with the duties of revising plans, conducting research and maintaining the currency of the data gathered by the Study in 1956-7. By this means, the pitfalls of the "one-shot" survey can be overcome and the processes of re-examination and revision (in other words, continuous planning) are declared as essential as the plan itself.

SCHEME OF PRESENTATION

The report of this Study is being presented in three volumes, divided generally to cover three major phases of the work. This first volume is concerned with the basic facts needed for long range planning. The method of study is worked out first and from this the needed factual data are identified. The balance of the volume describes the information collected. The presentation of facts is selected so as: (1) to describe the entire region; (2) to provide measurable data for the base year (1956) and (3) to indicate how reliable forecasts can be developed.

Volume II will be concerned with the growth and change in the region and in its travel requirements between 1956 and 1980. It will delineate the history of population and economic growth in the Chicago area and project these through 1980. The future uses of land will be detailed and, using this source, future travel requirements will be computed. These future travel requirements will be scaled against the existing supply of transportation services so that the magnitude of needed future improvements will be known. This will set the stage for plan making—which will be reported in the last volume.

Volume III will set forth the criteria for planning, including standards for transportation facilities and for servicing the various land uses. Plans for express highways and rapid transit facilities will be developed and tested. At this point, benefits will be weighed against costs, tax requirements will be estimated and financial feasibility measured. Closing this last volume will be a plan for the staging of work so as to obtain the greatest community benefit as construction proceeds.



The Study Area contains approximately 84 per cent of the population of the six county metropolitan area. Most of the remaining population lives in small cities which, except for those in Lake County, Indiana, are largely self-contained in their traffic patterns. The Study Area boundary was fixed to contain most commuter trips.

Chapter II

DESIGN OF THE STUDY

When work on the Study began, three interrelated decisions had to be made. These were to specify the content of the fact gathering operations, to outline the process of preparing the necessary transportation plan and to define the geographic area for which data would be gathered. The decisions reached on these subjects constituted the design for the conduct of the Study.

The Study design rests upon the central idea that travel within an urban area is extremely orderly, measurable and basically rational. Travel is, in fact, so much a condition of urban life and is so regular, that it can almost be described in terms of natural laws. If travel were chaotic or random, the planner would be helpless. As it is, the orderliness in travel permits plans to be prepared and, furthermore, to be tested. Hence it is one of the primary purposes of the inventories to determine where regularity exists in travel; it is the primary purpose of the planning process to use these regularities to develop and test plans.

A study design does not, of course, spring into being overnight. A great deal of experience in many American cities stands behind it. Thus the content of the inventories could be carefully stipulated to obtain just those data needed to develop and test a plan. An additional advantage of having a study design is that the work of a variety of specialists can be integrated and all analytical and research work focused on the key problems of forecasting and planning.

THE INVENTORIES

Originally, the only information available for transportation planning was the volume of vehicles using roads, or the number of persons on a mass transportation system. These traffic volume data merely showed how a given transportation facility was being used at one point in time. Although useful in some ways, they provided little indication of what the usage of a new facility would be.

The origin-destination survey was developed to provide data which would improve estimates as to what travelers would do if a new route were built, or an old route improved. By knowing the origins and destinations of trips, it became possible to reallocate travelers to proposed new routes. This was a major change in approach because it provided objective measures of how well new facilities would serve travelers. The origin-destination survey became, therefore, a standard requirement for transportation planning and this was the type of travel inventory taken for the Chicago area. This inventory obtained data representing all travel by persons and vehicles within the Study Area on an average weekday. For each trip the address of origin and destination was obtained, together with information on mode of travel, trip purpose, land use at terminals and travel time.

Even knowing how present travelers might use new transportation facilities, a more difficult problem appeared: how to forecast the number and location of future travelers. Plans must be made for the solution of anticipated future problems, not just those of the present. It takes one or two years from the date of a survey to prepare plans and from three to ten years to build even a portion of a major new transportation system. Furthermore, a region does not grow evenly in all its parts and hence it is certain that travel will not grow evenly. The simple expansion of existing travel demands obviously is inadequate. Forecasting, therefore, is vitally important to state the dimensions of future traffic demands.

To make forecasts of future travel, the Study worked on the hypothesis that there is a measurable relationship between land use and the amount and distribution of traffic. This is a reasonable assumption — people must leave home to work, to shop, and to go to school and recreation facilities. Those who build industrial and commercial buildings base their investments on some assurance that workers and shoppers will come to their buildings. The movement of persons and goods is the means whereby separate land use activities can exist and yet function each day.

On the basis of this reasoning, a land use survey was taken as the second of the major inventories. This inventory measured the areas of all lands within the Study Area according to type and by detailed location. In effect, this inventory provided a basis for the description of the spatial distribution of urban activities. Since land use can be predicted with some assurance, future traffic demands can also be predicted.

Finally, to measure the supply of existing transportation, an inventory of transportation facilities had to be undertaken. This inventory measured the length and determined the carrying abilities of all arterial streets, boulevards, expressways, bus lines and rapid transit lines (including suburban railroads) within the Study Area. The data obtained were particularly useful in measuring the capacity of a transportation system to serve passengers and vehicles, and in measuring the quality of the service rendered. This, then, provided the basis for computing the additional transportation facilities to be added to overcome existing deficiencies and to meet growing needs.

The inventories to be taken, therefore, were three in number: inventories of land use, of travel and of transportation facilities. Brief descriptions of these inventories will be given in the following chapters. Complete details are available in survey manuals which have been published separately.

transportation
facilities

land use
travel

THE PLANNING PROCESS

The steps leading from the accumulation of facts to a completed plan involve, essentially, forecasting urban growth, simulating the traffic consequences of this growth and, finally, measuring the impact of this traffic growth on existing and proposed transportation systems. Estimating urban growth and simulating future travel might be compared to the engineering of an advanced rocket. Here, design by trial and error is too expensive; therefore, tests are made using small scale models. Sometimes rocket flights are simulated using electronic computers. In the case of cities, scale models with miniature vehicles and people cannot be built and operated, but the consequences of growth can still be simulated by a variety of techniques and the results observed. In these processes lie the mechanics which provide the basis for careful planning.

The planning process is made up of five distinct steps. These include forecasting land use, forecasting travel demands, preparation of plans, testing and evaluating. These steps are described below.

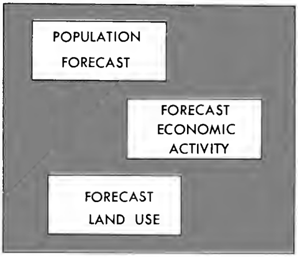
Forecasting Land Use

Population estimates are the beginning point for estimating future land use; they indicate the magnitude of urban growth. A population forecast, expressed in terms of families, can be used directly in the process of estimating the amount of land which will be developed for residential purposes. Population data, however, cannot be used readily to provide estimates of employment in commercial or industrial activities. Economic projections had to be prepared, therefore, and from these the number of workers in each industry type could be derived.

Both population and employment estimates were matched against data provided by the land use inventory in order to estimate the locations of activities and their land requirements. The location of future residential and nonresidential activities had to be estimated because the pattern of future travel depends upon the location as well as the kind and intensity of land uses.

The land use survey showed that there were significant spatial regularities in the proportions of land in different uses, in density of development, and in percentage of development. Using these facts, then, residential population and non-residential activities were distributed throughout the Study Area in their most probable future locations.

The land use forecast is thus a three part procedure. It involves first, estimating future population and secondly, economic growth. A procedure is then required for distributing these new urban activities geographically.



Forecasting Travel Demand

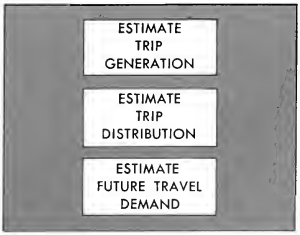
Future land use must be translated into future travel in order to complete the preparation for planning. The theory of forecasting travel from land use is relatively simple, but the application is extremely difficult. Detailed description of the steps involved will be included in Volumes II and III of this final report.

In simplest terms, given the present trips within the Study Area (from the inventory of travel) with each end identified as to its terminal land use connections, and given the areas in each land use (from the land use survey), the rates of trip generation can be determined. The results might be 60 trips per acre of industrial land use, or 200 trips per acre of commercial land use per day. These rates, with necessary adjustments, can be applied to future land use to determine the future numbers of trips beginning and ending in any area.

The next step is to determine how the beginnings and endings of future trips are linked with one another. Data obtained by the inventory of travel provide those indications of regular behavior which permit estimates to be made. For example, there is a known distribution of trips by trip lengths indicating that more trips are made to nearby destinations than to similar destinations located farther away. With this and other controls, travel volume between origin and destination points can be estimated.

Predicted travel must be split by mode used and allocated to the appropriate networks. The rules for this procedure, known as traffic assignment, are obtained by relating current travel volumes to existing transportation facilities. The purpose of assigning future trips to a transportation network is to discover those places in the network where travel demands are most severe. These are the trouble spots upon which attention must be focused when preparing plans.

The process of forecasting travel thus starts with a forecast of land use. The number of trips beginning and ending in each small area can then be estimated. These beginnings and endings are linked up as connections and, finally, the impact of this travel demand upon a transportation system is studied. This knowledge is a necessary base for the stage of designing the new transportation system.



Plan Preparation

Up to this point, the planning process has consisted of forecasts of future conditions. These estimates of future land uses and traffic demands give the dimensions of the problems which must be solved by planning, and some of the limits which control solutions. At this point, judgment and ingenuity must be applied in deliberate attempts to arrange transportation facilities against the distribution of urban activities in patterns which will function more efficiently than those of the past. Planning a new transportation system is thus a creative process.

Statements of objectives and standards to be achieved in the transportation plan are therefore necessary. These range from the general objectives of reducing travel frictions, keeping costs down and relating highway locations to land uses, to the specific standards and criteria which influence the design, spacing and location of new transportation facilities. These objectives influence the plan strongly but they, in turn, must be evaluated for consistency and reasonableness in the light of the resulting plan.

The actual planning of new transportation facilities is not done on a clean slate; the process, rather, is one of successively imposing limits within which the solution must be found. Existing expressways, boulevards and transit lines are one set of limits. Land uses (such as housing developments, industrial districts and commercial centers) impose other limits. The forecasts of future traffic demands fix the magnitude of the improvements which must be made. Finally, objectives and standards control the solutions greatly.

Only in the presently undeveloped parts of the metropolitan area is there much freedom. Here land use planning and highway planning can aid one another, to provide proper access for land development and to regulate lands adjoining arterials and expressways so that the new investment in transportation facilities will be preserved better than in the past.

Testing

Even within such limits, it is possible to arrive at more than one solution. Further, there is no way of knowing whether any proposed plan would, in fact, do the job which it is designed to do if planning stopped at this stage. Therefore, the two or three planned transportation systems which seem best must be tested to see whether they will actually carry the loads which future land uses are bound to generate.

The process of testing is similar to the process of forecasting the over-all travel demand. The difference is that the traffic demand generated by future land uses is assigned to a planned new transportation network. The results are measured in terms of volumes on all the parts of this network. These test results must then be evaluated. In this evaluation process the objectives come under new scrutiny, because the test results may show that some of the objectives and standards are inconsistent with each other or may have unforeseen results which are undesirable.

The Study design is diagrammed on the facing page as a series of steps which proceed from the inventories to the preparation and testing of a plan. First, inventories are taken of travel, land use and transportation facilities. Second, forecasts of population, economic activity and land use are prepared. Land use serves as the input to the process of forecasting travel demands; the steps of this process depend on the rules of travel developed from the major inventories. The plan preparation stage utilizes these forecasts of travel demand and through successive imposition of limits, including objectives and standards, comes up with one or more plans. These are then tested by developing traffic volumes on all routes and the tests are evaluated. Final checking includes a re-evaluation of the objectives and a comparison of the plan against the objectives.

DEFINING THE STUDY AREA

As the final element of the Study design, a limit had to be set to the area for which inventories were to be made and for which plans were to be prepared. The area decided upon is called the *Study Area* and is bounded by a cordon line. The setting of the cordon line did not, however, create another artificial boundary. The Study Area was simply considered the primary area upon which to focus attention. Data were collected beyond this line where necessary, so that the planning area could be extended if this should prove advisable.

For the purposes of planning, the Study Area had to be sufficiently large to include the area

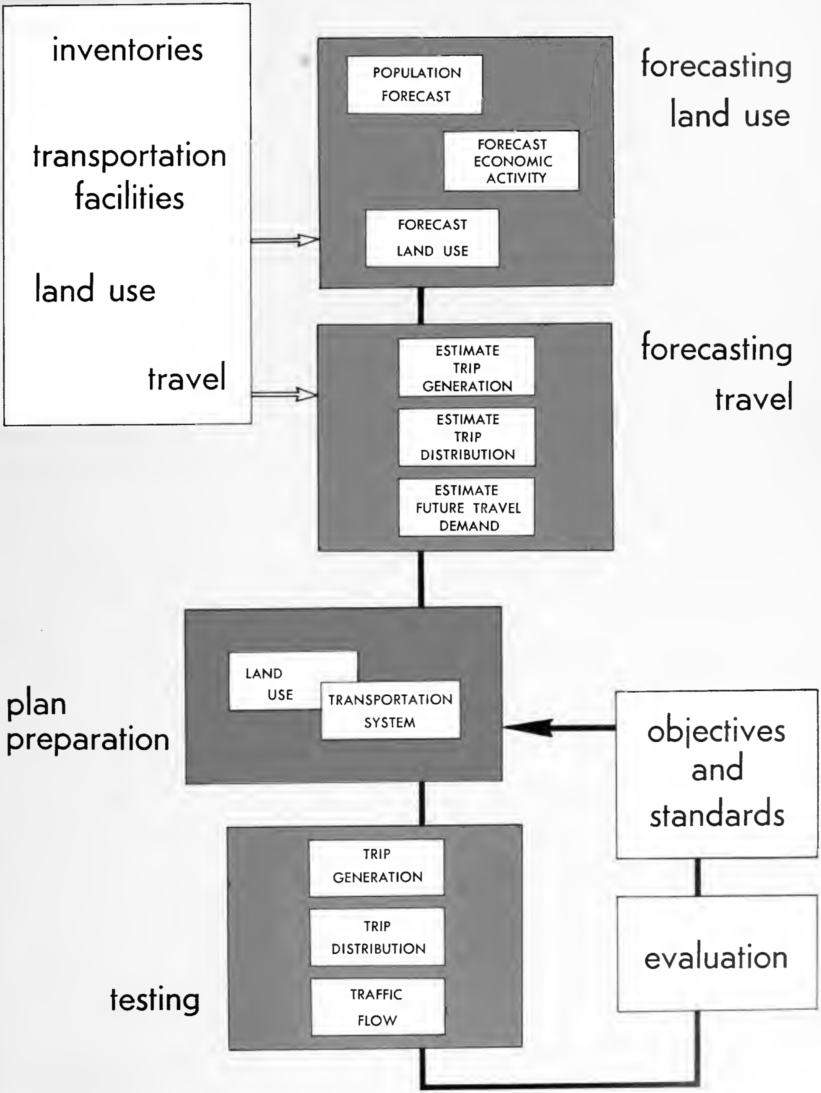
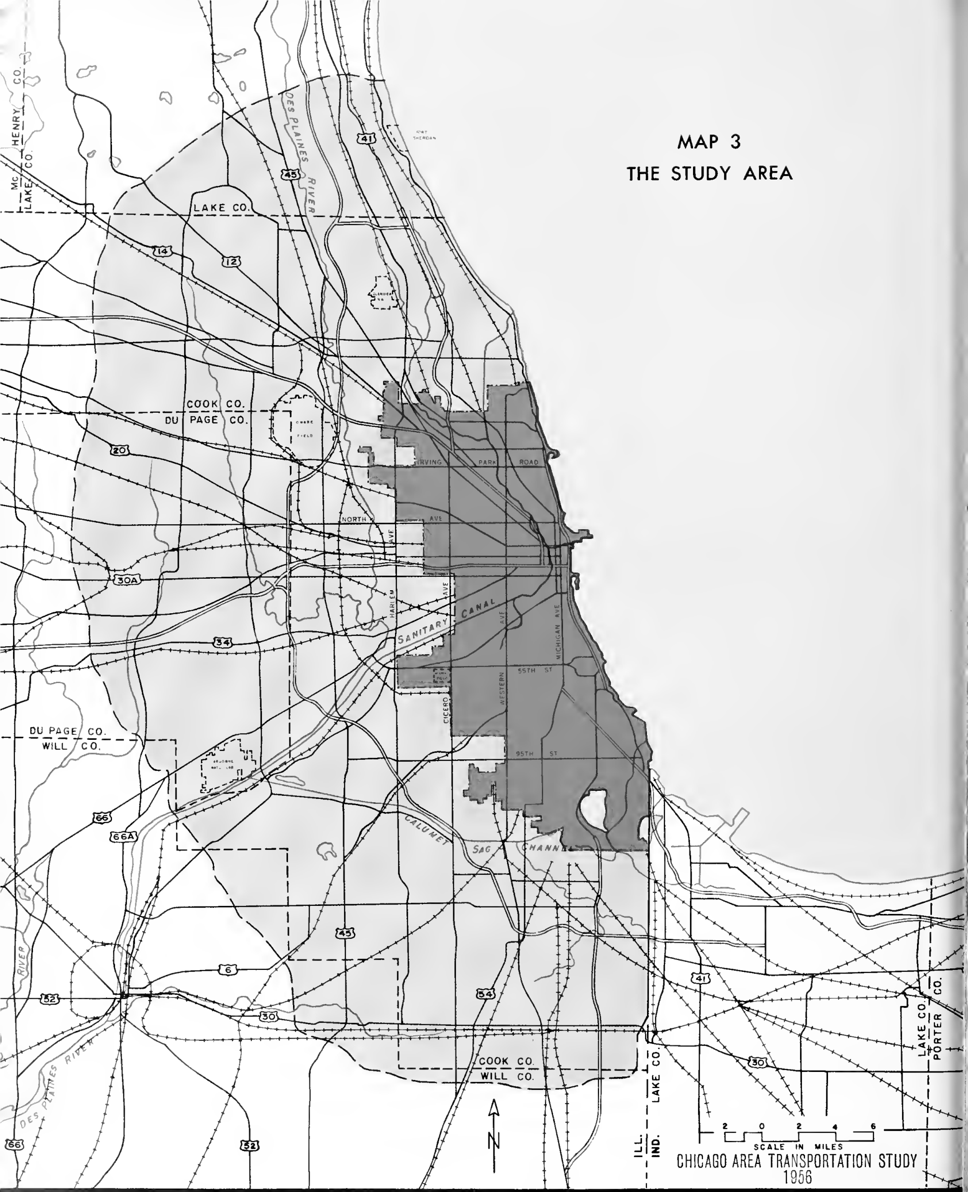


FIGURE 1—THE PLANNING PROCESS

This diagram illustrates the processes used in moving from inventories and forecasts to the preparation, testing and evaluating of a transportation plan.



This is the standard Study Area base map; most displays of data will be shown at this scale. The 1,236 square mile Study Area contained a population of 5,170,000 persons in 1956.

within which most of the expected population growth would take place during the next 24 years. Since most of this growth would take place at fairly low densities, a correspondingly large area had to be taken. The cordon line bounded an area of 1,236.5 square miles, of which 673.7 square miles are either vacant or in agricultural use. The total area is large enough to house more than nine million persons and their associated urban activities according to current patterns of density. This is 75 per cent more than the present population.

The operational requirements of the inventories themselves determined the detailed location of the cordon line.[1] Of these inventories, the travel inventory was the most expensive and the most important. Most travel in large urban areas is made by residents of the area and this travel is most effectively sampled by the home interview. Those residents who live at greater and greater distances from Chicago make fewer and fewer trips to Chicago. Hence, at some point it is easier to cease interviewing residents at their homes and to interview at a cordon line only those trips made by nonresidents which affect the Study Area. This line was drawn at the boundary of the *commuter-shed,* outside of which relatively few trips are made daily to Chicago. By this selection, the essentially independent communities such as Aurora, Elgin, Joliet and Waukegan were excluded.

At about ten miles distance beyond the cordon line a second line was drawn. This outer line, including areas in Indiana, provided a sort of safety zone within which special forecasts of population and traffic growth could be made and examined as to their influence on the Study Area.[2]

[1]For location of cordon line interview stations, see Appendix Map 22.

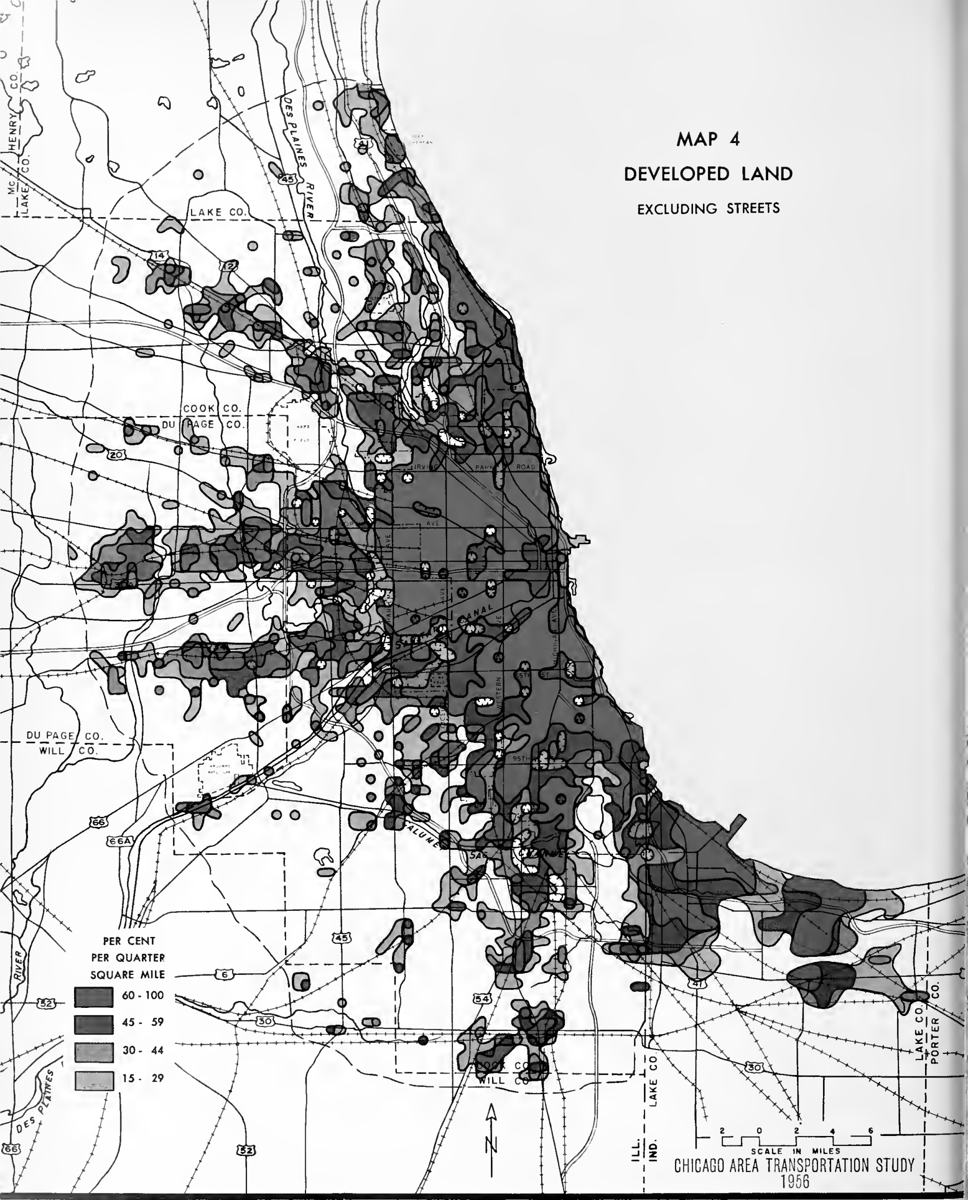
[2]For definition of this second line see Appendix page 102.

SUMMARY

It is a basic theory of the Study that there is an order in human travel behavior in urban areas which can be measured and described. This order provides the basis for intelligent forecasting which is necessary so that solutions will cope with the problems of the future — not just those of the present or past.

In order to ascertain the regularities in travel and to apply them to the planning of a transportation system, a Study design was prepared. This design stipulated the contents of the three major inventories of travel, land use and transportation facilities. Second, it indicated a chain of reasoning for preparing plans. This planning process proceeds from population and economic estimates to the estimation of land use and then of future travel demands, concluding with the preparation, testing and evaluation of plans. Finally, the Study design included a definition of the Study Area.

These decisions outline the basic system of attack upon the problem of preparing a transportation plan. They also describe the schematic framework within which the remainder of this report will be presented.



The 1956 distribution of residential, transportation, manufacturing, public buildings and commercial land is shown for the Study Area and northern Lake County, Indiana. These activities occupy 300 square miles. Glenview Naval Air Station, O'Hare Field and the Arganne National Laboratory are not shown.

Chapter III

LAND USE

A large urban region like the Chicago area contains a host of specialized activities each of which requires space. Residential activities use an average of one thousand square feet of land per capita. The moving of people and goods requires land: one-third of all developed land is used for streets and all other types of transportation combined, or about one thousand square feet per capita. All other types of activities — manufacturing, business, recreation, government — use up another one thousand square feet of land per capita. All told, 562.8 square miles of developed land were needed for all these activities for the 5,170,000 persons living in the Study Area in 1956.

Activities not only require space, but they also have their own peculiar locational requirements. Industry must have good transportation — railroad, highway or waterway. Businesses must be in locations having a high degree of accessibility to their trading areas. Residences must be located in areas where they can make their own favorable environment. For the most part, these activities cannot occupy the same land and, therefore, they must necessarily be located in different places.

Since different urban activities are thus spatially separate, it follows directly that people must travel in order to get from one type of activity to another. This is an absolute requirement. Therefore, travel within cities is logically studied as a function of the kinds, amounts, locations and intensities of the activities which demand that travel be undertaken. For this reason, a detailed survey was made to measure and locate the land occupancy of these activities throughout the Study Area.

THE INVENTORY OF LAND USE AND FLOOR AREA

For Study purposes, land use was considered to be the best basis for studying urban activities. Other measures could have been used, such as sales, payrolls, or the number of persons working and visiting a particular site. These measures, however, were not easily adapted either for being related to travel, or for being used to forecast the locations of future establishments. Land use was well suited for these two purposes. Moreover, land use has the additional advantage of being employed by city planners and of being reconcilable with the classifications used in forecasting the growth of economic activity.

Given this decision, procedures were developed for inventorying land use.[1] To start with, and to put all the inventories on a common geographic basis, the Study Area was divided into quarter square mile units by superimposing a grid, with lines at half-mile intervals, over the map of the Study Area. (See Appendix page 100.) This grid was numbered in a regular x, y co-ordinate system with the intersection of State and Madison Streets at the point $x = 500$, $y = 500$. For the city of Chicago the grid lines coincided with the major north-south and east-west streets.

Within each grid square the uses of land were identified and measured. Identification of each parcel's use was made through a combination of source data, including public utility meter cards, insurance atlases and aerial photographs. Ten different types of uses were identified: residential, manufacturing, transportation, commercial, public buildings, streets and alleys, public open space, parking, miscellaneous and vacant. Vacant land was further subdivided into three categories (residential, commercial and industrial) as determined by zoning.

An inventory of floor space was conducted as a companion to the land use inventory. Floor area data provide a means by which the intensity of use can be measured; furthermore, they permit a more refined study of travel generation, since two or more different activities often occupy a single parcel of land. Floor area was measured for a 295 square mile area, including

[1] *Land Use Survey Manual* (15.210), *Determination of Land Use Categories* (15.100), *Land Use Survey Manual—Suburbs* (15.210), *Land Use Survey Manual—CBD* (15.210) (Chicago: CATS, 1956-1958).

all of Chicago, Evanston, Oak Park, Cicero, Berwyn and parts of other, smaller suburbs.[2] The unit measured was the establishment, classified into ten major types corresponding to the land use survey, but with additional detail allowing for eighty-eight minor types. Identification was made through the use of electric utility meter cards and insurance atlases, supplemented by telephone and field checks; measurements were made directly from insurance atlases.

Both land and floor area data were summarized to quarter square mile totals. These values were printed on gridded maps and from these values numerous study and display maps were prepared. In some cases, as in Map 4, values were isolined (contoured) and then colored to connect quarter square mile areas having equal ranges of value.[3] In other cases, models were constructed with the heights related to the value in each grid square. These presentations were designed to summarize tremendously detailed data so that major patterns within the urban area can be discerned.

THE USE OF LAND IN THE CHICAGO AREA

The pattern of land in urban use, as contrasted with vacant or agricultural lands, is basic. Of the 1,236.5 square miles in the Study Area, 45 per cent is in urban use. Map 4 portrays the percentages of developed land in each quarter square mile in both the Study Area and northern Lake County, Indiana. It can be seen at a glance that the urban area pictured here is a single unit whose shape bears no relation to political boundaries.

A stranger examining this map — perhaps not knowing that it represents a city — would remark that it pictured something living, which has a definite structural shape. In these observations he would be right. A city is a colony of people, alive with movement and activity. At the same time, the city pictured here has a definite structure: a semi-circular concentration, where nearly all the land is used, from which radiate five fingers of urban development, not counting the Indiana area.

Why has the Chicago area developed in this particular fashion? One reason is the raw fact of growth itself. From a small settlement at the mouth of the Chicago River, the urbanized area has grown out steadily in all directions, as shown on Map 5. Growth has been horizontal rather than vertical, because it evidently has been found cheaper, in this area, to absorb new lands into urban uses rather than to build up into the air. With faster and more versatile transportation provided by the automobile, agricultural and vacant lands are being absorbed at an increasing rate and at lower densities.

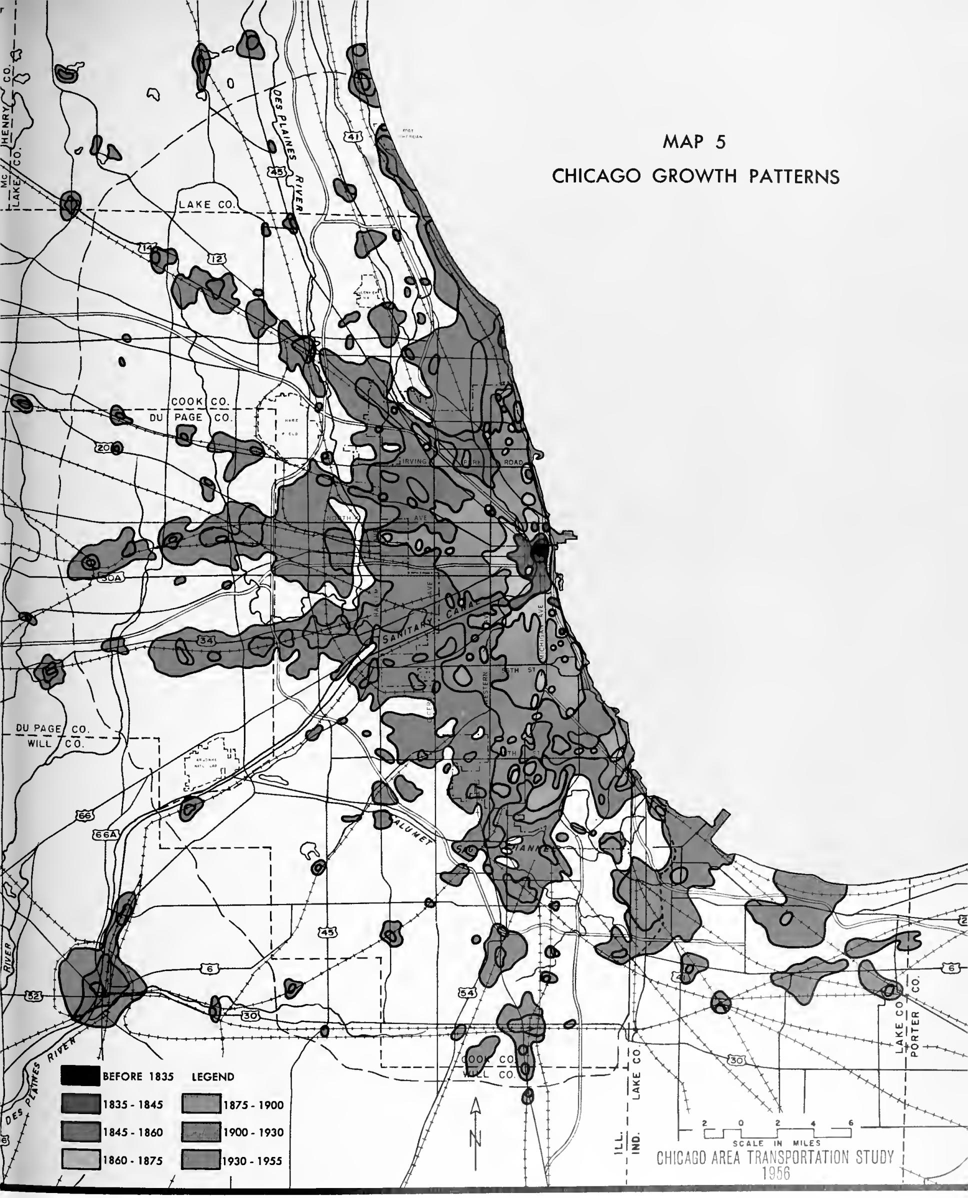
The form of this horizontal expansion has been shaped by transportation even from earliest times. Horse cars and cable cars on State Street accelerated growth southward in the period 1860-75. The suburban railroad lines created fingers and islands of urban development. The latest wave of expansion, taking place in the age of the automobile, has filled out the railroad pattern and has extended the semi-circular area of complete development. The persistence of a particular form, even into a new era of transportation, can be explained by the process of growth. This is growth by accretion. Each new subdivision and each new commercial and industrial area, is influenced by the great mass of the existing city, with no real prospect of breaking away from old patterns to start new ones.[4]

From this broad viewpoint, movement of people and goods can be identified with urban development. Where there is more development, there is bound to be more traffic. Where there is less urban development, there will be less traffic, except for long-distance, inter-city movements. These are generalities. For a deeper understanding of transportation, examination must be made of successively finer parts of this urban whole.

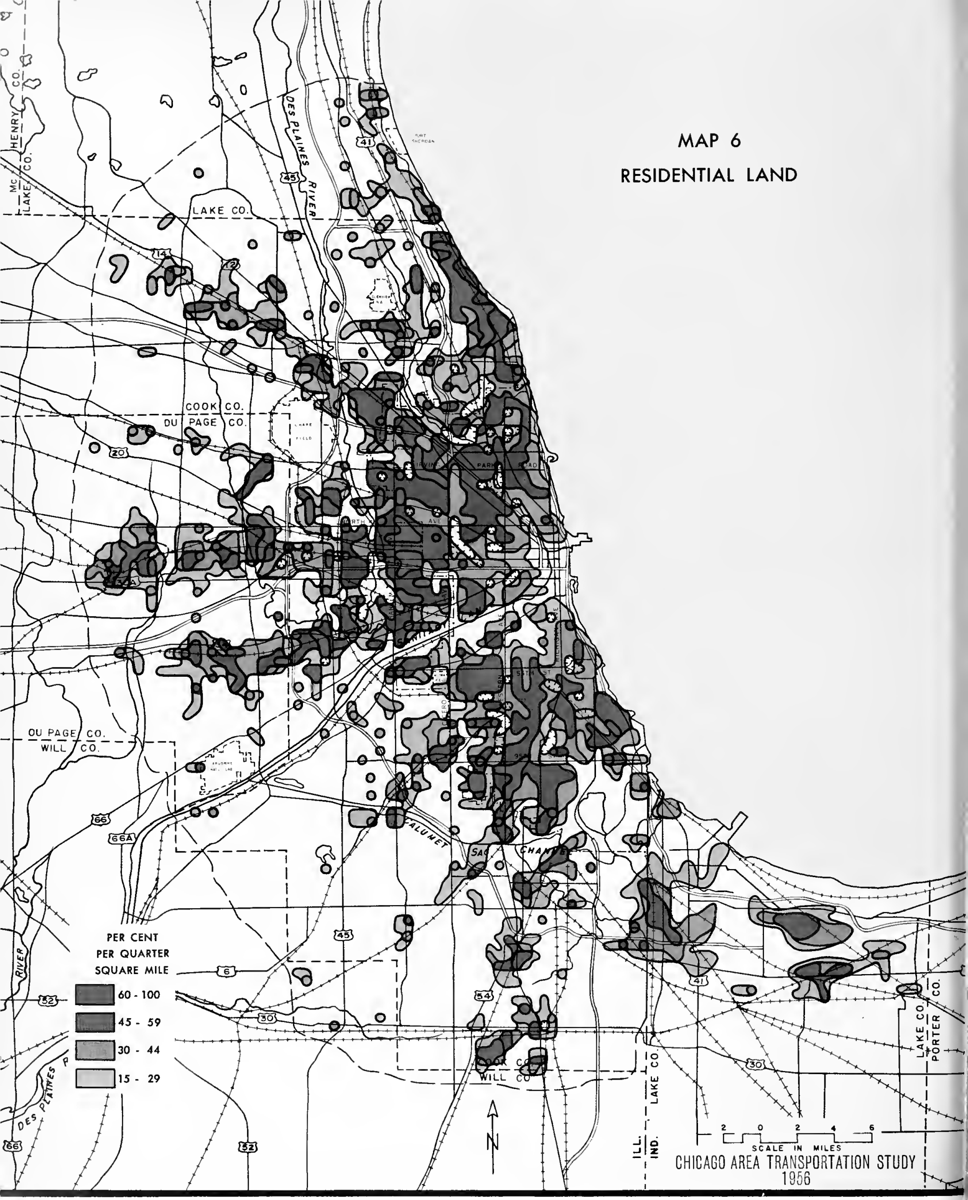
[2]See Appendix page 121 for a map showing the precise area limits of the floor space inventory.

[3]For a description of presentation techniques, see Appendix page 96.

[4]It takes a tremendous thrust of energy, analogous to the launching of a satellite, to break away from the mass of an old city to start a new pattern of urban development. Perhaps only governments can do this, as in the case of the British new towns.



The urbanized area has spread out in waves from the site of the original settlement. The finger development has followed the suburban railroad lines.



An estimated 1,731,000 dwelling places used 180.6 square miles of land within the Study Area at an average density of 15 dwelling places per net residential acre. Since over 25 per cent of all land in urban use is normally in streets, areas with more than 60 per cent of the land in residential use are almost exclusively residential.

PRELIMINARY ESTIMATES OF LANDUSE IN COOK COUNTY
PREPARED BY THE NORTHEASTERN ILLINOIS PLANNING COMMISSION

	CATEGORY	TOTAL ACRES
1.	RESIDENTIAL	139634.7
2.	MANUFACTURING AND PROCESSING	20761.[illegible]
3.	TRANSPORTATION, COMMUNICATION, UTILITIES	[illegible]173.[illegible]
4.	RAILROAD RIGHT OF WAY	7403.[illegible]
5.	AIRPORTS	[illegible]
6.	STREETS	[illegible]
7.	PRIVATE SERVICES	12854.[illegible]
8.	INSTITUTIONAL SERVICES	12304.1
9.	MILITARY FACILITIES	1330.[illegible]
10.	CEMETERIES	[illegible]
11.	ENTERTAINMENT [illegible]	12[illegible].
12.	PUBLIC [illegible]	1[illegible].
[illegible]	[illegible]	[illegible]7317.
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]1?1.

DUPAGE

TABLE 1—AREAS AND PERCENTAGES OF MAJOR LAND USES WITHIN THE STUDY AREA*

Land Use Type	Square Miles	Percentage
Residential	180.6	32.1
Streets and Alleys	146.1	25.9
Public Open Space	114.9	20.4
Transportation	50.7	9.0
Manufacturing	24.7	4.4
Public Buildings	23.1	4.1
Commercial	21.1	3.8
Parking and Miscellaneous	1.6	0.3
Total in Urban Use	562.8	100.0
Vacant or not in Urban Use	673.7	
Total Study Area	1236.5	

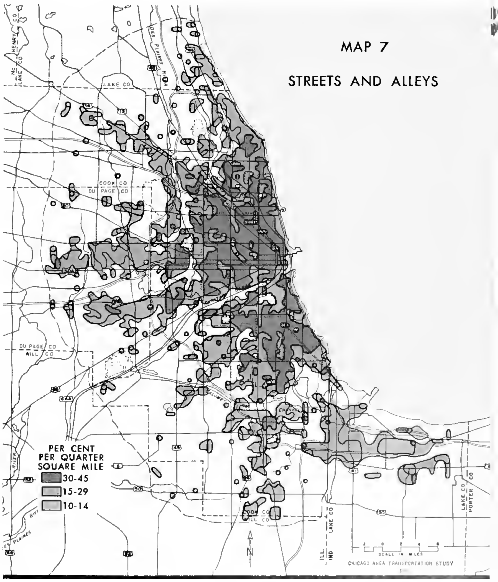
*For further details and for Indiana area, see Appendix, Table 21.

Residential land is the largest single land type (excepting vacant land) in the area. The influence of residential land is actually even greater than the figure of 32.1 per cent of used land[5] would make it appear, since a large proportion of streets and public buildings serve it exclusively, together with some public open space. If these uses are included, upwards of sixty per cent of used land in the area is residential in character.

This explains the similarity between the pattern of residential land, as seen in Map 6, and the pattern of total developed land, as seen in Map 4. The similarity is especially marked in the outer areas. At the center, however, the commercial and industrial uses have pre-empted the land, so that there is a void where very little land is used for residential purposes. Similar voids occur in the industrial and commercial areas along the Sanitary Canal, Cicero Avenue and in the forest preserves and major parks.

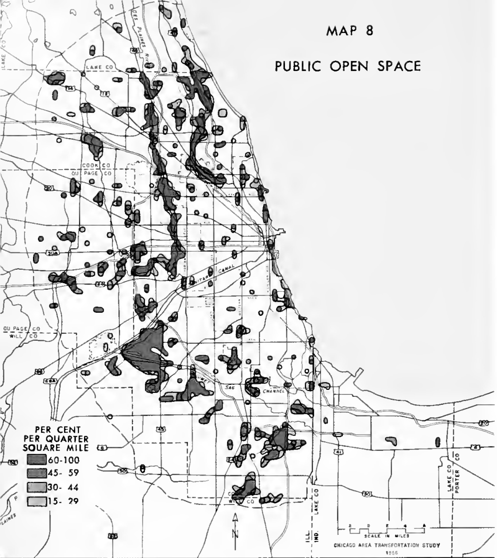
The forces shaping residential land patterns are easily understood. Residences and their accompanying land uses occupy large areas. Residences cannot compete — nor do they need to compete — with business and industry for central locations or for sites with particular transportation or other locational advantages. Growth, therefore, takes place on the outskirts where land is cheaper. Yet, residential activities cannot be dispersed completely; they must have good connections with the city where work opportunities and other necessary services concentrate. Hence they cling to the mass of the city as closely as possible and this is the reason why transportation, which provides the necessary connections, is so important in shaping urban development.

Streets use the second largest amount of land in the Study Area, with 25.9 per cent of the total of used land (31.7 per cent excluding public open space). The distribution of streets is almost exactly like the distribution of developed land. In fact it must be, because, for land to be developed, it must have access and this is by way of streets. This is another way of saying that where there is development there must also be traffic.



About 25.9 per cent of all land in urban use is used for streets and alleys.

[5]Public open space in this chapter is considered as *used* land, but not as *developed* land. The distinction is necessary because public open space occurs in the Chicago region in very large parcels which are unusual and, in a sense, non-recurring land uses.



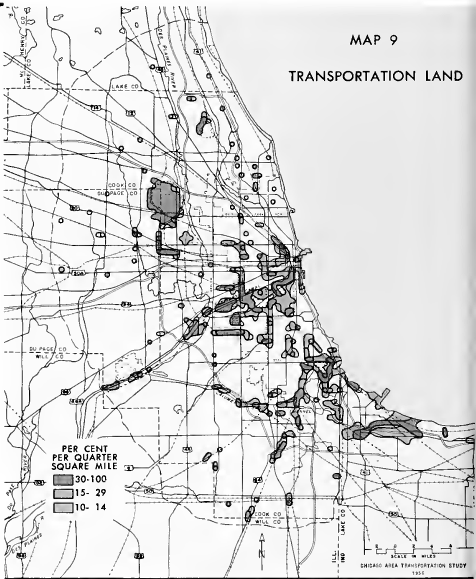
Public open space takes up 20.4 per cent of land in urban use. Included are parks, cemeteries and golf courses.

Public open space is the third largest category of land use, with 114.9 square miles of land devoted to this purpose. Of this area, 69 square miles are held by the Cook County Forest Preserve District. An additional nine square miles are held by the Chicago Park District. The remainder is taken up by cemeteries, golf courses, race tracks and the like. The distribution of public open space in Chicago is irregular, not really well related to the distribution of population or residential land. The location of public open space depends on the location of those sites with certain natural qualities which make them suitable for recreational use.

The category of transportation, communications and public utilities land takes up about half as much land as the public open space category and, like it, is not a substantial generator of travel. Of the 50.7 square miles in this use, about 16 square miles are used for airports; the remainder is in railroad properties, miscellaneous other transportation facilities and public utilities. The areas used for these purposes are highly selective: they occur at the airports and near the waterways and rail lines. Most of the areas registering in Map 9 are rail yards; an ordinary rail line does not take up enough land to be represented.

Transportation lands have historically been most concentrated on the south side of the Chicago area and in Indiana. Here is where the canals connecting Lake Michigan with the Mississippi River and the convergance of rail lines at the southern end of Lake Michigan have combined to produce the transportation complex shown on Map 9. Only recently has O'Hare Field placed more weight of transportation in the northern part of the region.

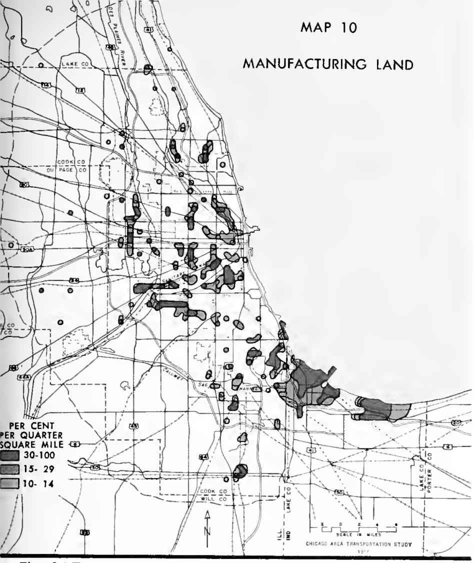
Manufacturing occupies only 4.4 per cent of the land in the Study Area. About 7.6 per cent of all person trips and 8.8 per cent of all vehicle trips have destinations on this land. About one-third of all workers are employed in



Of all land in urban use, 9.0 per cent is employed for transportation purposes, principally railroad properties and airports.

MAP 10

MANUFACTURING LAND



The 24.7 square miles of land used for manufacturing is located in close relationship to water and rail transportation facilities.

manufacturing so that such land becomes something of a focal point for travel, and its location is thus of great interest. Map 10 shows this pattern, which is very closely related to the pattern of transportation lands.

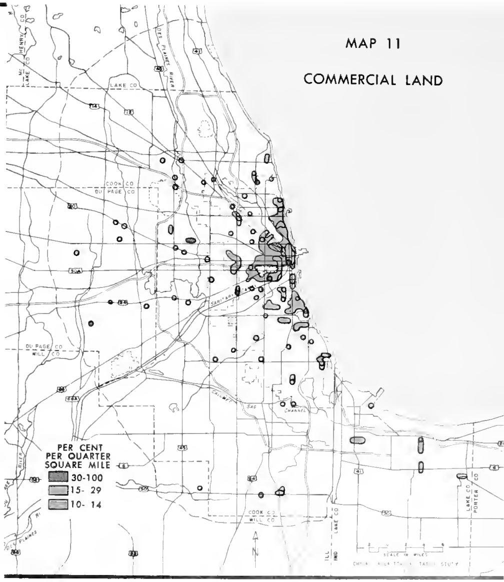
While public buildings occupy nearly as much land as manufacturing, these lands are so evenly scattered around the area that no pattern is discernible. The only exceptions are the Argonne Laboratory, Glenview Naval Air Station and Fort Sheridan.

Commercial land encompasses a variety of activities, not just retail stores. Personal and business services, wholesaling, offices, automotive sales and some contracting and building trades are included in the definition. Even with this broad definition, commercial land occupies only 3.8 per cent of used land. Despite its small area, over 23 per cent of all trips go to commercial land, thus qualifying it as the most intensively used land type.

Map 11 shows the locations of commercial areas. The greatest concentration is in the Loop and its vicinity. With the exception of this concentration, commercial land is scattered lightly and evenly over the remainder of the developed area. The pattern of commercial land is explained by the functions of commercial activities, which are to bring buyers together with assortments of goods and services. Accessibility is thus the prime requirement and commercial land has always had an affinity for the central places which are closest to most people. Accessibility of the Loop area has been riveted down by the construction of mass transportation facilities which made this the time-center of the area, even if it is not the geographic center. The scattering of other commercial uses is simply a reflection of the fact that it is more economic to bring some goods and services closer to the consumers, at places which are central to smaller, less specialized, trading areas.

MAP 11

COMMERCIAL LAND



Commercial activities use 21.1 square miles of land, of which one-fifth is located within four miles of the Loop.

Figure 2 shows how the proportions of land in each of six major uses change as distance from the Central Business District increases.[6] Commercial land as a percentage of these six uses decreases from 28 per cent of the total at the Central Business District[7] to about three per cent of the total at twelve miles distance and remains at about this proportion all the way out to the cordon line. The amount of residential land increases to about 40 per cent of the total eight miles from the Central Business District and remains more or less constant at about that level. Streets take up over 40 per cent of the land within two miles of the Loop, then decrease to about 32 per cent. Between 15 and 28 miles from the Loop, streets are a variable, but gradually increasing, proportion of the total. The variability occurs because transportation and public buildings are variable at this distance from the Loop. The increasing percentage of streets takes place because, in this area, there is more vacant land and hence, what streets

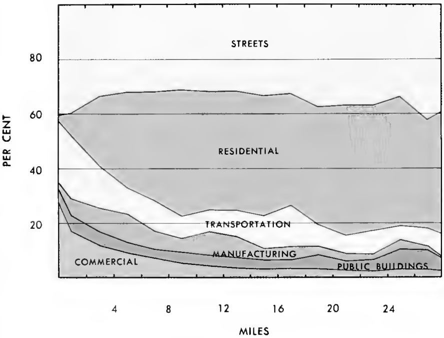


FIGURE 2—THE PERCENTAGE DISTRIBUTION OF SIX LAND USES BY DISTANCE FROM THE LOOP

O'Hare Field (15-17 miles) and the Argonne National Laboratory (19-21 miles) are not included.

[6] Values plotted in Figure 2 are averages for two mile bands, e.g., the average values of 0-1.9 and 2-3.9 are plotted at one and three miles. A special extra plot has been shown at 0 miles to give the Loop's land use percentages.

[7] In this report the two terms "Central Business District" and "Loop" will be used interchangeably. The Loop is considered to be the square mile area centered on the intersection of State and Madison Streets; this district takes its name from the loop of elevated structures which run on Wabash Avenue, Lake, Wells and Van Buren Streets.

there are take up a larger proportion of used land.

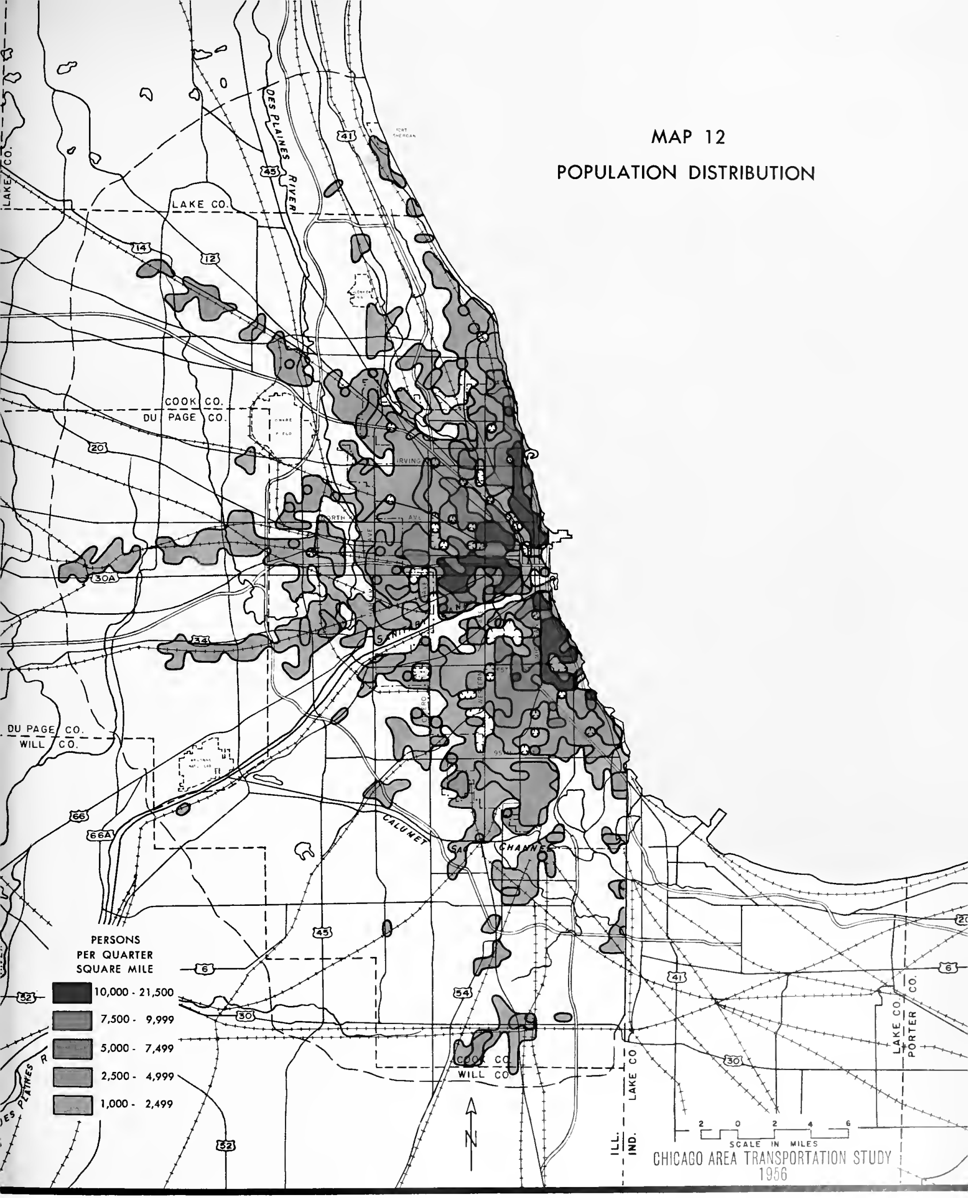
In this same figure transportation takes up about 22 per cent of land at the urban center, but thereafter averages about ten per cent, except where unusually large rail yards build up its share, as at the 17 mile mark. Manufacturing has two peaks, at five and 11 miles; elsewhere it remains about four per cent of the total. Public buildings are remarkably constant, but at 25 and 27 miles there seems to be a concentration of major public buildings, including Fort Sheridan and some small colleges.

The preceding pages have described the manner in which land was used in the Study Area in 1956. The nonresidential uses tend to be concentrated in the center, but elsewhere have minimum levels below which they do not go. Residential uses surround the nonresidential uses and are fingered out along the railroad lines. The prevailing movement of people then, is bound to be from the outer areas in toward the core in the morning and out again in the evening.

As population increases, additional lands must be brought into urban use. The proportions of this new land devoted to each type of use fall within fairly strict limits, as shown both by the data and by sheer necessity. All developed lands must be served by streets; business can afford only so much land; only so many schools and firehouses are needed and so forth. The data summarize the results of years of city-building practice in Chicago. This detailed land accounting then provides the basis for understanding traffic patterns and is the firm base on which future predictions can be built.

DENSITY OF LAND DEVELOPMENT

Patterns created by areas of different land uses are basically two dimensional; they show how land is being used in different parts of the metropolis. Transportation studies, however, require a third dimension — the dimension of intensity of use. For if on one acre of land there are four dwellings and on another seventeen, it is obvious that the more densely



The 1956 Study Area population of 5,170,000 persons was distributed as shown on this map. The average gross density for the Study Area was 9,200 persons per square mile in urban use. Average net residential density was 28,500 persons per residential square mile. For further details see Table 19 in the Appendix.

settled acre will generate about four times as many trips as the former.

As Measured By Population

One way of measuring density is to count the number of persons residing in a given area such as an acre or a quarter square mile. This can either be a gross area, including *all* land uses, or it can be a net area, restricted to one type of use and excluding streets and all other land uses. So there are gross population densities and net population densities. An example of the latter might be 30,000 persons per net residential square mile.

Fortunately, the travel inventories provided a means for estimating the population of the Study Area, an extremely important fact, since people are the basic underlying source of travel. The home interview survey sampled every thirtieth dwelling place and obtained population as well as travel data from the residents. By this means, it was ascertained that the 1956 population of the Study Area was 5,170,000 persons. This population occupied 1,667,000 dwelling places—an average of 3.1 persons per occupied dwelling place. See Appendix, page 120.

The population data were recorded by quarter square mile so that they could be displayed as gross population densities. They were also related to the area of residential land in any grid square, and studied as net residential densities. Map 12 is a display of gross population densities; it might be considered as a population dot map where those areas with the same number of dots per square mile have been given a distinguishing color for easier identification.

Compare Map 12, showing the distribution of population, with Map 6, showing the location of residential land. Population is concentrated very heavily close in toward the Loop, with fewer and fewer people as distance from the Loop increases. Residential land, however, takes up very little area around the Loop, while the greatest quantities of residential land occur beyond six miles from the Loop. Gross population, divided by net residential land, equals net residential density. With great numbers of people living where there is relatively little residential land, very high population densities result. These sometimes exceed 150,000 persons per net residential square mile. In contrast, the suburbs have densities ranging from 10,000 to 15,000 persons per net residential square mile. The decline in density with increasing distance from the Loop is quite regular, as shown in Figures 3 and 4.

FIGURE 3—NET POPULATION DENSITIES BY SECTOR
Population density declines sharply from a peak equivalent to 78 families per net residential acre to densities ranging between four and five families per net residential acre.

The pattern of population density is related to age of development. When Chicago was in its most explosive period of growth, from 1860 to 1910, the principal means of travel was by mass transportation, with some travel on foot and a minor amount by horse and carriage. These slow means of transportation required that houses be built close together with multi-family structures wherever possible. Slow transportation and high density dwelling mutually reinforced each other.

However, as the average speed of travel has increased over the years, more and more land has fallen within tolerable commuter distance and hence has become available for urban development. The automobile has been a dominant influence in bringing new land into the urban market. With these improvements in transportation, residential lots could be made larger and this has gradually reduced densities of urban settlement.

Population densities are often called "night-time" densities since they are true only for that part of the day when all the members of a family are at home. "Daytime" densities are different, since large numbers of persons are at work, or are shopping or in school. Employment densities are a particular kind of daytime density, and refer only to the number of employees working in any given area. They do not include shoppers or visitors who may, in commercial areas, greatly outnumber employees.

Densities of commercial employment show much the same pattern as the densities of population. This employment is concentrated in the core area, with worker densities exceeding 1,130 persons per acre of commercial land (700,000 per net square mile) at the very center. This shows the mutual reinforcement of mass transportation and high density. It was not an accident that elevated trains and steel-framed skyscrapers were developed side by side in the same period, 1884-1897.

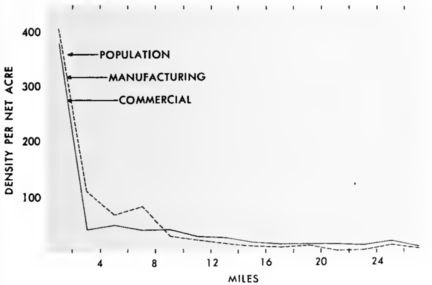


FIGURE 4—POPULATION AND EMPLOYMENT DENSITIES BY DISTANCE FROM THE LOOP

Not included here are Loop and Central Area densities which are substantially higher.

Manufacturing employment densities show a similar pattern: the closer to the Central Business District, the higher the density of employment. Here again strong forces have influenced the density of development. Manufacturing employment had to be dense in the Nineteenth Century partly because factories had to be centrally located to obtain an adequate labor supply. Compact production arrangements were necessary because power was transmitted to machinery by means of belts and shafts. Further, with less mechanical power available, manufacturing required more employees per given unit of output.

Current technology modifies these effects. Power is transmitted to machinery by electricity. More power is available for each worker. The workers themselves travel by cars and require parking space. All these conspire to reduce the density of manufacturing employment.

In summary, there is a pattern of population and employment density which is superimposed on the several land use patterns. Both land use and density must be known for studies of transportation. Densities for all uses peak at the Central Business District and decline rapidly with increasing distance from the center. Peak densities at the center accentuate the demand for movement to that predominantly nonresidential area.

As Measured by Floor Area

A concentration of population or employment in any small area requires a similar concentration of buildings to shelter people and their activities. Density, therefore, can be measured in terms of square feet of floor area per acre of land, as well as by population density. Each measure has its own applications in analysis, forecasting and planning.

Floor area measures are useful because they permit the study of establishments. This is a more direct and detailed index of the amount and kind of activity taking place on a parcel of land than is provided by land use measures. Floor area data are particularly valuable for planning and studying traffic generation in such areas as the Central Business District where land is used so intensively and at such varying rates.

Although floor area was not inventoried for the entire Study Area, the 295 square mile area

FIGURE 5—TOTAL FLOOR AREA MODEL

The 295 square mile area where buildings were measured contains 2.2 billion square feet of floor area. The vertical dimension of each block represents the amount of floor area within a quarter square mile grid square.

which was surveyed in 1956 did contain 80 per cent of the population of the Study Area and an estimated 86 per cent of the total floor area. The breakdown of this floor area by types is shown in Table 2.

TABLE 2—FLOOR AREAS AND PERCENTAGES BY MAJOR CATEGORIES WITHIN THE 295 SQUARE MILE INVENTORY AREA*

Type of Establishment	Floor Area In Millions Of Square Feet	Percentage Of Total Floor Area
Residential	1,301.0	58.4
Commercial	351.9	15.8
Manufacturing	309.5	13.9
Transportation	103.5	4.6
Public Buildings	162.5	7.3
Total	2,228.4	100.0

*For district data see Appendix, Table 20.

Put in human scale, the total floor areas in residences works out at about 940 square feet per dwelling place. (Measurements are exterior wall measurements and include all public halls and stairs in apartment buildings.) This is very close to what might be expected, since new single family houses run about 1,200 square feet and new two-bedroom apartments run about 720 square feet, both using inside measurements and not including public halls and stairs. Floor area for manufacturing workers runs a little over 300 square feet per worker.

The density of floor area in Chicago is dramatically portrayed in Figures 5 and 6. These models, showing the total amount of floor area per quarter square mile, illustrate perfectly how land is used more and more intensely as one approaches the center of the

FIGURE 6—TOTAL FLOOR AREA MODEL

The highest value shown on this model is 32,000,000 square feet. Quarter square mile grids with less than 1,000,000 square feet of floor area are not shown.

city, until in the actual Central Business District there is a boiling up of activity which towers over, and completely dominates, the entire metropolitan area.

In the four, quarter square mile zones which comprise the Loop district, there are 92.3 million square feet of floor area. The single quarter square mile bounded by State Street, Madison Street, the Chicago River and Harrison Street, has over 32 million square feet. This is in contrast with the lowest blocks shown on the model, each of which represents one million square feet of floor area per quarter square mile. Since very few suburban areas approach this rate of land utilization, the model as a whole represents a good approximation of the whole Study Area even though floor area measurements were not taken in most suburban and rural sections.

Readers familiar with the area will recognize the resemblance between the models and the actual skyline of Chicago. Both the Loop and the near north side stand out. The more intense use of land along the lake front can be seen with such special peaks as those caused by the dense apartment development at 51st Street and the Outer Drive, to the south. The remainder of the model shows a gradual lessening of densities, with the exception of a few isolated peaks. These peaks are caused, for the most part, by manufacturing concentrations.

To give these models and figures a scale which can be related to everyday experience, the ratio between floor area and land area can be used. Floor area ratios can best be described by example. If the total floor area in the Loop is divided by the Loop's net land area (excluding streets, public open spaces and unusable land) a floor area ratio of 6.8 is attained. This means that if every net square foot of land in the Loop were covered with buildings, the buildings would average nearly seven stories in height. To attain such a ratio, many buildings must be twenty and thirty stories high. By contrast, the remainder of the city of Chicago seldom has a floor area ratio exceeding 1.5. For such a ratio, buildings must generally be two and three stories high. The suburban parts of the Study Area generally have a floor area ratio of less than 0.5.

Figure 7 does not show floor area but represents instead the number of person trips which terminate in each quarter square mile on an average weekday. Compare this figure with the model of total floor area shown in Figure 6. The similarity between the two is great, although, of

FIGURE 7—TOTAL PERSON TRIP DESTINATIONS

The destinations of 10,212,000 person trips, on the average weekday, are distributed throughout the Study Area as shown in this model. The highest blocks in the model represent 144,000 trip destinations per quarter square mile grid, the lowest blocks 5,000, the shaded areas less than 5,000 but more than 2,500.

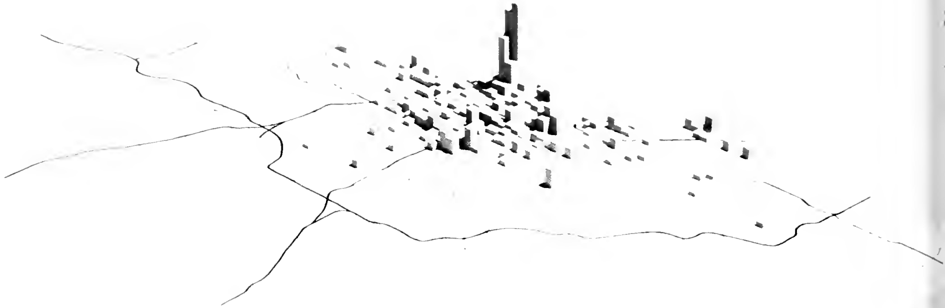


FIGURE 8—NONRESIDENTIAL FLOOR AREA MODEL

This model shows the distribution of 927,400,000 square feet of nonresidential floor area. The highest value shown is 29,700,000 square feet; quarter square mile grids with less than 1,000,000 square feet of floor area are not shown.

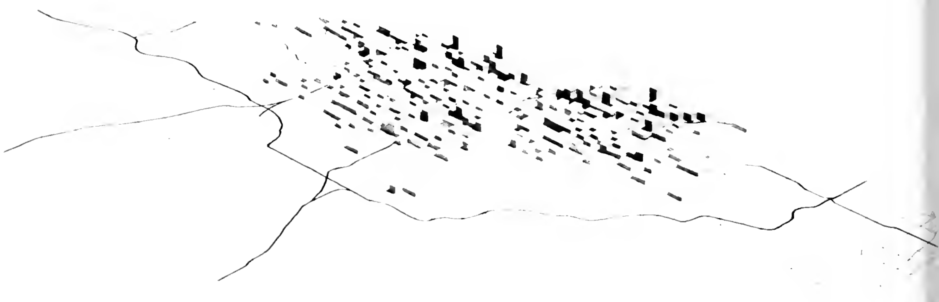


FIGURE 9—RESIDENTIAL FLOOR AREA MODEL

Buildings measured contained a total of 1.3 billion square feet of residential floor area. The highest value shown is 8,400,000 square feet. Values of less than 1,000,000 square feet per quarter square mile grid are not shown.

course, not perfect. The concentration of floor area in the Loop is matched by an equal concentration of persons whose trips are destined to that spot. Elsewhere, there are much smaller amounts of floor area, fairly evenly distributed, and a similar even distribution of person trip destinations. The model of person trip destinations extends farther into the suburbs because the floor area survey was limited in extent. Even in the details there is comparability: for example, just west of Lake Calumet is the former town of Pullman with its factories and shopping center, and this shows up clearly on both models.

This is a general demonstration of the truth in the basic assumption that travel is related to land use. Succeeding chapters will detail this impression with facts and figures, but this is the first and perhaps the most vivid demonstration that travel is a precise and measurable function of the activities taking place on land.

Figure 8 shows just the floor areas of nonresidential building uses. Nonresidential floor area is packed within a semi-circular area having a radius of about six miles centering on the Loop. This is the three dimensional expression of the commercial and industrial land use maps previously shown in Maps 10 and 11.

The concentration of floor area in downtown Chicago is extremely high: 4.1 per cent of the total floor area measured is in the Loop (District 01)[8] which has a land area of one square mile or less than 0.1 per cent of the entire Study Area. Within the Central Area (Districts 01 and 11) there is 16.2 per cent of the total floor area measured, 40 per cent of the commercial floor area, 20 per cent of the manufacturing floor area and 36 per cent of the transportation floor area. This is in contrast with the fact that Districts 01 and 11 combined contain only one per cent of land area in the Study Area! This is the apex of density in land utilization.

[8]See Map 21 in Appendix for the boundaries of districts and zones. Hereafter the Loop will be considered the same as District 01 and the Central Area the same as Districts 01 and 11 combined.

Certain alignments of nonresidential activities can be discerned. There are a number of densely developed quarter square miles along Cicero Avenue, from the southern end of the Edens Expressway to a point south of Midway Airport. There is also a mass of industrial buildings along the Sanitary Canal and, a bit further east, the Stockyards can be identified. Many of these lesser peaks of nonresidential floor area are active with the handling of goods and do not require so many people. This is one reason why the model of person trip destinations (Figure 7) tends to be more even than the model of total floor area.

Figure 9 shows residential floor area. This is the complement of the model of nonresidential floor area; both of them, if added together would produce the model of total floor area shown in Figure 6. Naturally, where there is a great deal of nonresidential floor area, as in the Central Area or along the Sanitary Canal, there is correspondingly less residential floor area.

There tends to be slightly more residential floor area just outside the Central Area. Also, greater amounts of residential floor area are found along the lake front, showing the advantage which has been taken of this desirable site, with its high degree of accessibility to the Loop via the Outer Drive. This pattern agrees closely with the population map shown on page 21 (Map 12).

These residential and nonresidential floor area models are excellent indexes of the kinds and density of human activities taking place at locations within the Chicago area. Since people are the active agents in generating travel, these floor area facts are tapping and measuring the basic underlying cause of traffic patterns. The density of street traffic itself, and of passenger loads in mass transportation systems, are related to these data. So also is the general inward and outward movement of people and vehicles from residential to nonresidential activities and back again.

SUMMARY

A land use survey is necessary to a transportation study because it permits measurement of the connection between land use and trip making. The resulting trip generation rates are one of the basic pieces of information needed to forecast future travel. They must, however, be applied against an estimate of future land use, and here again the land use survey is essential because it provides the factual information necessary to land use forecasting. Land use survey data can be kept current to aid the continuing processes of planning, or can be obtained for additional portions of the metropolitan region in order to estimate travel patterns outside the cordon line. All of these processes depend upon accurate measurements of land uses within carefully controlled geographic areas.

This chapter has presented data obtained from the 1956 inventory of land use and floor area. These data have been organized to give a clear idea of the form, structure and density of the Chicago area. The total impression is one of orderly development, whether expressed in composition, or location, or density of land development.

The growth of an urban area takes place by the addition of increments of residential and nonresidential land uses, neither of which can depart radically from the form or the site of development already in place. These increments, however, are occupying successively larger areas because they are developed at lower densities. The forces shaping new development are not radically different from those of the past. Foremost among them is the level of accessibility which is determined by the character, location and efficiency of transportation facilities.

Patterns of the different land uses show a definite structure arrayed around the Central Business District. This structure is related not only to historical development but also to the functions which the different land uses represent. Commercial activities, requiring the highest degree of accessibility, are concentrated at the center, where there are also large areas in streets and other transportation uses. Manufacturing land is related partly to population and partly to transportation lands. Residential land, together with its supporting land uses (streets, public buildings and small amounts of other land uses), is symmetrically arrayed around the Central Business District in varying degree near jobs and services.

Decline in intensity of land utilization with increasing distance from the Central Business District is quite regular for all land use types. Changes in density are slowed by powerful forces. The social costs of increasing residential densities over any substantial area are quite great. The costs of increasing any densities (especially nonresidential) include the costs of providing additional transportation facilities and this cannot be borne indefinitely. It may be cheaper to relocate or reorganize certain activities as the city grows. There are probably lower limits to densities as well. The cost of moving people and goods past undeveloped property is one of the reasons why it is hard to hold land out of use and there are other community inefficiencies in extremely low density development.

So it can be seen that the development of urban land is affected by transportation and transportation is affected by the uses of urban land. This mutual interaction takes place because travel and urban activity are both phases of human activity in urban areas; they are parts of the same whole. This is the basic reason for studying land use. After the presentation of travel in the following chapter, these land use data will be used with the travel data to demonstrate, in Chapter V, the degree to which trip generation rates can be fixed by land uses.

Chapter IV

THE AMOUNTS AND CHARACTERISTICS OF TRAVEL

The primary reason for taking an inventory of travel is to discover those evidences of orderliness in travel which make it possible to estimate the traffic and mass transportation demands of the future. These estimates are necessary if plans are to be prepared. With measured regularities it is also possible to test plans, so as to know whether proposed transportation improvements, once built, will accommodate the traffic demands thrown upon them.

A second reason for taking a travel inventory is to describe travel clearly, forcefully and in objective terms. This is necessary to gain an accurate perspective; to see the parts in proper relationship to the whole; to understand the characteristics of each kind of travel and the forces acting upon it. Further, it is fundamental that stock must be taken of the existing amounts of travel as a base for forecasting and planning, and for comparison with the supply of transportation services.

A discovery of regularity in travel, coupled with careful, quantitative measures of travel, shows that the "traffic problem" is not overwhelming either in size or complexity. It is something which can be dealt with intelligently. This provides the confidence that improvements can be made in accordance with a rational plan.

THE TRAVEL INVENTORIES[1]

The travel inventories were designed to represent travel undertaken in the Study Area on the average weekday in 1956. Every trip made by a person or vehicle within the Study Area had to be represented. It was necessary, therefore, to consider the different kinds of trips being made and to find the most reliable and economical means of sampling each type. Obviously a complete enumeration of 10,500,000 daily trips was impossible.[2]

Trips made within a bounded region such as the Study Area may be classified into three types on the basis of the location of their origins and destinations. A trip may have both origin and destination within the Study Area, or one end in and one end outside, or both ends outside.

Those trips having both origin and destination inside the Study Area were sampled in the "internal" travel surveys. These were broken down into two parts: the home interview survey which obtained data on trips made by persons (whether by automobile or public transportation), and the commercial vehicle survey which obtained data on trips made by trucks and taxis. Those trips with one or both ends outside the Study Area were sampled at the cordon line bounding the area. The cordon line or external surveys were of two types: a roadside survey which sampled trucks, taxis and private automobiles, and a survey of suburban railroad passengers. The total travel accounted for by each survey is reported in Table 3.

The vast bulk of all trips made in the Chicago area have both ends inside the Study Area. Only 5.3 per cent of all trips made by persons, and 5.2 per cent of all trips made by vehicles, were

[1]For details see the *Home Interview Manual* (14,203), *Truck-Taxi Manual* (13,303), *Mass Transit External Survey* (12,100), *External Survey Manual* (11,101), *Roadside Interview Manual* (11,110) (Chicago: CATS, 1956-1957).

[2]A person trip is defined as a one-way journey by a person traveling as a driver or passenger in an automobile, or as a passenger in a taxi, truck, or mass transportation vehicle, taking the person outside the block of trip origin. A vehicle trip is defined as a one-way journey by an automobile, taxi, or truck, taking the vehicle outside the block of trip origin. In this report, person trips are linked trips. In a linked trip, a person using two or more modes of transportation to proceed from origin to destination is considered as making only one trip, although most travel surveys consider each link as a separate trip. The mode of travel in the linked trip is defined as the mode having highest priority in the following list, taken in the following order: 1) suburban-railroad, 2) subway-elevated, 3) bus, 4) auto driver, 5) auto passenger. Or where the driver of a car dropped or picked up a passenger enroute to his main destination, the stop involving the passenger was eliminated. For further details, see *Coding Manual* (21,000) (Chicago: CATS, 1956).

recorded at the external surveys. Among the internal surveys, the home interview survey accounted for 94.7 per cent of all trips made by persons, and 78.4 per cent of all vehicle trips. Although the home interview survey was the most expensive to undertake, it provided data on the largest segment of average daily travel.

TABLE 3
PERSON AND VEHICLE TRIPS BY TYPE OF SURVEY

Survey Type	Completed Sample Interviews	Expanded Person Trips Per Weekday	Expanded Vehicle Trips Per Weekday
INTERNAL SURVEYS			
Home Interview	49,591	9,931,638	4,824,773
Truck Interview	7,346	....	801,951
Taxi Interview	147	....	171,478
EXTERNAL SURVEYS			
Roadside Survey	73,078	555,143	337,286
Railroad Survey	5,239	33,446	....
Total	135,401	10,520,227*	6,135,488*

*Includes through trips.

Home interviews were made at every thirtieth dwelling place throughout the Study Area, approximately 58,000 sample units. Using the dwelling place as the basic unit permitted the sample to be selected very carefully,[3] and the interview could be conducted without haste and hence more thoroughly. Another advantage of the home interview technique was that travel by all types of transportation could be recorded.

At each home, two kinds of information were obtained. The first covered the characteristics of the sample unit itself, including type of dwelling place, number of residents, sex and race of head of household, car ownership, number of drivers and total number of trips made. This was, in effect, a sample census of population. The second type of information concerned the trips which were made by each member of the household. This included the address of each trip's origin and destination, trip purpose, land use at origin and destination, mode of travel (by automobile, bus, subway, elevated or suburban railroad), and time of departure and arrival.[4]

[3] *Home Interview Sample-Design* (23,300) (Chicago: CATS, 1958).

[4] For further details, see the *Home Interview Manual* (14,203), and the *Coding Manual* (21,000) (Chicago: CATS, 1956).

Commercial motor vehicles registered within the Study Area were sampled from lists obtained from the State of Illinois. Trucks were sampled at the rate of one in every fifteen (6.67 per cent). Taxis were sampled at the rate of one in thirty (3.33 per cent).[5] Interviews were conducted with the driver of each vehicle or with his dispatcher, and data similar to those obtained by the home interview survey were recorded.

Trips made by automobile, taxi or truck, which had one or both ends outside the Study Area, were interviewed at a series of roadside interview stations set up on all the principal roads crossing the cordon line. When these stations were in operation, a sample of about 25 per cent of the stream of vehicles in each direction was interviewed. Trip data as to origin, destination, purpose, land use and number of persons per car were recorded.

Finally, to insure completeness of coverage, a survey was taken of those persons commuting across the cordon line into the Study Area by suburban railroad. Inbound passengers were given postcards asking for information comparable with that obtained in the other travel surveys. The returns provided a sample in excess of fifty per cent of such travelers.

Accuracy Checks

In order to check the accuracy of the various surveys, a special survey was conducted on a screen line dividing the Study Area into two parts. As shown on Map 22 in the Appendix, the screen line was located along the line of the Chicago Sanitary and Ship Canal. Drivers of vehicles crossing this screen line were interviewed as well as counted, so that the travel they represented could be used to verify completeness of coverage of the same kind of trips which were sampled in the home interview and commercial vehicle surveys. Since over 416,000 internal automobile driver trips crossed the screen line on an average day, this was a good checking device.

[5] *Truck-Taxi Sampling Procedure* (13,100) (Chicago: CATS, 1956).

The screen line check indicated that expanded survey trips accounted for 87.6 per cent of automobile driver trips intercepted on this line and for 98.5 per cent of commercial vehicle trips. These are better-than-average results for an origin-destination survey in a large city. After the check was completed, the home interview survey was expanded at the points where the comparison showed that under-reporting was most marked.[6] Trips made for social-recreation and personal business were generally least well reported and were increased in weight. Trips to and from work, shopping and school agreed almost exactly with the screen line counts and so, needed no weighting. Truck trips required no further expansion and a factor of 1.1 was applied to taxis. These selective expansions insured that the over-all travel demand was at the proper level. As seen in Figure 10 they also brought the sample data into close agreement, time-wise, with ground counts.

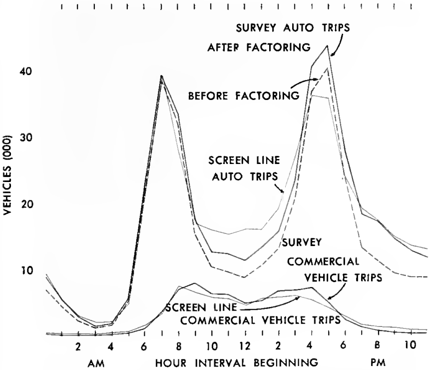


FIGURE 10—SAMPLE SURVEY TRIPS COMPARED WITH SCREEN LINE COUNTS BY HOUR

See Tables 27 and 28 in Appendix.

In addition to the screen line check, other checks were made against data obtained from independent sources. These checks have been described in the *Report on Accuracy Checks.*[7]

[6] *Factoring Procedures and Screen Line Check* (23,100) (Chicago: CATS, 1958).

[7] *Report on Accuracy Checks* (23,601) (Chicago: CATS, 1958).

The results indicate a high level of accuracy and reliability for the purposes for which the data are to be used.

NUMBER AND CHARACTERISTICS OF WEEKDAY TRIPS

Just over 10.5 million person trips were made in the Study Area on the average weekday in 1956. Of these, 10.2 million were made by residents and 300,000 by nonresidents.[8]

Vehicles made 6.1 million trips within the cordon line. Of these, 5.9 million trips were made by residents in their automobiles and by trucks and taxis registered in the area.

For most analytical purposes, the figures of 10.2 million person trips and 5.9 million vehicle trips will be used. This is partly because these trips are related to the resident population, and partly because these trips are directly related to the land area within the cordon line.[9] The following paragraphs give the most important breakdowns of these totals.

Trip Production Rates

There were in 1956 over 1,667,000 occupied dwelling places in the Study Area. These units housed 5,170,000 persons, at an average rate of 3.1 persons per occupied dwelling place.

The population living in these dwelling places reported owning 1,342,000 automobiles. This is an average of 0.8 automobiles per occupied dwelling place; it can also be expressed as 260 automobiles per thousand population.[10] In addition to automobiles, 130,000 trucks and 5,600 taxis were registered and garaged in the Study Area. Trucks make up about 8.2 per cent of the total number of vehicles registered.[11] The total rate of vehicle ownership is 310 vehicles per thousand population.

[8] The number of resident trips equals, for all practical purposes, the number of trips having destinations within the Study Area. The reason is that inbound nonresident trips are canceled by an equal number of outbound resident trips.

[9] Person and vehicle trips overlap, with 76 per cent of all person trips being made in automobiles which are also included in the total of vehicle trips. Throughout the report these two separate, but overlapping, universes of person and vehicle travel will be employed as the basis for analysis and planning.

[10] These figures do not include approximately 120,000 automobiles owned by business firms or governments.

[11] This rate is lower than the rates of most large cities, but compares closely with those of Detroit and Cleveland.

If the total number of resident trips with destinations in the Study Area is divided by the number of persons, the figure of 2.0 trips per person per day is obtained. This is the equivalent of one round trip per person on the average weekday. So, if a million persons are added to the population of the Study Area, at least two million additional trips will be made each weekday.

The average household's automobile in 1956 made about 3.7 trips per weekday, or the equivalent of about two round trips per day. Trucks made 6.4 trips per day, on the average. This can be pictured as five deliveries and a return to garage, or as three round trips, such as might be made by a coal truck. Taxis averaged 30.5 trips per day!

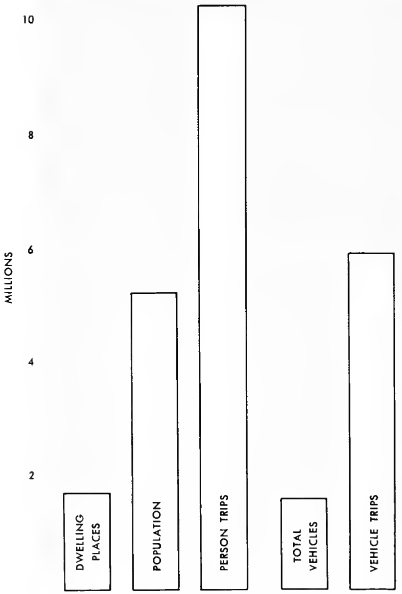


FIGURE 11—TOTAL DWELLING PLACES, POPULATION VEHICLES, AND WEEKDAY TRIP PRODUCTION

See Table 38 in Appendix.

Mode of Travel; Vehicle Type

Of all person trips, roughly three-quarters were made by automobile in 1956. One-quarter was made by all forms of mass transportation, including buses, subway and elevated trains, and suburban railroads.

Buses carried 16.5 per cent of all person trips—nearly 1,700,000 trips per day. Elevated and subway lines carried 480,000 trips (4.7 per cent of all person trips) and suburban railroads served 266,000 riders (2.6 per cent of all person trips) on the average weekday. As will be described later, these trips take on an added significance because of their length and their concentration in time and place.

Just over 63 per cent of all person trips made by automobile were made by automobile drivers. The average number of persons per car is therefore roughly 1.5. This does not include children under five.

Although comprising only 8.2 per cent of all vehicles, trucks made 13.9 per cent of all vehicle trips. The reason is that trucks make more trips daily per vehicle. Taxis, with 0.3 per cent of all vehicles, made 2.9 per cent of all vehicle trips. The remaining trips—83.2 per cent or about four-fifths of the total—are made by automobiles.

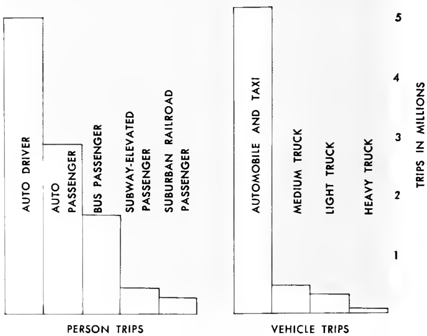


FIGURE 12—PERSON TRIPS BY MODE OF TRAVEL AND VEHICLE TRIPS BY VEHICLE TYPE

See Table 38 in Appendix.

Purpose of Travel and Land Use

The dominant trip purpose of persons is to home; 43.5 per cent of all person trips are made for this purpose.[12] Since an equal number of persons must leave home, almost 87 per cent of all person trips are anchored with one end at the home. This is a powerful influence in organizing travel patterns.

Work trips make up one-fifth of all person trips. Again, an equal number must come from work as go to work, and so it can be said that roughly forty per cent of all person travel is work oriented.

Other trip purposes are individually much less important. Personal business trips and social-recreation trips each account for about one-tenth of all person trips. All other trip purposes combined, including shopping, school, ride, serve passenger and eat meal, make up about one-eighth of all person trips.

There is a strong and logical correspondence between trip purposes and the land use to which the trip is destined. While but 43.5 per cent of all person trips are returning to their homes, more than half of all person trips are destined to residential land. The reason for the difference is that a number of work and social-recreation trips are made to residential land. Work trips by domestics and servicemen and visits by families or friends are good examples. Residential land, like the home trip purpose, is of great importance in fixing the location of travel.

Trips made to service establishments and to wholesale and retail locations make up 24 per cent of all person travel. These types of activities fall in the broad category of commercial land use. Thus slightly more than half of those trips not bound to residential land are bound to commercial land.

All other land uses combined attract 21.1 per cent of all trips. Manufacturing (both durable and non-durable) gets 7.6 per cent of all person trips, and public buildings (schools, churches, post offices and the like) attract 7.7 per cent. The remaining land uses (such as public open space and transportation) are minor generators of travel, as might be expected.

Vehicle trips[13] have a land use distribution similar to that of person trips. The similarity is natural because automobiles and taxis carry three-quarters of all person trips. As a result, slightly less than one-half of all vehicle trips go

[12] This percentage is higher than found in most origin-destination surveys, because these trips are linked trips. All "change mode of travel" trips and many "serve passenger" trips have disappeared in the linking process.

[13] Purpose is useful for studying travel of persons, but not for vehicles. Therefore, purpose and land use breakdowns are provided for person travel, but only land use breakdowns for vehicle travel.

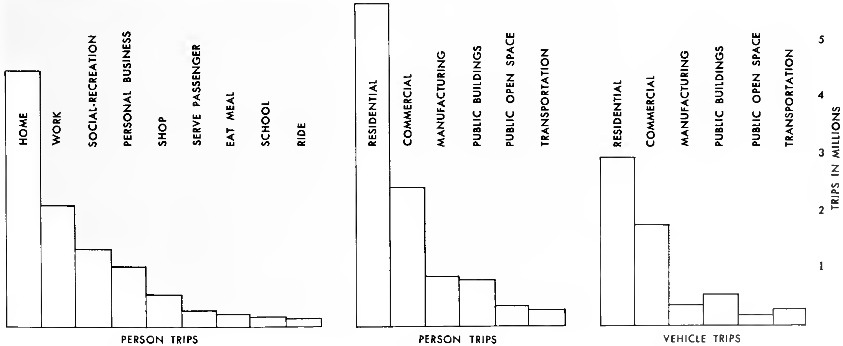


FIGURE 13—PERSON TRIPS BY PURPOSE AND LAND USE AND VEHICLE TRIPS BY LAND USE

See Table 38 in Appendix.

to residential land, whereas slightly more than one-half of all person trips go to residential land. On the other hand, more vehicle trips (28.8 per cent) go to commercial land than do person trips (24.0 per cent).

The difference between the land use distribution of person trips and vehicle trips is caused by three factors. First, 72 per cent of all truck trips are bound for nonresidential activities. Second, people use different modes of travel according to their trip purposes. For example, a smaller proportion of vehicle trips than of person trips is made to public buildings because more children go to school by bus than by car. And third, car loading varies for different trip purposes.[14] Over-all land use distributions of person and vehicle trips are shown in Figure 13.

The foregoing summaries have given the principal characteristics of average weekday travel in the Chicago area. Yet these figures and proportions will eventually become dated. More trips will be made in 1970 and still more in 1980. It is likely that the proportions of trips made by automobile and by public transportation will change, and other characteristics are likely to shift in time. Therefore, a search must be made for those relationships which have some stability and which will be useful in making estimates of future travel.

PATTERNS OF TRAVEL IN TIME AND SPACE

It is difficult for an individual, driving in a stream of traffic or traveling by bus or rapid transit, to see the orderliness in the travel patterns of which he is an infinitesimal part. But upon reflection, the principal patterns are obvious. He knows when and where traffic peaks are high or low, and when buses or trains will be most or least crowded. Clearly, he can only know this if travel patterns are repetitive in time and space.

Time

Throughout the year, the amount of travel taking place within the Chicago area is quite even. Figure 14 shows the daily vehicle counts of five permanent counter stations maintained by the Study, and also the average weekday and weekend travel for the mass transportation system operated by the Chicago Transit Authority. As shown in this figure, the variation about the annual average weekly travel seldom exceeds plus or minus 12 per cent, despite the fact that two out of the five permanent counter stations (U.S. Route 14, the Northwest Highway, and U.S. 45, La Grange Road) are subject to summer seasonal loads.[15]

Although these particular street traffic and mass transportation data cannot be added together, it can be seen that when automobile traffic increases, mass transportation usage de-

[14]For details on the number of persons per car by purpose and land use, see Table 29 in the Appendix.

[15]See tables 26 and 31 in the Appendix.

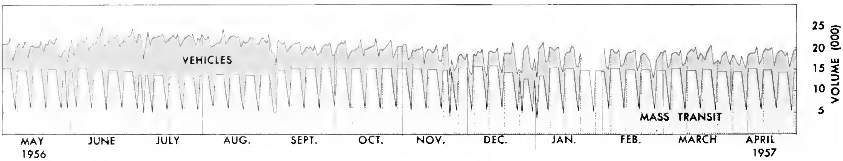


FIGURE 14—VARIATIONS IN AVERAGE DAILY TRAVEL ON STREETS AND MASS TRANSPORTATION, 1956-57.

Street data are averages from five permanent counter stations; see Table 26 in Appendix. Mass transportation data are averages of weekdays and weekend days obtained by dividing total revenue passengers of the Chicago Transit Authority by the number of C.T.A. routes; see Table 31 in Appendix. The break in the street volume line is due to bad weather.

clines, and vice versa. Thus, there is a certain cancellation of peaks and valleys in travel, leading to an even greater steadiness in the amount of trip-making within the Chicago area throughout the year.

Within the yearly pattern there is a repetitive weekly pattern broken only by holidays. The variation of the days of the week about average weekday traffic is of the same order as the seasonal variations. Within the week, high and low traffic volumes differ by plus or minus five per cent from average weekday travel. Mondays and Tuesdays are slightly under average; Friday is typically the busiest day. Weekend traffic is generally less than weekday traffic.[16]

In sum, seasonal variations in travel are slight. Variations in travel within the week are also slight. Both follow a regular pattern. All this is reasonable since continuous activity is necessary if a large community like Chicago is to keep producing the goods and services which keep it alive. The concept of average weekday travel is therefore valid and can be used for planning purposes.

The fact is that the greatest variation in travel occurs within the day, and not within the week or year. The average 24-hour weekday has a regular cycle of travel, as shown in Figure 15. The peaking of travel in the morning rush hour is twice, and in the evening rush hour two and one-half times, the average hourly travel. It is this peaking within the day which causes the most severe traffic problems.

Why travel is organized in this way is readily explained by the purposes for which travel is undertaken, as shown in Figure 15. At 4:00 in the morning the urban area is very nearly at rest. From 7:00 A.M. to 10:00 A.M. there is a big surge of travel to work. This is matched by a slightly greater movement back home in the period 4:00 P.M. to 7:00 P.M. Other trip

[16]It should be noted that on certain roads near the cordon line the heaviest volumes of trips do occur on weekend days, especially in the summer months, and these weekend volumes are influential in determining the future designs of such roads.

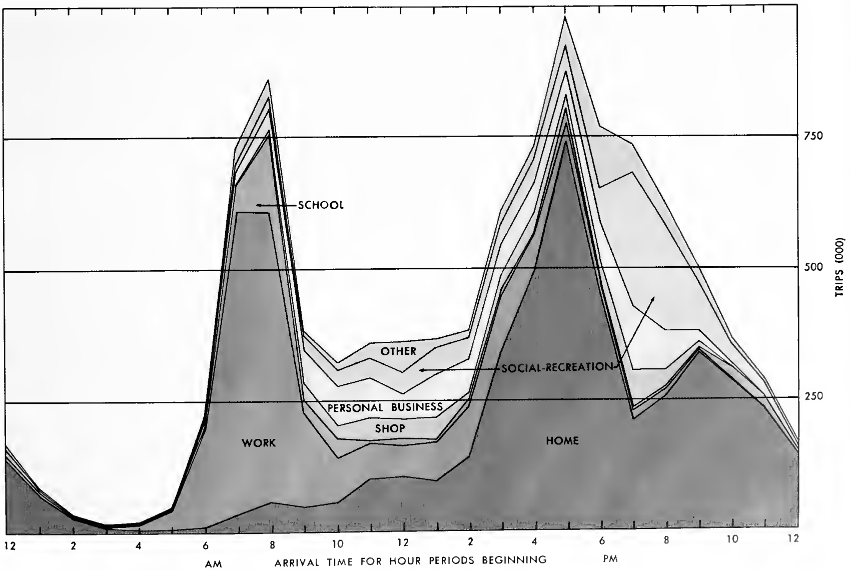


FIGURE 15—HOURLY DISTRIBUTION OF INTERNAL PERSON TRIPS BY TRIP PURPOSE

purposes have their own patterns. Personal business trips are fairly evenly spaced throughout the day, as are shopping trips. Social-recreation, as might be expected, peaks in the period between 6:00 P.M. and 10:00 P.M. While trips to work and home make up the greatest part of peak hour travel, other trip purposes, such as school, shopping, personal business and social-recreation, combine to form 35 per cent of the morning peak and 25 per cent of the evening peak.[17]

It can be seen that the reasons for the daily cycle of traffic are founded in the whole way of life of an urban society. Barring major catastrophes, or significant changes in social organization, it is unlikely that there will be any real shifts in this cycle. The times of the day when people eat, work and rest tend to be stable—basically, they are geared to the sun's rising and setting. Therefore, it is quite reasonable to use current data in forecasting time distribution of travel.

The application of these time regularities is made in computing the capacities of streets and mass transportation systems. Given an estimated average 24-hour load on a street or mass transportation route, the portion of that load which will take place within the peak hour can be estimated quite accurately. Factors can also be applied to account for variations within the week and within the year.

Space

Travel also has definite regularities in space. For example, during the average 24-hour period, the number of trips entering any given area equals, for all practical purposes, the number leaving that area. This principle is one which is supported by common sense. More people could not come into a small area than leave it, day after day, without accumulating an excess population very rapidly. In another example, if people leave a residential area they must also return to that same residential area during an *average* 24-hour period or else it would become deserted.

Empirical proof that arrivals equal departures during any 24-hour period is readily available. The number of persons entering the Study Area on the average weekday is 175,000. The number leaving is 177,000. This is a difference of less than one per cent. Of the 44 districts making up the Study Area, only two had a difference between inbound and outbound travel of more than one per cent.[18] One was the Loop and the other district contained Midway Airport. Both districts are noted for their transient populations and for their intercity travel. Despite the difficulty of keeping precise records on travel in and out of such districts, the difference between inbound and outbound travel in each case was less than two per cent. In all these cases, the difference between input and output was always less than the sampling error.[19] Thus, as far as sample data can prove a rule, it has been demonstrated that inbound travel equals outbound travel for any area during the average weekday.

Related to the foregoing is the rule of directional symmetry of travel. Travel in one direction equals travel in the opposite direction for any 24-hour period. If 1,000 trips leave Evanston to go to Elmhurst, then an equal number will leave Elmhurst to go to Evanston within the same day.[20]

Figure 16 shows the percentage differences between directional flows between 44 randomly selected pairs of zones. All the differences in directional travel lie within the 95 per cent

[17]Truck trips, which comprise 14 per cent of all vehicle trips, have a different time distribution, as seen on page 51. The time distribution of trips by mode of travel is shown in Figure 24, page 48.

[18]See Table 30 in the Appendix.

[19]In dealing with sample data, there is always a range of error resulting from the fact that a sample, and not 100 per cent of the universe, was interviewed. Sampling error is a function of sample rate, number of events predicted and size of the universe. Table 18 on page 107 in the Appendix gives an approximate measure of sampling error for the travel data.

[20]It might be argued that many trips are made from home to work and then to a shopping center before returning home, and that this kind of a triangular trip would destroy the directional symmetry of travel. It appears, however, that the quantity of this type of triangular trip is not sufficiently great. Moreover, if one person goes from Zone A to Zone B and then to Zone C before returning to Zone A, another person is likely to make the reverse triangular trip, going from A to C and then to B before returning to A. Thus the two triangular trips cancel one another.

confidence limits of sampling variability and the distribution of differences approximates what would be expected from sampling error alone. This is a demonstration, within the confines of a sample survey, that there is directional symmetry of travel.

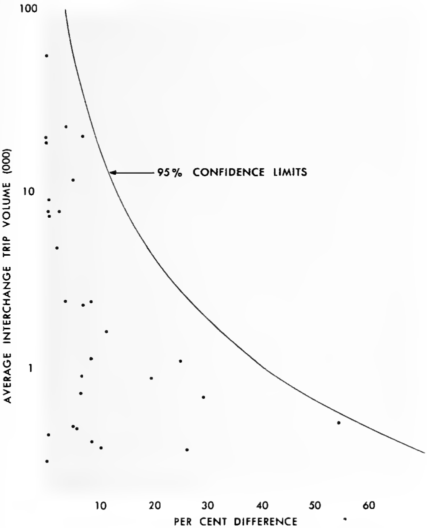


FIGURE 16—PERCENTAGE DIFFERENCES BETWEEN DIRECTIONAL TRAVEL FOR 44 PAIRS OF ZONES

The explanation for the fact of directional symmetry lies in the dominant position of the home as the base from and to which most trips are made. Of all person trips, 43.3 per cent begin at home and 43.5 per cent terminate at the home. Therefore, about 87 per cent of all trips have home as the purpose from which or to which they are going. Most of these are single purpose trips — the husband going to work and returning, the wife going shopping and returning home. Tied to home base, and restricted by limited time, it is almost inevitable that there should be symmetry of travel by direction.

Table 4 summarizes trips both by purpose from and purpose to. It shows that 1,652,000 trips go to work from home and 1,581,000 trips return to home from work. This is a difference of about four per cent. About 405,000 trips go from home to shop while 432,000 go from shop to home. This is a difference of less than seven per cent. Slightly more trips go to work than come home directly from work, while slightly more trips return to home from shopping than go to shop from home. Thus, a small percentage of trips do make a triangular trip from home to work and then to shopping. Only 5.2 per cent of all trips are unmatched triangular trips, computed on a purpose basis.[21] This

[21]Precisely, the sum of the absolute differences between directional travel between pairs of trip purposes.

TABLE 4

TRIP PURPOSE AT ORIGIN RELATED TO TRIP PURPOSE AT DESTINATION FOR ALL INTERNAL PERSON TRIPS*
(in thousands)

	Trip Purpose at Destination								
Trip Purpose At Origin	Home	Work	Shop	School	Social-Recreation	Eat Meal	Personal Business	Serve Passenger*	Total
Home	. . .	1,652	405	182	924	83	753	308	4,307
Work	1,581	290	28	3	27	57	42	1	2,029
Shop	432	5	55	1	23	4	24	. . . .	544
School	159	7	1	1	5	4	2	. . . .	179
Social-Recreation	1,042	3	17	1	160	42	36	4	1,305
Eat Meal	109	49	3	4	21	1	18	. . . .	205
Personal Business	689	26	38	1	99	20	145	2	1,020
Serve Passenger*	307	1	. . . .	. . . .	6	. . . .	2	26	342
TOTAL	4,319	2,033	547	193	1,265	211	1,022	341	9,931

*Includes "Ride" trips.

shows that triangularity is quite limited and its importance should not be exaggerated.

Knowledge of the fact of directional symmetry, which almost amounts to a natural law, permits the transportation planner to deal with trips in one direction only, with full confidence that the number of trips in the opposite direction will so nearly be equal that equality may be claimed for all practical purposes. This fact is well known to traffic engineers. Over a 24 hour period, directional travel on individual streets is equal and turning movements balance one another.

Trip Length

Regularity of travel is evidenced in another important way: the number of trips made varies systematically with trip length. Short trips are made most frequently and progressively fewer are made as trip length increases. The frequency distribution of trips by length is extremely regular, as shown in Figure 17.

It is worth speculating on the reasons why this occurs. First, there seems to be a natural conservation of travel costs, so that for any given objective, such as a trip to buy groceries, there is a strong tendency to buy at the nearest store. Then there is a tendency to relate the length of the journey to the reward obtained; for example, no one would drive twenty miles to buy cigarettes. Finally the trip maker has a whole spectrum of needs which range from daily needs such as work, shopping and school to the less frequently felt needs for recreation, for medical care and for vacations.

To meet people's requirements, stores, services, churches, factories, hospitals and colleges are located at different intervals throughout an urban area. Food stores are close together because people must buy food frequently. Department stores are farther apart because shopping trips for clothing and furniture are made less frequently. Moreover, each kind of urban activity has its own internal requirements which affect spacing, among which are the collection, handling, storage and distribution of goods. Generally, the more specialized the activity, the farther it is located from the average traveler.

So the result is a balance between the requirements and travel costs of the trip maker on one hand and the requirements of activities on the other. This balance may operate to conserve total energy resources, or to maximize productivity. One evidence of this is the decline of trip frequency with increasing trip length.[22]

Another way to see this is to examine trip length as related to trip purpose. As might be expected, purpose has a great deal to do with trip length. Shopping trips are usually short, averaging 2.8 miles in length. The longest trips are those made to work, with an average length of 5.3 miles. Trips to home average 4.4 miles in length; those made for social-recreation purposes are 4.3 miles in length.

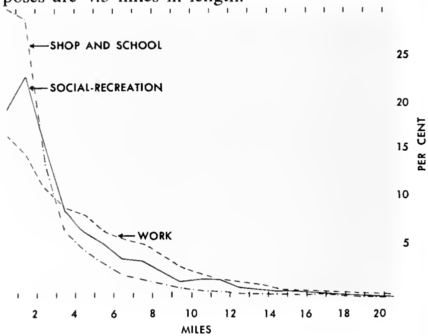


FIGURE 17—PERCENTAGE DISTRIBUTION OF INTERNAL PERSON TRIPS BY TRIP LENGTH BY TRIP PURPOSE

The relationship between trip length and trip frequency is useful in estimating the ways in which trips will move between parts of the area in the future. For example, if Zone A is two miles from Zone B and ten miles from Zone C, more trips will be expected to move from Zone A to B than from A to C. This, of course, is the simplest sort of example and does not include consideration of mode, time of travel, type of trip or land use connections, all of which influence the precise amounts of travel between zones.

The preceding data have shown that when dealing with large masses of trips, there do exist

[22]See Table 32 in the Appendix for average trip lengths to different land uses.

regularities in travel patterns. The behavior of a single person cannot be predicted successfully but major transportation facilities are not planned for single persons or even small groups. They are planned to serve very large groups of travelers — perhaps of the order of 10,000 or more persons per day. The travel inventories show that travel habits of these large groups can be estimated reliably.

This orderliness in travel is useful for prediction. The methods for prediction have only been suggested here; more complete treatment is reserved to Volumes II and III. The reasons for regularity of travel are so tied in with all the living and working habits of an urban community that it is hard to imagine any sudden or substantial change. Plans based upon these relationships, therefore, are on a stable base.

THE LOCATION OF PERSON TRAVEL; MODE OF TRAVEL

The location of travel is dictated by land use; this is the simplest and most obvious of the relationships needed to understand and work with travel data. The number of trips coming to each small area within the Chicago region is determined by the kind, amount and intensity of land use going on there. No more can come than will be served there by jobs or services; no more will go to live than there are houses to live in.

At this point it is necessary to distinguish between a trip as a single event, and a trip as a journey having the property of length. When considering numbers of trips or the generation of trips, any trip is counted as one unit. But when considering the *amount* of travel which takes place in an area, trip length must be included in the measure. Amount of travel is therefore measured in vehicle miles of travel or in person miles of travel. It is a good representation of the impact upon, or use of, a transportation system since each trip is appropriately weighted by its length.[23]

The miles of person or vehicle travel which take place within a defined area then become a function both of the number of trips which are destined there, and of the position of that area with respect to other land uses. Areas like Oak Park or Cicero not only have travel within them because they generate trips but they also have travel because of their position between the western suburbs and the city of Chicago.

The amount of both through and local travel can be portrayed by the use of desire line maps. A desire line map shows the sum of all the straight lines connecting the origins and the destinations of all trips. The desire line is the shortest line between origin and destination, and expresses the way a person would like to go, if such a way were available. The desire line is, of course, unrealistic, but it is a simple, completely unbiased presentation and gives the viewer a strong impression of the location and magnitude of travel within an urban area.

The desire line maps shown here were prepared from Cartographatron prints. The Cartographatron[24] is a machine which reads travel information recorded on magnetic tape and displays selected trips by drawing a straight line on the face of a cathode ray tube. In seven minutes 20,000 trip records can be read and displayed. A camera, focused on the tube, records and accumulates the desire lines on a continuously exposed negative. From the exposed photographic plates the figures on the following pages were prepared.

In showing the location of travel by desire line maps, it is most convenient to deal separately with the modes of travel. This helps to build an understanding of the special ways in which the various modes are used. At the end of this section the separate modes of person travel will be summed to provide a desire line map of all internal person travel. This can then be understood more readily as the sum of the components of travel which preceded it.

These Cartographatron displays summarize person or vehicle miles of travel at locations. They provide a summary picture of travel demand for the entire area within the cordon line. While the Catrtographatron shows each trip

[23]Alternate weighting systems could be used, such as weighting by time to measure the duration of use of a transportation system.

[24]For details, see page 97 in the Appendix.

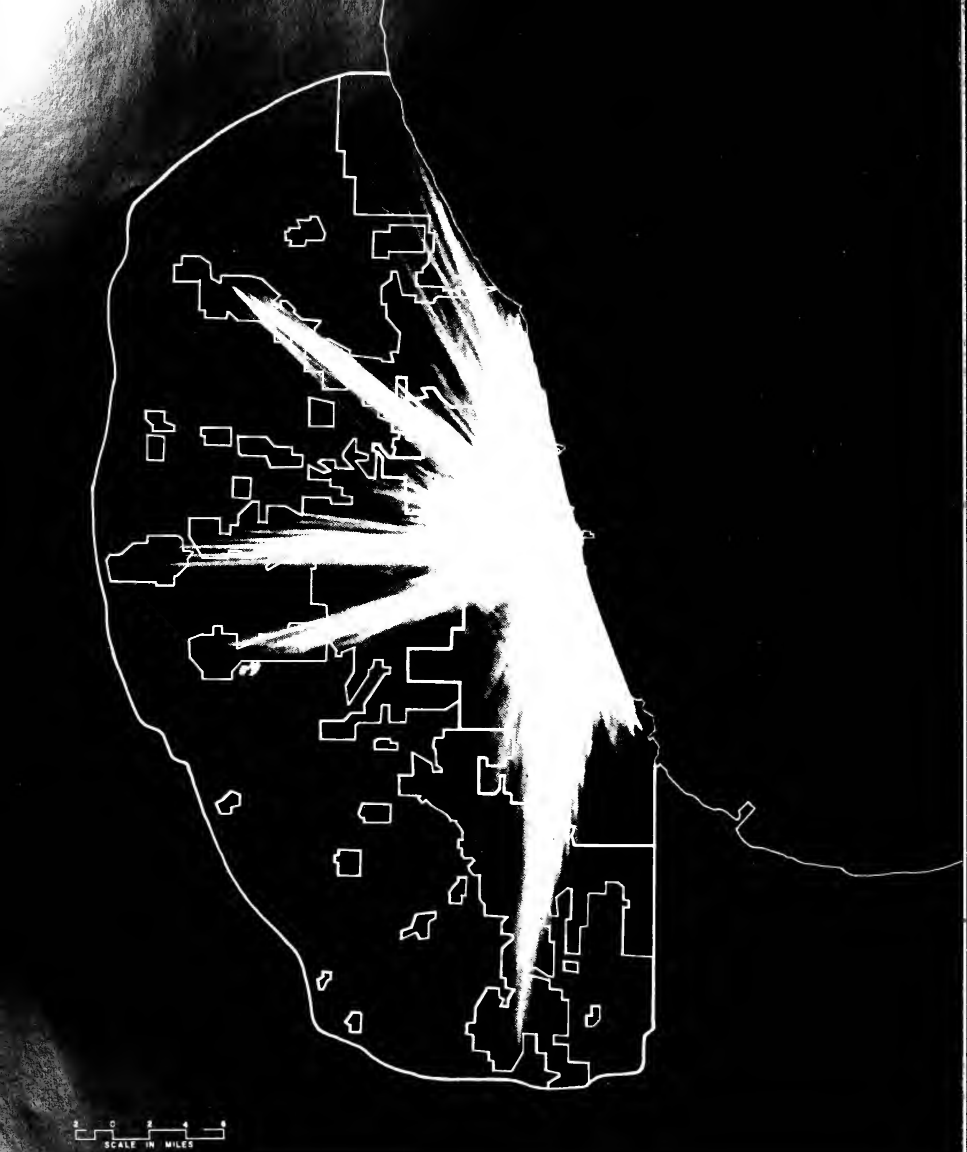


FIGURE 18—DESIRE LINES OF INTERNAL PERSON TRIPS USING RAPID TRANSIT

The 729,000 person trips using suburban railroad and subway-elevated trains are represented here by their combined travel desire lines. Each desire line is traced from the trip's origin to its destination, for a total 6,744,000 desire line miles of person travel. Since this display presents only 16.3 per cent of all internal person-miles of travel, its exposure relative to Figure 23 has been increased 1.07 times.

precisely in its proper geographic location, it is not details which are of concern here. At this scale, it is more valuable to accumulate and hence submerge the details in order to emphasize the major patterns of travel for the Chicago area.

Internal Rapid Transit

Figure 18 shows the desire lines of all internal person trips using rapid transit, here defined to include suburban railroad lines (whether diesel or electrified), elevated trains and subways. This figure is presented first among the Cartographatron displays because one can see in it most clearly how thousands of individual desire lines combine to form a distinct over-all pattern of travel. Further, this display is an excellent demonstration of the way in which the land use pattern of a city, combined with a particular transportation network, can dictate the patterns of travel.

This figure shows dramatically the focusing of rapid transit travel upon the Central Business District. Although it represents less than one-twelfth of all person trips, and only one-sixth of the miles of person travel, the concentration of these trips makes rapid transit extremely important, especially to the Loop and the Central Area. Table 5 shows the distribution of trip destinations in the Loop by mode of travel. Over 45 per cent of all trips to the Loop are made by rapid transit. Over 71 per cent are made by all means of mass transportation combined.

TABLE 5
ALL PERSON TRIP DESTINATIONS IN THE LOOP AND CENTRAL AREA, BY MODE OF TRAVEL

Mode of Travel	District 01 (Loop)	District 11	Districts 01 and 11 (Central Area)
Auto Driver	78,556	256,266	334,822
Auto Passenger*	57,168	132,175	189,343
Suburban R.R.	84,134	33,243	117,377
Elevated or Subway	126,678	65,363	192,041
Bus	119,645	211,564	331,209
TOTAL	466,181	698,611	1,164,792

*Includes a few truck passengers and all taxi passengers.

The other side of the coin is the dependence of mass transportation upon the Loop traveler as a source of income. About 54 per cent of all subway, elevated and suburban railroad passengers have an origin or destination in the Loop and 81 per cent have an origin or destination in the Central Area. There is thus a strong mutual dependence between the commercial core of the region and rapid transit.

In no other part of the Study Area does rapid transit play so important a part. In District 11, which is the 12.4-square-mile area surrounding the Loop, only 14.2 per cent of all trips come by rapid transit, while 44.5 per cent come by both rapid transit and bus. The proportional use of both rapid transit and bus transportation declines rapidly with distance from the Central Business District, while that of the automobile rises steadily. This is shown in Figure 19. The percentage of trips by rapid transit at the Central Business District is very high, but then declines rapidly to about three per cent of all trips, maintaining itself at this level until the cordon line is reached at a distance of nearly thirty miles. Bus trips have their biggest share of person trips within ten miles of the Loop.

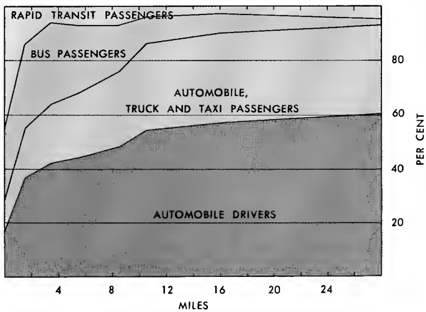


FIGURE 19—MODE OF TRAVEL RELATED TO DISTANCE OF TRIP ORIGIN FROM THE LOOP FOR INTERNAL PERSON TRIPS

Plots are averages for the Loop and seven rings.

In Figure 18, subway-elevated trips can be distinguished from the longer suburban railroad trips by the sudden jump in trip desire line intensity two-thirds of the way in from the cordon line to the Loop. This jump reflects the fact that twice as many person trips are made

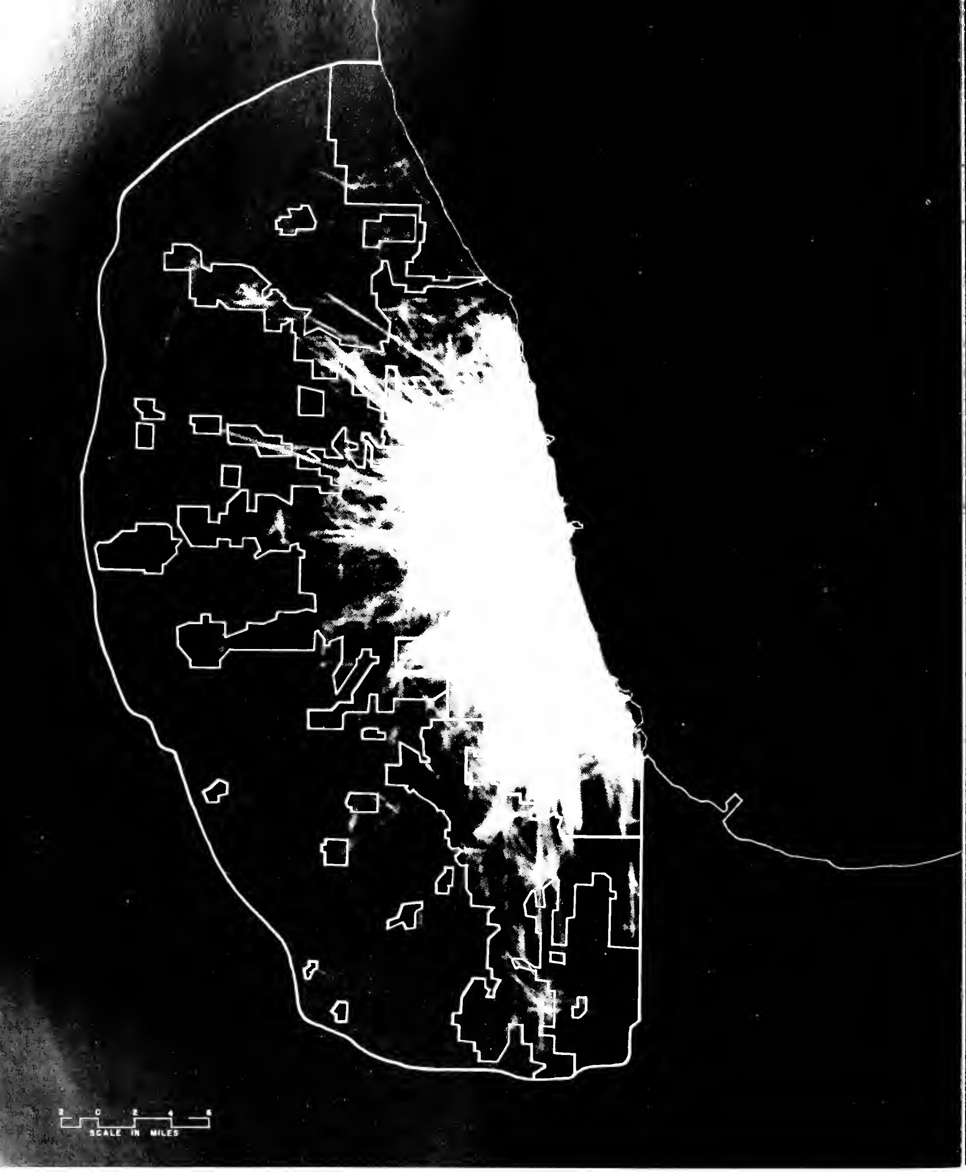


FIGURE 20—DESIRE LINES OF INTERNAL PERSON TRIPS USING BUSES

The 1,686,000 person trips made on buses in 1956 were concentrated chiefly in the city of Chicago. These trips account for 6,112,000 desire line miles of person travel, or 14.8 per cent of the total desire line miles of internal person travel. Exposure relative to Figure 23 is the same.

by subway-elevated train (480,000) as are made by suburban railroad (249,000). They also tend more to fan out radially from the Loop, rather than to be aligned closely with the right-of-way, like suburban railroad trips. This is because 57 per cent of all subway-elevated trips are linked with bus trips, which permits the subway-elevated line to draw from a slightly wider territory.[25] Notably, however, this fails to develop any substantial volume of non-radial trips.

Rapid transit, by these tokens, is an extremely specialized type of transportation. These trips are long; subway-elevated trips average 7.2 desire line miles in length and suburban railroad trips 13.3 miles. By contrast, all internal person trips average about 4.3 desire line miles. (See Figure 21.) As will be shown, rapid transit trips are mostly made in the peak hour. Over 70 per cent are between home and work. The starlike form of rapid transit radiates from the Central Business District and coincides exactly with the fingers of suburban development. Thus the connection with land use is clear. This is a unique pattern showing specialization of both living and working areas organized around a fast means of transportation.

Buses

The sum of the desire lines of all bus passenger trips[26] is shown in Figure 20. This is another unique pattern which goes to build up the total picture of all internal person trips. The contrast with the display of rapid transit trips is clear. Bus trips criss-cross and overlap each other within a relatively small area. The resulting pattern is compact, without the focus or strongly directional nature of rapid transit trips.

One reason for this pattern is that bus trips are short, averaging only 3.6 desire line miles in length. Half of all bus trips are less than 2.8 miles. Hence there is no real possibility of a unique focusing on the Loop. Another aspect of trip length is that while over twice as many trips are made by bus as by rapid transit, fewer person miles of travel are by bus.

Trips by bus passengers average slightly longer than automobile passengers (3.5 desire line miles) but less than automobile drivers (3.9 miles). Like them, bus trips have a smoothly declining frequency as trip length increases. (See Figure 21.) Subway-elevated trips and railroad trips have special patterns; obviously very few people use these facilities for short trips.

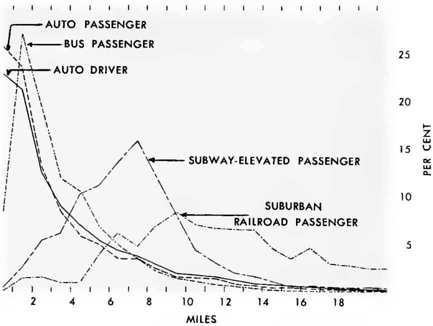


FIGURE 21—PERCENTAGE DISTRIBUTION OF INTERNAL PERSON TRIPS BY TRIP LENGTH BY MODE

Most bus trips take place within the city of Chicago, but there is some bus travel in the adjacent suburban communities such as Evanston, Oak Park and Cicero. Elsewhere, bus journeys show up very lightly on Figure 20. Certain ridges of travel desire can be discerned, particularly the Washington and Madison Street lines west of the Loop, but for the most part there is an even spread of bus travel.

The explanation for the limited extent of bus usage lies in the density of land use, and in car ownership. Bus service can be provided only where there are enough passengers to pay operating costs. (In some cases, profitable, heavily traveled lines can cover the losses of lightly traveled lines, but this principle cannot be extended too far.) There are enough passengers only in districts which have a certain density of development. This minimum density appears

[25] This is true only for the Chicago Transit Authority, which operates both buses and subway-elevated trains, with no extra fare for transfers.

[26] There were so few streetcars operating in Chicago in 1956 that their passengers have been grouped with bus passengers.

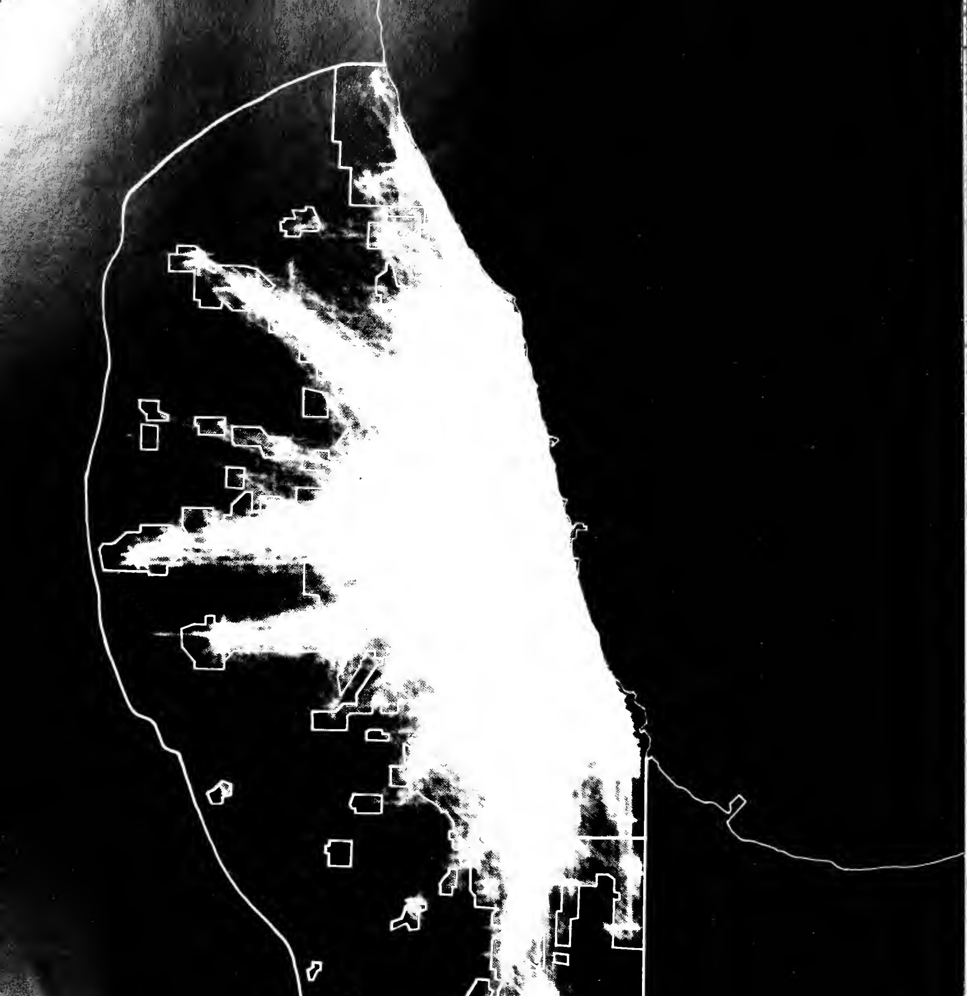


FIGURE 22—DESIRE LINES OF INTERNAL AUTOMOBILE DRIVER TRIPS

The 4,811,000 internal automobile driver trips made on the average weekday produce a total of 18,878,000 person (or automobile) desire line miles of travel. This is 74 per cent of all desire line vehicle miles. This pattern of automobile travel conforms closely to the shape of the urbanized area. Exposure is the same as Figure 23.

to be about 25,000 persons per net residential square mile. The areas where heavy bus usage shows up have these high densities. Where densities fall below this point, buses apparently cannot operate economically in local service.

Density and car ownership are closely related. Where residential densities are high, car ownership is low. Low car ownership is associated with greater use of mass transportation, particularly buses. It is worth noting that of those who used buses in the Chicago area in 1956, only 27 per cent could drive a car. By contrast, half of those using elevated-subway trains and two-thirds of those using suburban railroads could drive.

While bus trips are less specialized than rapid transit trips, they do not have the universal coverage of automobile travel. They are short trips which take place within areas of relatively high density. The use of buses on expressways in the future may change this pattern a little, but then the riders of express buses will probably have the characteristics of rapid transit users.

Internal Automobile Drivers

Figure 22 shows the pattern of trip desire lines made by automobile drivers within the Study Area on an average weekday.[27] This is equally a display of person trips and of vehicle trips. In both senses, these trips are dominant parts of the total picture of travel. Resident automobile drivers produce 46 per cent of all the person miles of desire-line travel made daily by residents; if passengers are included, this figure rises to 69 per cent of all person-miles of travel. As vehicles, automobiles produce 84 per cent of all the internal vehicle-miles of travel.

The pattern of internal automobile driver trip desire lines conforms exactly to the land development configuration of the urban area. Compare this desire line display with Map 4 on page 12 showing urbanized land in the Study Area. There is no significant difference between the two. Each of the suburban communities is clearly visible, as are such focal points as the Loop, Evanston, and Oak Park. It can be seen how much land use dictates the location of travel.

There is another way of demonstrating why travel patterns resemble land use patterns so closely. Most internal automobile driver trips—like bus or auto passenger trips — are quite short. Half are under 2.5 miles in length; one-fifth are under one mile in length. The shortest trips cannot depart from the urbanized area since both ends are bound to be at urban activities—a house, a store, or a factory. The longer trips are similarly constrained, but have the further property of being increasingly rare as they get longer. Hence those which depart from the prevailing patterns (e.g., which may drive from Wheaton to Fort Sheridan) are lost to view by the double effect of dispersed direction and infrequent occurrence. It is as if the urban area were a magnet influencing not only the particles of trips but the paths by which they move.

Within eight miles of the Loop there is a more even tone of density of auto driver trip desire lines. While there are ridges and valleys, they are not so apparent to the eye, especially when contrasted with the intense ridges of travel desire on the rapid transit and, to a lesser extent, the bus desire line displays. The location of the Loop stands out, but it does not have an intensity like that of the mass transportation modes.

The implication of these facts is that expressways and arterials built to serve the needs of automobile drivers in the Chicago area must be designed to provide service throughout the urbanized area. The focusing of all routes on a single point, such as the Central Business District, is not necessarily to be desired in view of the relatively wide dispersion of automobile desire lines.

[27]The gridded appearance of this and other displays is partly the result of the system of identifying trip origins. Since trips were traced from and to center points of quarter-square mile areas, regardless of exact position of origin or destination, many short trips appear as going due east-west or north-south, despite the fact that they may have been angling in directions. The effect of the prevailing gridiron street pattern in discouraging angled trips is of unknown magnitude.

FIGURE 23—DESIRE LINES OF ALL INTERNAL PERSON TRIPS

This display summarizes the desire line traces representing 9,931,000 internal person trips made by rapid transit, by bus, as automobile passengers and as automobile drivers. The average weekday travel of 41,327,000 desire line miles is nearly half the distance to the sun.

Automobile Passengers

The desire line pattern of automobile passenger trips is similar to that of automobile driver trips and a separate printing of an auto passenger desire line map was therefore not essential. One difference between the two patterns is that automobile passenger trips have relatively higher intensities in the suburban areas and lower intensities of travel desire within four miles of the Loop. This difference is caused by the higher car loadings in the suburbs where families are larger and make more social-recreation, shopping, and school trips, and of course use automobiles more.[28] Since such non-work purposes can be accomplished at many places within the Study Area, there is little need for these trips to move in large numbers toward the core of the urban area. Another difference is that there is a slightly greater tendency for automobile passenger trips to bunch at shopping centers in the outlying communities.

Automobile passenger desire lines have a lower over-all intensity than those of automobile drivers. There are only 56 per cent as many trips involved and, since automobile passenger trips have a shorter average length, only 51 per cent as many miles of travel.

All Internal Person Trips

The desire lines of all person trips by all modes of travel have been combined to produce Figure 23. This display is, in effect, a summation of the preceding figures showing rapid transit, bus, and automobile driver trips, plus the desire lines of automobile passenger trips. It represents the total demand which is placed upon the area's transportation system on an average weekday by the internal travelers.

The proportions of all person trips made by the five modes of transportation are shown in their true relationship in this display. The display of trips made by rapid transit, which was given a greater exposure in Figure 18 to permit effective presentation, has here been shown in its correct proportion. Table 6 gives the proportions of the person trips and the person miles of travel using each mode. Note that Figure 23 deals only with internal person trips, i.e., those recorded by the home interview survey.

The over-all pattern of Figure 23 is an automobile pattern, as it must be, with 69 per cent of the person miles of internal travel made by automobile. Yet within this pattern can be discerned the more specialized patterns of rapid transit and bus trips presented earlier in this section. The ridges of intense travel desire created by rapid transit users can be seen distinctly; their concentration accentuates the effect of the 16.3 per cent of internal travel made by this means of transportation. Also within the general area of the city of Chicago, the over-all intensity of travel desire has been increased by the bus trips made there in such large numbers. The effect of bus trips can be seen clearly by contrasting this display with Figure 22, which shows only automobile driver trips.

[28]See Table 34 in the Appendix, showing the relationship between trip purpose and mode of travel.

TABLE 6

PERSON TRIPS AND MILES OF PERSON TRAVEL BY MODE

Mode of Travel	Person Trips				Miles of Person Travel (Desire Line)			
	Home Interview Survey	Cordon Line Survey	Total	Percentage	Home Interview Survey	Cordon Line Survey	Total Travel	Percentage
Auto Driver	4,810,886	285,198	5,096,084	48.4	18,878,000	3,219,000	22,097,000	45.0
Auto Passenger	2,706,114	274,221	2,980,335	28.3	9,593,000	3,791,000	13,384,000	27.2
Suburban R.R.	248,851	33,674	282,525	2.7	3,300,000	827,000	4,127,000	8.4
Subway-Elevated	479,780	......	479,780	4.6	3,444,000	..	3,444,000	7.0
Bus	1,686,007	......	1,686,007	16.0	6,112,000	..	6,112,000	12.4
TOTAL	9,931,638	593,093	10,524,731	100.0	41,327,000	7,837,000	49,164,000	100.0

Desire lines of automobile driver and automobile passenger trips mark the general outline of the urbanized area quite distinctly. The suburban communities can be identified by minor concentrations of desire lines at their commercial centers. Natural barriers, such as the Sanitary Canal and Lake Calumet, restrict or prevent the trips from crossing them, and hence show up as areas of low desire line intensity.

High density of land use at the Central Business District focuses many lines of travel desire upon it, making it the peak point in desire line density. This intense concentration is made possible by the combined ability of rapid transit, bus and street systems to bring people to this point. In general, the greater the density of land development, the greater will be the desire line intensity for travel. More intense development retains not only its own locally-generated short trips, but also attracts a proportionate amount of long trips.

These displays suggest that maximum travel at any point would reach the levels shown if it were possible to proceed directly from origin to destination in a straight line. Besides providing an immediate and memorable understanding of the trip desire patterns of millions of travelers in the Chicago area, much can be read from the Cartographatron displays regarding the desirable spacing and location of highway capacity. These figures serve, therefore, as essential background material for planning.

From the individual displays of the several modes of travel and from the display of all internal person trips there emerges a conception of a complicated, yet regular, movement of persons which is closely related to the pattern of developed land. This demand for travel is satisfied, within limits, by a transportation system of three major elements. These elements are the rapid transit system which includes subways, elevated trains and suburban railroads, the system of buses, and the road network which carries automobile drivers and their passengers.

Each of these components operates best under certain conditions. These conditions are

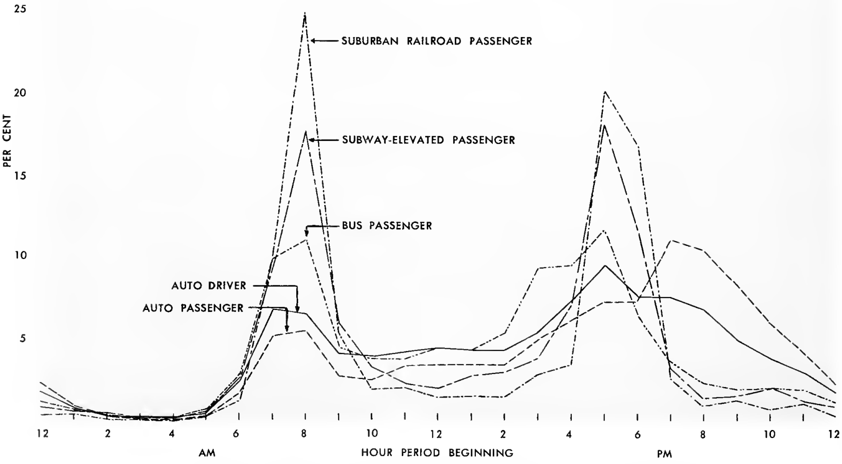


FIGURE 24—HOURLY PERCENTAGES OF TOTAL DAILY TRIP VOLUME OF EACH MODE OF TRAVEL

the result of a gradual and continuing evolution in which land development and transportation technology have adapted themselves to one another. The current situation can be thought of in terms of layers of transportation service. At the base is the road network, providing a fairly even supply of transportation service wherever there is urban development.[29] Where the demand for travel reaches a certain intensity, bus service can provide economically an additional and different capacity for movement. Finally, rapid transit provides a most specialized type of transportation serving a long distance, linear movement to the center of the city.

This layering of different service patterns in space is matched by a layering in time. Again, automobile travel may be called the base, providing the most even service through the day. Buses have much sharper peaks during the morning and evening rush hours, while rapid transit has the highest peaking of all. Figure 24 shows the relative peaking of hourly travel by bus, rapid transit and automobile.

This tendency toward peaking is one of the difficult problems in connection with provision of mass transportation service. In serving a more specialized group of riders, there is substantial loss due to idle manpower and equipment in off-peak hours, and it is in these off-peak hours that the greatest losses of riders have occurred. This does suggest, however, the complementary role played by the several modes of transportation. The mass carriers are extremely helpful in cutting down peak demands on highways. Seen as a whole, the various modes of transportation specialize, but also work together, to satisfy the region's travel requirements.

The completion of new limited access highway facilities, such as the Congress and Northwest Expressways with their companion rapid transit improvements, is likely to change the route of many trips, perhaps their mode of travel, and even their destinations (and origins). Such high speed facilities reduce the amount of time between certain parts of the urban area. Since more travel is made between points which are close together in time, the construction of high speed transportation facilities is likely to redirect more trip desire lines towards coincidence with their alignment. This accents the need to incorporate relatively more stable facts about travel (such as land use trip generation rates and trip length data) into devices which will be able to estimate the extent of such shifts in travel patterns.

THE LOCATION OF VEHICLE TRAVEL

Attention in the preceding section was focused on person trips—but only on those person trips with both origin and destination inside the cordon line. This section covers all vehicle trips, both internal and external.

Summaries of all vehicle trips are given in Table 7. The figures for vehicle trips and for

[29]As will be shown later, the supply of street service is also related closely to density of land development.

TABLE 7

WEIGHTED VEHICLE TRIPS AND WEIGHTED MILES OF VEHICULAR TRAVEL BY VEHICLE TYPE

Vehicle Type	Weighted Vehicle Trips				Weighted Vehicle Miles of Travel (Desire Line)			
	Home Interview and Truck-Taxi Surveys	Cordon Line Survey	Total	Percentage	Home Interview and Truck-Taxi Surveys	Cordon Line Survey	Total	Percentage
Automobile and Taxis	4,982,364	269,107	5,251,471	78.1	19,281,000	3,219,000	22,500,000	78.4
Light Trucks	297,221	13,496	310,717	4.6	818,000	110,000	928,000	3.2
Medium Trucks	896,738	31,774	928,512	13.8	2,496,000	385,000	2,881,000	10.1
Heavy Trucks	169,083	67,983	237,066	3.5	778,000	1,612,000	2,390,000	8.3
All Trucks	1,363,042	113,253	1,476,295	21.9	4,092,000	2,107,000	6,199,000	21.6
Total Vehicles	6,345,406	382,360	6,727,766	100.0	23,373,000	5,326,000	28,699,000	100.0

Includes 171,478 Taxi Trips

FIGURE 25—DESIRE LINES OF INTERNAL TRUCK TRIPS

Trucks made 1,363,000 vehicle trips (weighted in automobile equivalents) on the average weekday in 1956, covering 4,092,000 desire lines of weighted vehicle travel. The pattern resembles that of automobile desire lines. The exposure of this display is approximately that of Figure 29.

vehicle miles of travel are affected by the weighting of trucks.[30] Weighting is necessary so that trucks and automobiles can be compared rationally. Trucks take up more room than automobiles and are slower to accelerate, with the effect of increasing their occupancy of road space. To compensate for this, heavy trucks (combination units) were weighted as equal to three automobiles and medium trucks as equal to two automobiles. Light trucks (panels and pick-ups) were taken as equal to one automobile.

Since desire lines of internal automobile travel have already been displayed (Figure 22 on page 44), this section begins with a display of internal truck travel desire. Then external vehicle travel lines are shown—both automobiles and trucks—and finally a summary display of all internal and external vehicle trips.

Internal Trucks

Weighted figures were used in displaying the 1956 pattern of truck trip desire lines shown in Figure 25. Internal truck trips—that is, those recorded in the truck survey, which sampled trucks registered in the Study Area—make over 92 per cent of all the weighted truck trips (internal and external) and produce 66 per cent of all the weighted vehicle miles of truck travel. Internal truck travel is therefore a substantial proportion of all truck travel. Furthermore, internal trucks produce 14.2 per cent of all the weighted vehicle miles of travel, so that they are of real importance in the total picture of vehicle travel.

The pattern of truck trips is similar to that of all automobile driver travel but is more concentrated towards the center of the urban area. This concentration is caused to a great extent by the warehousing, commercial, industrial and truck terminal activities which are located within six miles of the Loop. The weighting of medium and heavy trucks also tends to increase intensity of the desire lines at the center. Generally, however, the patterns of automobile trips and truck trips are sufficiently alike to suggest that no special treatment of trucks will be warranted in locating new highways.

The truck pattern shows a few desire lines running counter to prevailing patterns. These lines seem heavy because they are isolated. They are identified as trucks working on construction projects, making large numbers of trips with loads such as sand and gravel. They are nonrecurring and hence not a factor in route planning. The precision of the basic information and presentation, incidentally, is indicated by the fact that truck trip destinations do not appear along the Outer Drive (where trucks are prohibited) and do show a considerable movement to the Navy Pier area.

While the spatial pattern of truck trips is not greatly different from that of passenger cars, trucks do travel at different times of the day. Auto trips are made to get people to places where they can do things, such as work. Hence, peaks occur before and after the work day. But the truck driver's trip is his work, and is conditioned by the hours of receiving, shipping and production workers. The truck is, in effect, an extension of the production line.

As seen in Figure 26, truck trips are made mostly between 7:00 A.M. and 6:00 P.M. This corresponds to the eight hour working day, with some overlapping caused by those trucks which

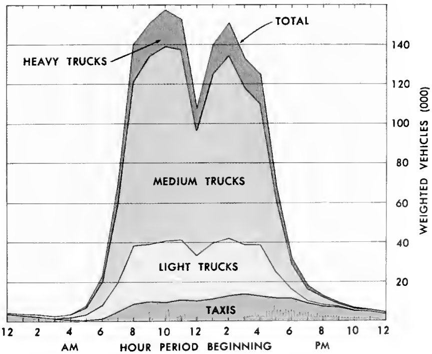


FIGURE 26—HOURLY DISTRIBUTION OF TOTAL INTERNAL TRUCK TRIPS (WEIGHTED) AND TAXI TRIPS BY VEHICLE TYPE

[30] An unweighted summary of vehicle trips and vehicle miles of travel is given in Table 33 in the Appendix.

operate on unusual schedules—milk trucks are a good example. There is a notable drop in truck traffic during the lunch hour, as might be expected. Taxis, which are shown in the same figure, begin their work later in the morning and spill over into the evening hours. This is to be expected because taxis normally operate on a two shift day.

Truck trips have many of the same characteristics as person trips; they follow the same rules of travel behavior. Truck trip origins equal truck trip destinations for any area, within any 24-hour period. Symmetry of directional travel for trucks is a fact. But truck trips are substantially shorter than automobile trips. The average truck trip is 2.7 and the average taxi trip is 2.1 miles in length. Truck and taxi trip length frequency distributions are shown in Figure 27.

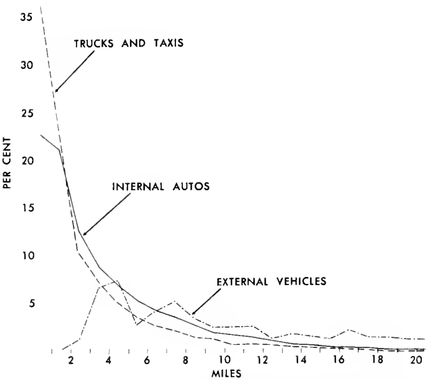


FIGURE 27—PERCENTAGE DISTRIBUTION OF INTERNAL AUTOMOBILE AND TRUCK TRIPS (WEIGHTED) AND EXTERNAL VEHICLES BY TRIP LENGTH

No Cartographatron display was made of taxi trips, because these form such a small part of the total average daily travel, just 1.7 per cent. Taxis are highly localized in the Loop area and provide a service to major airports, especially Midway. However, their use declines rapidly as distance from the Loop increases.

All External Vehicles

Desire lines of trips by automobiles, taxis, and trucks (weighted) which crossed the cordon line into the Study Area on the average weekday in 1956 are shown in Figure 28. These lines create an unusual pattern: except for a few straight bands caused by the through trips, external travel seems to spray out from the several external zone centers to all parts of the Study Area.

The origins of very long distance trips coming into the area (and the destinations of the same kind of trips leaving the area) have been grouped at ten entry points each located about ten miles from the cordon line in directions corresponding to sectors of the United States and Canada from which these trips come.[31] The rays of trip desire lines emanating from the strongest of these entry points to the north and east can be easily discerned.

Through trips, because they proceed from point to point, and are thus concentrated along their whole route, appear to have more importance than they actually merit. Only 16,000 vehicle trips pass completely through the Study Area each day, in *all* directions. Thus a bridge across the lower part of Lake Michigan, along the desire lines of some through trips, is definitely not indicated! Through trips constitute about five per cent of the total external trips and only 0.25 per cent of all vehicle trips—an occurrence at the rate of one through trip for every four hundred vehicle trips observed.

The strong intensities of desire lines in the Wolf Lake and Lake Calumet region are not long distance trips but many short trips between Gary, Whiting, Hammond and East Chicago on the one hand and the southern part of the Study Area on the other. This is really local travel, comparable to the internal truck and automobile driver desire line patterns shown in preceding figures. The arbitrary, but necessary, use of a state line as the cordon line in this part of the metropolitan area cuts across this moderately dense region of local travel.

[31]See Map 21 in Appendix for locations of sectors and entry points.

FIGURE 28—DESIRE LINES OF ALL EXTERNAL VEHICLES—TRUCKS WEIGHTED

All vehicle trips with one or both ends outside the cordon line—a total of 382,000 weighted ... here by their desire lines. These trips produce 5,326,000 weighted vehicle miles of tra... 18.6 per cent of the total vehicle desire line mil... This display has been given an exposure ...

It is difficult to assess the importance of external trips exactly. Although comprising only 5.7 per cent of the total weighted vehicle trips, these external trips made 18.6 per cent of the total weighted vehicle miles of travel inside the cordon line. This is a result of their unusually great length (an average of 12.6 miles inside the Study Area) and the high proportion of heavy trucks. So it can be said that nearly one-fifth of all vehicle travel, which is a measure of the use of the road system, is a result of external travel.

In spite of these facts, external trips, with the one exception of the Wolf Lake-Lake Calumet region, have very little impact on any given part of the Study Area. Their internal destinations are scattered and seem to be spread evenly wherever there is urban development. Even the Loop does not stand out as a significant generator of such external trips; only 6,000 arrive at the Loop on an average day.

This indicates that local or internal traffic is of dominant importance within the urbanized area. In preparing plans, external desire lines have their greatest influence near the cordon line. Elsewhere, the intensity of external desire lines is light, so that these trips must yield to the far more numerous local trips in importance. This suggests that if an adequate internal transportation system is designed, and if connectors are constructed between that internal transportation system and state and interstate highways, then the requirements of external travel should be satisfied.

All Vehicular Trips

The total demand placed upon the network of streets and expressways by all vehicles is illustrated in Figure 29. Here have been combined, in their true proportions, the desire line displays of trips made by internal automobiles, internal trucks, and all external vehicles. This display represents the 28,699,000 desire line miles of vehicle travel (trucks weighted) made on the average weekday.

Since four-fifths of the desire line miles were made by internal trips and since this travel is concentrated, it is clear why the internal patterns stand out in this Cartographatron display. This pattern is the shape of the urbanized area since both ends of internal automobile and truck trips are tied to an urban activity. To a degree this is true even in the details. Lake Calumet shows up as a dark area, and the influence of the Sanitary and Ship Canal can be traced. The Palos Park Forest Preserve and O'Hare Field are extensive areas where very few trips are made. Of course the Lake Michigan shore line is precisely delineated.

The influence of external trips in relationship to the internal pattern is not great. Some idea of the impact of external travel can be obtained by comparing this display with that showing all internal person trips (Figure 23). The pattern of all vehicle desire lines is slightly more blurred. One reason for this is that the eye is distracted by the pin-point sources from which external trips into the Study Area are drawn. This is particularly noticeable in the cases of Whiting, East Chicago, Hammond, and Gary in Indiana. All trips from communities lying outside the Study Area were drawn by the Catrographatron from a single point, whereas in actuality the origins of these trips are scattered. The result is a slight exaggeration of the importance of external travel, particularly in the Indiana area which is so closely tied, by a number of roads, to the Study Area.

In other parts of the Study Area, however, there is some validity in drawing trips from a single source, because there is a limited number of good highways by which they can approach the Study Area. In the northern and western suburban areas, particularly, it can be seen how the long distance external trips are superimposed upon the local, short-trip patterns of some of the suburban communities. If the two types of trips are allowed to mix on the same street system, very difficult traffic problems can result. This is an important justification for separating the different classes of trips, placing long ones on separate, high speed facilities.

The density of trip desire lines rises markedly with increasing closeness to the Loop. This is the cumulative effect of increasingly dense land utilization and of the greater number of

FIGURE 29—DESIRE LINES OF ALL VEHICLE TRIPS—TRUCKS WEIGHTED

This display records desire lines representing 6,728,000 weighted vehicle trips and 28,6[illegible] miles inside the cordon line. Seventy-eight per cent of the vehicle trips and also of the veh[illegible] by automobiles and taxis.

trips being made through these areas to get to these and other dense areas. It is as if the urban area were a great magnet, with some parts more heavily magnetized than others. The power with which certain parts attract trips is related to the number of jobs, shopping opportunities, or houses that are located there. Those parts which have greater attractiveness have greater amounts of travel located in their vicinities.

In part, this also explains external travel. A large metropolitan region like Chicago attracts trips to it because it offers specialized services and products which cannot be obtained elsewhere. Very few people will pass through Chicago because Chicago has more goods and services to offer than any other nearby metropolis. Those who come do not come to a single point marked "Chicago"; they come to visit or to do business, and are thus scattered within the urban area in proportion to the degree of attraction provided by the various land uses.

SUMMARY

This chapter has summarized the essential facts obtained from the inventories of travel. These provide an understanding of the behavior of persons and vehicles as they move about within an urban area on the average weekday. This understanding of the characteristics of travel is as essential to the planning of a transportation system as is a knowledge of electricity in designing an electrical circuit or of fluids in designing a hydraulic network.

On an average weekday in 1956, 10.5 million person trips and 6.1 million vehicle trips were counted within the Study Area. The bulk of these were short, local trips made respectively by the resident population of 5.2 million people and by the vehicle population of 1.6 million registered motor vehicles. Three-quarters of all person trips were made by automobile and one-quarter by mass transportation. Forty-three per cent of all person trips were made to home, 20.6 per cent to work and 5.5 per cent to shop. About half of all person trips were to residential land, one-quarter to commercial land and one-quarter to all other land uses.

The trips made by persons and vehicles take place in repetitive, cyclical patterns in time. The greatest variation in travel takes place within the average weekday, but this pattern is so repetitive that peak travel can be safely predicted from average weekday travel volumes. There are also the important regularities of trip length, of equality between input and output, and of directional symmetry. These are all useful in forecasting travel and testing plans.

The patterns of travel within an urban area such as Chicago are dictated by the locations of trip origins and destinations. The total amount of travel, measured in desire line miles, which takes place at any given location, is the result of that location's land development and of its position with respect to through traffic. This was shown clearly in the displays of travel desire made by the Cartographatron.

This inventoried daily travel is satisfied within three major systems: rail rapid transit (suburban railroad combined with subways and elevated lines), the network of bus lines, and the network of highways. Each of these systems has different characteristics and each operates best in a particular environment. The rapid transit system serves longer trips which are made from dense or specialized residential areas to the Central Business District. Buses operate best in dense areas of development, and so the bulk of the bus usage falls within the built up parts of the city of Chicago. Automobiles and trucks, however, have a pattern which is spread more evenly throughout the urbanized area.

Vehicle travel, consisting of the components of truck and automobile travel, takes place wherever there is urban development. Movement of vehicles seems to be synonymous with human activity on the land. Truck travel does have a significant concentration towards more central, commercial areas, especially when the heavier units are weighted as automobile equivalents. External travel tends to be spread evenly throughout the urban region but at low levels of concentration, except in particular locations near the cordon line. Although it amounts to nearly one-fifth of all weighted vehicle miles, external travel is not a dominant element of the traffic pattern.

These objective and impersonal descriptive devices show the pattern of travel as it existed in 1956. However, it is known that the construction of new transportation facilities changes not only the routes by which persons and vehicles move between origin and destination, but also the choice of destination. It also is likely to change the means of travel which persons will use in going from origin to destination. And finally, the accessibility which is created by a transportation system is likely to change the use of land and its intensity of development.

Changes in transportation facilities may thus create changes in travel habits and also in the urban structure. But the urban structure changes almost at a glacial tempo, while mode of travel and destinations are being adjusted continually. These adjustments are made within the limits of a mixture of land uses and therefore against somewhat constant trip generation requirements. Yet land use changes may require or initiate changes in transportation. So it is of importance to fix the relationships between land use and trip generations. Estimations of future linkings of origins and destinations by mode and route can then be adjusted as changes within the transportation network are planned.

Chapter V

TRIP GENERATION

Trips are made for profitable purposes. While not all such profits are tangible, this does not mean that they are not real. A man leaves his home to go to work in a factory, and his earnings justify the cost of his journey; a woman drives to the library for a book and gets her reward from reading the book. At least ten per cent of consumer income is spent for personal transportation; none of this would be spent if there were no rewards to be gained. Hence, the key to the explanation and understanding of travel lies in the rewarding activities which generate travel.

Land use is a convenient way to classify and study these trip generating activities. The use of land is a tangible, stable and predictable quantity which can be measured. This chapter develops the numerical relationships between land use and the trips which it generates. It also investigates one of the most crucial aspects of transportation planning—the significant factors which affect choices regarding the mode of travel.

COMPUTING THE GENERATION OF TRAVEL

Each person interviewed in the travel inventories was asked to identify the kind of establishment or land use at the origin and destination of each trip. In comparable travel surveys in over 100 cities, this was the first case in which land use at each trip end was recorded. Responses permitted both person and vehicle trips to be classified by kind of activity or land use, using the same ten major and 88 minor categories employed in the land use and floor area surveys. Table 8 shows all trips made by persons, broken down by six major activity types of their destinations.[1]

By dividing the numbers of person trips with destinations in a given land use category by the number of square miles of land in that category, rates of trip generation can be computed. This type of computation is used throughout to obtain the trip generation rates which are necessary in estimating future trip making.

TABLE 8

PERSON TRIP DESTINATIONS AND GENERATION RATES BY TYPE OF LAND USE

Type of Land Use	Person Trip Destinations	Area In Square Miles	Person Trip Destinations Per Square Mile
Residential	5,606,527	180.6	31,000
Manufacturing	779,340	24.7	31,600
Transportation	280,270	50.7	5,500
Commercial	2,449,468	21.1	116,000
Public Buildings	781,960	23.1	33,800
Public Open Space	314,833	114.9	2,700
Total	10,212,398	415.1	24,600

The rates shown in Table 8 are for the Study Area as a whole. Surprisingly, residential, manufacturing and public building lands all generate trips at the same average rate—about 32,000 person trips per net square mile. Commercial land generates trips at nearly four times this rate. This identifies commercial land as being most likely to have a greater potential for traffic congestion, parking and other transportation problems. Transportation land, which includes extensive railroad yards and airports, has a low rate of trip generation. Public open space, including the forest preserves and parks, is almost by definition a low generator of trips.

Gross rates, however, do not disclose the great variations in trip generation within the Study Area. As shown in Figures 30 and 31, there are extremely high rates of trip generation in the Loop—both of person trips and of vehicle trips. In the suburban areas, the number of trips destined to (i.e., generated by) each small area is quite low. In between these extremes there is a whole range of different rates. Clearly, the average trip generation rates for the Study Area must be refined if there is to be an understanding upon which projections for small areas can be based.

[1] Greater detail about trip destinations in the commercial and manufacturing categories was dropped to permit comparison with the six land use types for which land area was measured. Streets and alleys, parking, and vacant land, for which land area measures were also obtained, do not generate trips as defined in this report. Table 24 in the Appendix gives the number of person trips by 88 categories of establishments.

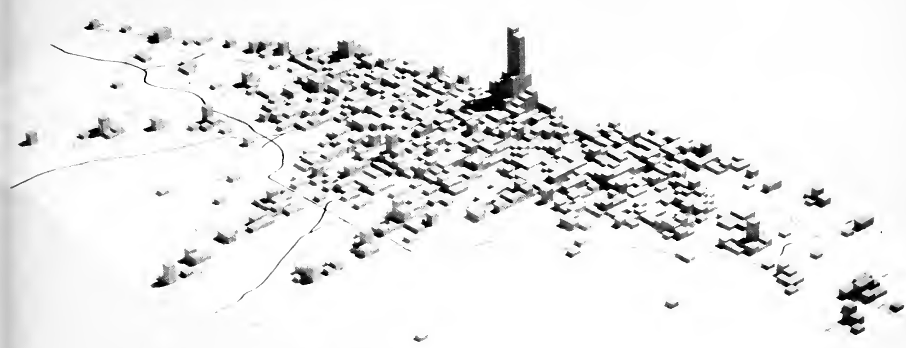


FIGURE 30—MODEL OF ALL VEHICLE TRIP DESTINATIONS

Over 6.5 million weighted vehicle trip destinations from all surveys are represented by this model. Block heights are proportioned to the number of destinations in each quarter square mile grid. The highest block represents the 52,530 weighted vehicle destinations in the quarter square mile grid immediately northwest of the intersection of State and Madison Streets. The lowest blocks have a value of 2,000 and the shaded areas from 1,000 to 2,000 weighted vehicle destinations per quarter square mile grid.

FIGURE 31—MODEL OF ALL PERSON TRIP DESTINATIONS

More than 144,000 person trips are destined to each of the two highest quarter square miles in the Loop. In contrast, the lowest rates given vertical dimensions in this model have 5,000 person trip destinations, and shaded areas from 2,500 to 5,000 destinations per quarter square mile grid. On the average weekday, 10,212,000 persons have destinations in the Study Area. This model is based on trip data from all surveys.

Forecasts of the trip generation of small areas depend upon relating trip making to the density, as well as the kind and amount of land use, in each area. A comparison of Figures 30 and 31 with earlier figures of population and floor area density will demonstrate the close relationship between trip making and density of land development. Yet, even within a given land use type and a given density, there are variations in the intensity of trip making. For example, a retail grocery store needs many more trips than a furniture warehouse, although both are commercial activities and may have the same ratio of floor area to land area. While predictions will not be made at this level of detail, greater precision of study leads to greater security in making estimates of future trip generation.

In summary, the method for computing trip generation is to divide trips by land area. The variations in rates must be understood and hence need to be related to density as well as to type of land use. The objective for obtaining these more precise rates is to allow estimates of future trip making to be prepared for each of the 582 analysis zones[2] comprising the Study Area.

LAND USE TRIP GENERATION RATES

Trip generation rates themselves—both person trips and vehicle trips—have been calculated for six major land use categories, and are related to those variables, such as density, which permit the rates to be used reliably in making forecasts of the trip generation of analysis zones. For convenience, the six major land uses are grouped into two types: residential and nonresidential land uses. This is useful in later stages of the estimation of future travel demand because the movement of trips between residential and nonresidential land uses is dominant. Throughout this chapter, external trips and truck trips (weighted in terms of automobile equivalents) are included in the vehicle trip generation rates.

Trip Generation of Residential Land

Table 9 shows the rates of residential trip generation which were computed from the 1956 inventories of travel and land use. The data are summarized to rings at different distances from the Central Business District because such an organization shows most clearly the regular changes in the rates.

[2]See Map 21 in the Appendix for details.

TABLE 9

PERSON AND VEHICLE TRIPS GENERATED BY RESIDENTIAL LAND BY RING*

Ring	Average Distance From Loop In Miles	Person Trip Destinations Per Acre	Vehicle Trip Destinations Per Acre
0	0.0	2,228.5	1,336.9
1	1.5	224.2	93.3
2	3.5	127.3	54.0
3	5.5	106.2	49.5
4	8.5	68.3	35.5
5	12.5	43.0	25.3
6	16.0	31.2	19.4
7	24.0	21.1	13.3
Study Area Average		48.5	26.1

*For definition of ring boundaries see Map 21 in the Appendix.

Residential trip generation rates exhibit an extremely regular decline as distance from the Central Business District increases. This drop is the result of two opposing factors, the first of which completely dominates the second. The first factor is the decline in number of dwelling places per net residential acre, which was illustrated in Figure 3 on page 22. Obviously, the fewer dwelling places per acre, the fewer trips will be made per acre.

Opposing the decline in numbers of dwellings is the increasing number of trips destined to the average dwelling place, with increasing distance from the center. The typical dwelling place, located two miles from the Loop, will generate about two person trips each weekday; the dwelling located ten miles from the Loop will generate four person trips, while the typical dwelling twenty miles from the Loop will generate 5.5 person trips. These rates are shown in Figure 32, which also indicates the inter-relationship between the number of dwellings per acre and the number of trips per acre at various distances from the Central Business District.[3]

[3]There is a slight drop in trip making per dwelling place near the cordon line because of the influence of older and more self-contained communities such as Chicago Heights and Wheaton.

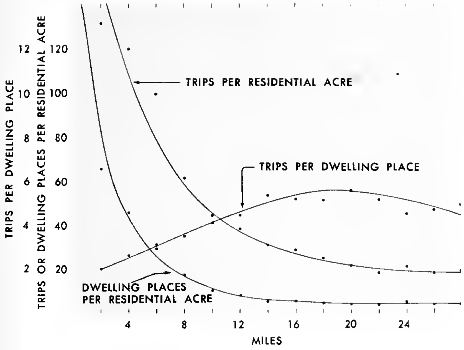


FIGURE 32—PERSON TRIP DESTINATIONS PER DWELLING PLACE RELATED TO TRIP DENSITY AND DWELLING PLACE DENSITY BY DISTANCE FROM THE LOOP

Plots are made at the mid point of the two mile band which they represent. Curves are hand fitted.

Why more trips are made to dwelling places which are located at greater distances from the Central Business District is not completely understood. One explanation may be that travel, like food and housing, is a type of consumption. Data indicate that the proportion of income spent for travel rises slightly as income rises[4] and thus a higher income family is likely to make more trips. It also may be cheaper, and is probably easier, to make trips in areas of lower density development than it is in high density areas, because of congestion on the streets and the difficulties of parking at both ends of each trip. Families are also larger in suburban areas (3.5 persons per occupied dwelling in the suburbs as against 3.1 in Chicago) and so create a greater potential of trip making per dwelling place. The net result, as seen in Figure 33, is a higher rate of trip generation per dwelling place in areas of lower density.

Vehicle trips, in Table 9, show a decline, with increasing distance from the Loop, like that of person trips. This also is associated with two opposing factors: a decline in the number of dwelling places per acre, and an increase in the number of vehicles owned per dwelling, with increasing distance from the Loop. Density of dwelling places per acre is the most important factor which gives the rate of vehicle trip generation its characteristic declining curve with greater distance from the Loop.

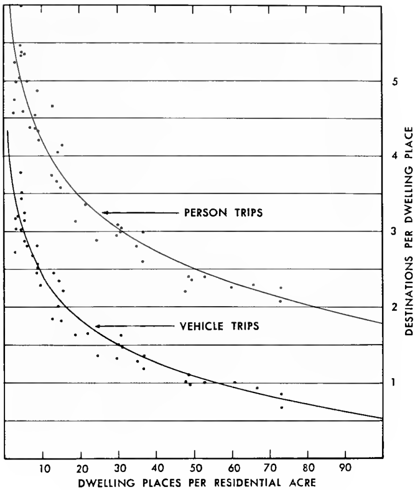


FIGURE 33—PERSON AND VEHICLE TRIP DESTINATIONS PER DWELLING PLACE RELATED TO RESIDENTIAL DENSITY

See Table 37 in the Appendix.

The steady increase in person trips per dwelling place as more cars are owned is completely reasonable; people do not buy automobiles to keep them in garages! Figure 34 shows the relationship between vehicle and person trip generation and the number of vehicles owned per dwelling place. It is impossible to escape the similarity between the curves of person and vehicle trips. This is reasonable, considering that 76 per cent of person trips are made by automobile, and automobiles account for 86 per cent of vehicle trips.

Since vehicle ownership is so significant for both person and vehicle trip making, it becomes necessary to know something about its geographic distribution. Variations in the rate of

[4]*Forecasting Economic Activity: Consumer Expenditures* (36,132) (Chicago: CATS, 1958).

The lowest rates of automobile ownership coincide with high density residential development and with subway-elevated routes. In the city of Chicago, automobile ownership generally is less than 1.0 autos per dwelling place; elsewhere, rates generally are higher. With 1,342,000 automobiles reported owned by residents of the Study Area, average auto ownership is 0.8 automobiles per occupied dwelling place.

automobile ownership per occupied dwelling place are shown in Map 13. Within the city of Chicago, most small areas average less than one car per dwelling place—often as low as 0.4 cars per dwelling, which means that at least 60 per cent of the households in such areas do not own cars. Outside the city of Chicago, the average car ownership rate is generally over 1.0, sometimes rising as high as 1.6 automobiles per dwelling.

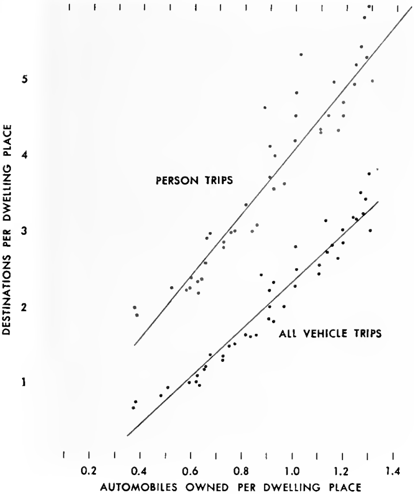


FIGURE 34—PERSON AND VEHICLE TRIP DESTINATIONS PER DWELLING PLACE RELATED TO AUTOMOBILE OWNERSHIP

See Table 37 in the Appendix.

In the suburban areas, 8.8 per cent of all families do not own a car while 69.5 per cent own one car and 21.7 per cent own more than one car. In the city of Chicago, 40.5 per cent do not own a car while 52.2 per cent own one car and 7.3 per cent own more than one car. It is quite clear, therefore, that high residential density goes with low car ownership.[5]

Since families without cars still must make trips, it is apparent that such families will make more trips by mass transportation. (It is still possible for them to make some trips by automobile either as passengers or as drivers of borrowed cars.) This connection between ownership and mode of travel will be developed more completely later in this chapter, but it is already quite evident in Map 13. It can even be seen that the figures of the very lowest automobile ownership coincide with the routes of subways and elevated trains—i.e., the lines of most frequent transit service.

In summary, trip generation rates of residential land show a steady drop with increasing distance from the Loop. The drop is consistent with the declining number of dwelling places per acre as distance from the Loop increases. Hence residential density is a powerful influence regulating the gross number of trips made to each acre of residential land. On the other hand, higher densities are associated with fewer trips made to each dwelling place, and with low car ownership. To the extent that density and car ownership can be anticipated in the Chicago region of 1980, there will be a firm basis for estimating trips to residential land.

Analysis of Trip Generation—Nonresidential

About 45 per cent of all person trips and 54 per cent of all vehicle trips (trucks weighted) are destined to nonresidential land. The trips to each type of nonresidential land use were matched with corresponding land areas, and rates of trip generation for each type were then derived, as shown in Table 10.

The difference in trip generation rates between the nonresidential land uses lies in the nature of these activities. Commercial land requires not only workers, but customers. Customers stay in these establishments only for short periods so that the same space can accommodate many persons during the day. Public buildings in the central area also have many "customers" — lawyers, people paying traffic fines, and students in downtown schools. Elsewhere public buildings land attracts fewer trips. Manufacturing land does not have many visitors; 91.6 per cent of internal person trips to

[5]The coefficient of correlation (r) between net residential density and car ownership is —0.71.

TABLE 10

PERSON AND VEHICLE TRIPS GENERATED BY NONRESIDENTIAL LAND BY TYPE AND BY RING

Ring	Average Distance From Loop in Miles	Person Trips Per Acre: Manufacturing	Person Trips Per Acre: Transportation	Person Trips Per Acre: Commercial	Person Trips Per Acre: Public Buildings	Person Trips Per Acre: Public Open Space	Vehicle Trips Per Acre (Trucks Weighted): Manufacturing	Vehicle Trips Per Acre (Trucks Weighted): Transportation	Vehicle Trips Per Acre (Trucks Weighted): Commercial	Vehicle Trips Per Acre (Trucks Weighted): Public Buildings	Vehicle Trips Per Acre (Trucks Weighted): Public Open Space
0	0.0	3,544.7	273.1	2,132.2	2,013.8	98.5	1,081.1	103.4	728.1	461.0	62.3
1	1.5	243.2	36.9	188.7	255.5	28.8	162.5	54.6	194.0	116.5	26.2
2	3.5	80.0	15.9	122.1	123.5	26.5	64.2	30.6	116.7	50.9	22.7
3	5.5	86.9	10.8	143.3	100.7	27.8	66.0	14.7	132.1	46.4	17.5
4	8.5	50.9	12.8	212.4	77.7	13.5	43.8	12.4	165.4	33.8	11.6
5	12.5	26.8	5.8	178.7	58.1	6.1	23.4	7.1	150.2	29.3	4.4
6	16.0	15.7	2.6	132.5	46.6	2.5	14.7	2.9	111.7	24.2	1.8
7	24.0	18.2	6.4	131.9	14.4	1.5	15.7	6.4	115.3	7.2	1.0
Study Area Average		49.4	8.6	181.4	52.8	4.2	38.6	10.2	144.6	24.2	3.1

this land are made by workers.[6] Transportation land generates few person trips per acre because it includes extensive railroad yards, railroad rights-of-way and airports. Public open space, with its golf courses, cemeteries, parks and forest preserves, naturally generates few trips per acre.

Like residential trip generation rates, these rates are at their highest at the Central Business District. From this peak they decline rapidly until a distance of about three miles from the Loop is reached. Here a curious reversal takes place: commercial land develops an increase in trips per acre, as distance from the Loop increases, to a secondary peak about eight miles from the Loop. Thereafter, commercial trip generation rates decline steadily until the cordon line is reached. There are other, lesser reversals but they are not pronounced and do not affect the general trend of the remaining nonresidential land uses to have lower trip generation rates with increasing distance from the Central Business District.

The variations in the rates of trip generation within the several nonresidential uses are the result of a number of factors. First and most important is the decreasing amount of floor space per acre of land with increasing distance from the Loop. Floor space is built to accommodate users; if there is less of it in any given area, there will be fewer trips made to that area, as a general rule. Figure 8, Page 26, shows the distribution of nonresidential floor space in the Study Area. This distribution corresponds generally with the declining trip rates visible on Figure 35. Here, then, is an indication of the controlling influence of floor area on land area trip generation rates.

Floor area attracts trips in different amounts depending upon the type of use. As shown in Table 11, there are significant variations between the different types. Retail and service activities attract the most person trips per thousand square feet of floor area while wholesale establishments attract the fewest. This explains in part why Figure 35, which shows person trips to nonresidential land, takes on a slightly different form than Figure 8, which shows nonresidential floor area. The wholesale, manufacturing, and transportation establishments in the rings close to the Loop have a great deal of floor area but require fewer people.[7] Farther away from the Loop, retail and service uses attract more people.

[6] In the two innermost rings, manufacturing trip generation is inflated because the loft buildings in which many manufacturing concerns are located often have commercial establishments on the first floor. Since the first floor activity determines the land use of a parcel, this operates to reduce commercial densities and increase manufacturing densities. It should also be pointed out that the trips to commercial land in the Loop are low to the extent that workers in the Loop walk to stores during the day.

[7] Note, however, that they require more truck trips. See Figure 36.

FIGURE 35—PERSON TRIP DESTINATIONS ON NONRESIDENTIAL LAND

Over 4,600,000 person trips are destined for nonresidential land on the average weekday. The highest value shown on the model represents 133,000 destinations. The lowest vertical value shown is 5,000. The shaded areas have values between 2,500 and 5,000 destinations per quarter square mile grid. Approximately one-fifth of all nonresidential person trip destinations are within two and one-half miles of the intersection of State and Madison Streets.

TABLE 11

FLOOR AREA TRIP GENERATION RATES BY TYPE OF ACTIVITY

Type of Activity	Person Trips[a] per Thousand Square Feet Of Floor Area[b]
Residential	3.2
Manufacturing	2.1
Transportation	1.9
Retail	7.0
Services	5.4
Wholesale	1.5
Public Buildings	3.5
All Types	3.3

[a]Internal person trips only.
[b]For the analysis zones for which the floor area data were available.

A number of other factors influence the generation of person and vehicle trips by nonresidential land. For example, the secondary peak in commercial trip generation in Ring 4 is caused by several factors. One is the composition of commercial land: in the Loop, retail and office uses are predominant while in Rings 2 and 3 wholesale uses take on greater importance. Beyond Ring 3 retail and service uses become more important and these generally attract a greater number of trips. Second, there is an increasing number of commercial trips per capita made by those persons who live at greater distances from the Loop. The location of major shopping centers such as Evanston, Oak Park, 63rd and Halsted, and 95th and Western may have an effect. Closer to the Loop there are fewer big centers and some shopping needs are satisfied by walking; farther away commercial land is less densely developed, with more parking space. This secondary peak in trip generation was also observed in Detroit.[8]

Once a nonresidential area has been completely developed, its density is likely to change only slowly. Moreover, the kinds of activities taking place there will tend to remain within the same generalized land use type. Therefore, existing rates of nonresidential trip generation per acre of developed land are going to be

[8]*Report on the Detroit Metropolitan Area Traffic Study* (Detroit: Detroit Metropolitan Area Traffc Study, 1955) Part I, p. 89.

much the same in the future. Where substantial changes in density or use may occur, however, floor area data may be used to provide additional precision in estimating future trip making. Examples of such changes are redevelopment projects or the changes envisioned in the Central Area Plan of the Chicago Department of Planning.[9]

Land Use Linkages

Land use has been shown to be related to trip making in reasonable and orderly fashion. In this sense, it is akin to the regularities of travel in time and in space. But it has a further usefulness: the explanation of trip linkages. Trip origins and destinations, predicted from land use estimates, provide part of the picture. Knowledge of which origins are likely to connect with which destinations is obviously critical in fashioning forecasts of travel.

Of all internal person trips 76.1 per cent move between residential and nonresidential land. These are work trips, school trips, shopping trips and miscellaneous other kinds of trips. They form the tide-like currents which sweep back and forth across the urban area each day, caused by the outer residential areas and the commercial and industrial core. Only one sixth—16.7 per cent—of all person trips have both origin and destination on residential land. These are trips from house to house, such as social-recreation trips. The remainder, 7.2 per cent, have both origins and destinations on nonresidential land. These are trips from work to lunch, from work to retail stores and so forth.

For vehicle trips, the linkage picture is somewhat different. While auto trips have much the same tendency to move back and forth from residential to nonresidential land, trucks tend to link the various types of nonresidential land together. Thus 61 per cent of all truck and taxi trips are from one nonresidential use to another. Eighteen per cent (milk trucks and the like), move between residential uses,[10] and 20.8 per cent move between residential and nonresidential activities.

This effect can be seen in the model showing weighted truck trip destinations per quarter square mile (Figure 36). Truck destinations are concentrated in the core of the Chicago region

[9]*Development Plan for the Central Area of Chicago* (Chicago: City of Chicago, Department of Planning, 1958).

[10]See Appendix Table 35 for a table of land use linkages.

FIGURE 36—TRUCK TRIP DESTINATIONS

Most truck trip destinations are within six miles of the Central Business District. Over 1,418,000 weighted truck trip destinations are represented by this model. The highest block represents 15,600 destinations and the lowest 2,000 destinations per quarter square mile grid. The shaded areas have values between 1,000 and 2,000.

where the commercial and industrial activities predominate (see Figure 8). By contrast, all vehicle trip destinations (Figure 30) and all person trip destinations (Figure 31) show a much more extensive distribution throughout the urbanized area and illustrate how these trips are more evenly split between residential and nonresidential activities.

The way land uses are arrayed, whether in concentrated or dispersed fashion, has a great deal to do with the comings and goings of travel. Given an estimate of future land use, both intensity of trip generation and linkages between land uses can be estimated. This is another means of fastening down a reliable forecast.

To summarize the land use trip generation findings, rates have been determined for six major residential and nonresidential land uses. Both models and graphed data indicate the dominant characteristic: declining rates as distance from the Loop increases. This characteristic is basically the result of varying concentrations of people. People in cities must travel to satisfy their needs, so there are minimum numbers of journeys per capita. Under certain conditions of income, car ownership and density, additional trips will be made. But trip making cannot increase indefinitely—there are upper limits related to the money, time, and energy which can be spent on travel in competition with other needs. Hence trip generation of persons—and of the business and governmental corporations which people create—is closely circumscribed. This prevents rapid changes, and so helps to insure the reliability of forecasts based upon current behavior. Present trip generation rates may be expected to hold through time and should provide a reliable ingredient for estimating travel changes coming about with changes in land use. This provides not only a basis for planning but also a means for updating data obtained by the very expensive travel inventories.

In addition to trip generation, land use determines, to a large extent, the connections which are made by trips between origins and destinations. Of these connections, the residential to nonresidential linkage is most important and provides one key to estimating travel demands on streets and mass transportation routes.

CHARACTERISTICS OF THE TRIP MAKERS

Attention must be focused ultimately on people, who are the basic producers of travel. People create the stationary activities here called land uses. People also cause themselves to be moved about between these activities in automobiles and mass transportation vehicles, and create demands for the movement of goods in trucks. The characteristics of these trip makers are important. The volume of trips is related to human needs; while these may vary from family to family, there are similarities which are of considerable interest because they suggest the existence of ceilings on travel requirements. Studies of trip making by persons and by commercial vehicles are also useful because they allow total trip estimates for the region to be made from forecasts of population and vehicle registration. These estimates can be used to check the prediction of total travel arrived at by summing the land use trip estimates for all the small geographic areas within the Study Area.

Trip Making of Families

The number of trips generated by a family is not the same as the number of trips which are destined to a dwelling place on an average day. It is about twice the dwelling place trip generation rate. This is because the trips made by the members of a family include those trips leaving the dwelling place as well as those arriving, and also include those trips made completely away from home. The total of trips generated by all the families in the Study Area equals the total number of person trips made by residents of the area and so includes both their trips to residential and to nonresidential land.

The number of trips made by families is related to residential density. The lower the density of dwellings per net acre of residential land, the greater the trips per family. A family living in a house with a lot of 10,000 square feet is likely to make nine person trips per day.

A family living in an apartment house, with only 600 square feet of land as its share, is likely to make only four trips per day. Figure 37 shows these relationships.

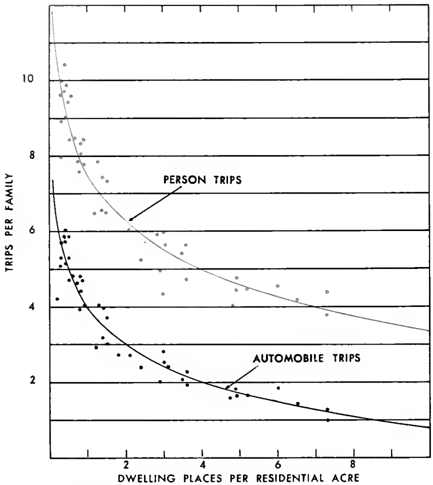


FIGURE 37—PERSON AND AUTOMOBILE TRIPS MADE PER FAMILY RELATED TO DENSITY

The occupants of a defined dwelling place constitute a family. For equation data see Appendix, Table 37.

Congestion, which is obviously greater in denser areas, probably reduces travel as rust in a pipe reduces water flow. It takes effort to walk to a bus or to get a car out of an alley garage. Furthermore, the cost of travel is a real item in the family budget, and in high density, low income areas it probably operates to reduce trip making. Finally, high density areas are more likely to have a variety of activities packed sufficiently close together so that vehicular trips are less necessary.

For similar reasons the amount of trip making by families is related to car ownership. The higher the car ownership, the more trips —both person trips and auto trips—will be made on the average weekday. A one-car family is likely to make 7.0 person trips and 3.7 auto trips per day; a two-car family 11 person trips and 7.3 auto trips per day, while a family with no car will make 3.1 person trips but less than 0.1 auto trips per day.[11] Figure 38 gives averages for districts within the Study Area.

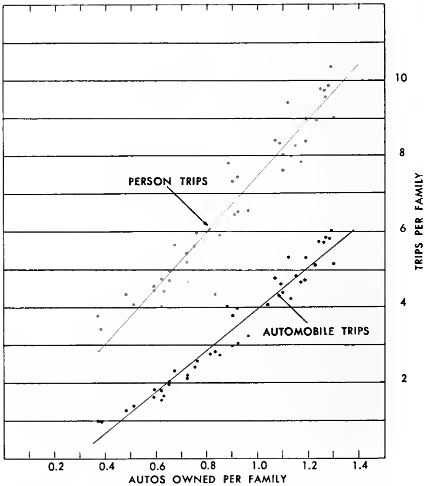


FIGURE 38—PERSON AND AUTOMOBILE TRIPS MADE PER FAMILY RELATED TO AUTOMOBILE OWNERSHIP

The occupants of a defined dwelling place constitute a family. For equation data see Appendix, Table 37.

As families make more trips, they make them for different purposes. Figure 39 shows that a typical family making four trips per day has half of its travel made to and from work (one quarter to work and one quarter from work). The family which makes ten trips per day makes only about one quarter of its trips to and from work. The additional travel is usually for a greater number of social-recreation, shopping, school, serve passenger and eat meal trips.

Those families who make more trips tend to make shorter trips on the average. The average trip length for a family making ten trips per day is 4.1 miles, for a family making six trips per day is 4.7 miles, and for a family making

[11] These averages are computed directly from home interview data, and cannot be compared with Figure 38 which was plotted from district averages. Area averages rarely go below 0.4 or exceed 1.4.

two trips is 5.2 miles. This agrees with the trip purpose distribution as shown in Figure 39; those families making more trips have more shopping and social-recreation trips, which are shorter on the average.

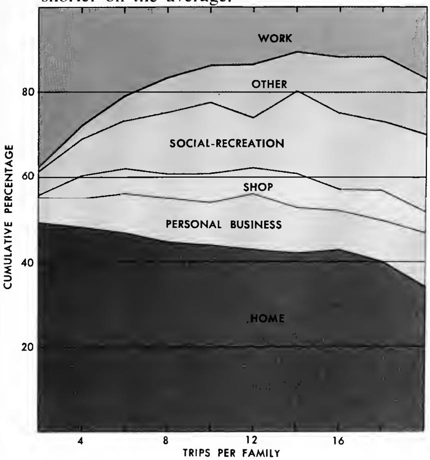


FIGURE 39—PERCENTAGE DISTRIBUTION OF TRIPS BY TRIP PURPOSE RELATED TO TRIP MAKING PER FAMILY

This evidence reinforces the view that trip making by families is stable as related to car ownership and density. Those families which reported making more trips also reported making the kinds of trips which go with higher income, higher car ownership and lower density areas. All these things fit together closely. For significant shifts to be made in trip making, there would have to be disruptions in the proportions of income which are spent for travel—and for other purposes.

Trip Making By Commercial Vehicles

Person trips can be estimated using resident population forecasts and family trip generation rates. But similar estimates of trips made by commercial vehicles depend upon a separate estimate of future truck and taxi registrations. Against these registrations, trip making rates can be applied. In 1956, trucks registered in the Study Area averaged 6.4 trips per weekday. Taxis averaged 30.5 trips.

All the evidence which can be obtained indicates that the number of miles driven by the average truck has recently leveled off at 10,800 miles per year.[12] Furthermore, given a limited number of working hours each day, it is natural that only so many trips can be made. So it seems probable that these rates will continue substantially the same in the future.

In conclusion, the total number of trips made in the Study Area can be determined in large measure from estimates of future population and future registrations of trucks and taxis. In the case of population, the estimates must be modified by estimates of density and car ownership. Land use forecasts, however, are still necessary to pinpoint the locations of the origins and destinations of all trips—both of persons and of vehicles.

MODE OF TRAVEL

In 1956, people in the Chicago area made one-quarter of their trips by mass transportation and three-quarters by automobile. Why in this proportion? If the reason for reaching this collective decision is known, then it may be possible to estimate the proportions which will use mass transportation in 1980, a vitally important factor in preparing a transportation plan.

Many transportation studies have sought to determine choice of mode of travel by asking questions like: "*If* a certain type of transportation were provided, would you use it?" The reliability of answers to such questions is uncertain because of the difficulty of including within such questions all the factors which might influence a decision.

In Chicago a different basis for study was employed. There are in the Study Area thousands of different situations involving mass transportation, having varying types of service, of density, of car ownership and of land use. The actual choices which people made as to the use of mass transportation or automobile could be related to these and other variables. From these collective decisions—pre-

[12] *Automobile Facts and Figures* (Detroit: Automobile Manufacturers Association, 1958), p. 40.

sumably thoughtful ones because they were made by people after years of experience—the factors affecting choice could be identified.

The inventories of travel provided data indicating that the geographic distribution of mass transportation trips is extremely orderly, as can be seen in Map 14. Those zones with the lowest percentage of mass transportation trips are farthest from the Loop. Closer in, more mass transportation trips are made, and along the subway and elevated lines still higher percentages use this means of travel. The highest usage is at the Loop itself, where 71 per cent of all person trips arrived via mass transportation. Such regular patterns imply the existence of strong forces affecting mass transportation usage.

Density of land development appears to be a strong force. Where density is highest, the use of mass transportation is the highest; where densities are low then the use of mass transportation is low. The measured relationship is seen in Figure 40. Of course Chicago is not unique in this respect; it is well known that in older and more dense eastern cities the use of mass transportation is at a higher level, whereas low density places like Detroit and Los Angeles have much lower percentages of mass transportation use.

The impact of density is completely reasonable: a high density of land development provides that environment within which mass transportation can operate successfully. All other things being equal, there just are more people in a high density area and there is a greater probability that there will be sufficient passengers to pay the fares needed to make such a system operate. Then the service will be good and will attract passengers. But in low density areas there are not enough persons to make adequate service pay and the resulting poor service does not attract customers.

Automobile ownership is another factor. A family which does not own an automobile is most likely to use mass transportation if it is to make a trip (as defined) within the Study Area. A family which owns one car is less likely to use mass transportation, and still less likely if it owns two cars. Having made an investment in the automobile, it is natural to want to use it. So it is not surprising how closely mass transportation usage and car ownership are related, as can be seen by comparing Map 14 with Map 13. Where there is high auto ownership, then mass transportation is not used much. Along the lines of the subways and elevated trains, where more than forty per cent of all trips are made by mass transportation, car ownership is generally below 0.4 cars per family—the lowest rate in the Chicago area.

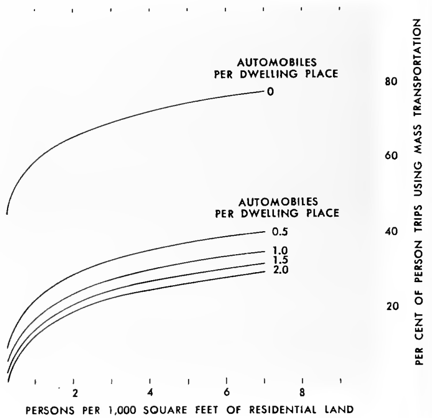
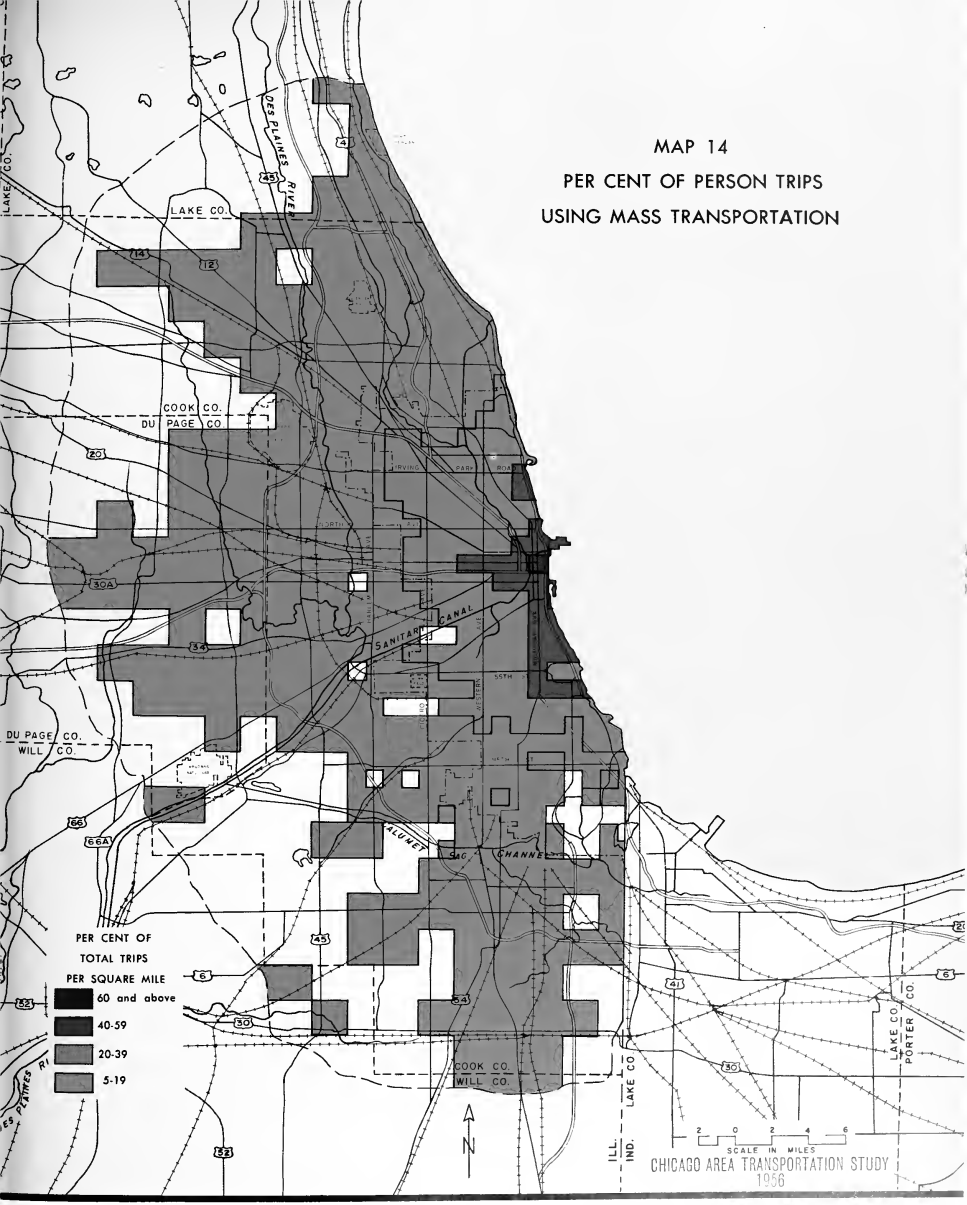


FIGURE 40—MASS TRANSPORTATION USAGE RELATED TO POPULATION DENSITY AND AUTOMOBILE OWNERSHIP

Auto ownership and density are naturally closely related to one another, but not perfectly. So, knowing both factors provides an even greater understanding of mass transportation usage.[13] For two areas having the same density but different automobile ownership rates, the one with the greater automobile ownership will have the fewer trips by mass transportation. Conversely, for two areas with the same auto-

[13]The coefficient of correlation (r) between percentage of trip origins by mass transportation and net residential density is +0.84 and between mass transportation usage and car ownership —0.71 (±1.00 is perfect correlation). Knowing both density and car ownership increases the coefficient to 0.86 ($r^2 = 0.76$). These data provide a statistically significant basis for making estimates of mass transportation users.

MAP 14
PER CENT OF PERSON TRIPS USING MASS TRANSPORTATION



Approximately 24 per cent of 9,931,000 internal person trips on the average weekday use mass transportation. The proportion of trips using mass transportation varies throughout the Study Area. The greatest percentage of use is in the city of Chicago, especially along the subway-elevated lines. Map prepared from analysis zone data.

mobile ownership, the one with a higher density will have more trips by mass transportation. This can be seen in Figure 40.

Models of trip destinations by mode of travel provide another way of examining the choices made by Chicagoans as to mode of travel. Figure 41 shows the number of bus trip destinations in each quarter square mile within the Study Area. Figure 42 does the same for rapid transit trip destinations. Taken together, these two models represent the destinations of all trips by mass transportation in the Study Area.[14]

The use of buses is fairly well restricted to those areas which have high population densities. As shown both in Figure 41 and in Map 14, intense bus usage is within eight to ten miles from the Loop. Within this area population densities generally exceed 25,000 persons per net residential square mile, which is about twelve families per net acre. A close examination of this model will show that the ridges of more intense use of buses correspond to similar ridges of high gross population density seen in Map 12.

The destinations of trips made both by suburban railroad and subway-elevated trains provide a convincing display of concentration of rapid transit usage at the Central Business District. It is only in the two and one-half square mile area which is the core of the central area that the number of trip destinations is sufficient to show. The highest point on this model represents 75,500 trip destinations—more than half the trips to that quarter square mile. This is the area bounded by Madison, State and Harrison Streets, and the Chicago River. Shaded areas on the model indicate quarter square miles having more than 2,500 but less than 5,000 trip destinations per quarter square mile. Nowhere else in the Study Area are there more than 2,500 rapid transit trip destinations in any quarter square mile. In fact, the vast bulk of all the grid squares—even those adjacent to the suburban rail lines — have less than 500 rapid transit trip destinations.

By these tokens, rapid transit is a specialized form of mass transportation. One of its components, the subway-elevated system, does serve areas of high residential density and low car ownership. Suburban railroads, however, connect the Loop with residential areas of medium to low densities and high car ownership. The extent of specialization is indicated by the increased average trip length, 7.2 desire line miles for subway-elevated trips and 13.3 for suburban railroad trips, as against 3.6 for bus trips.

Other indices of specialization are shown in Table 12, which describes some of the more important characteristics of persons using the five modes of travel. Suburban railroads are quite specialized, not only by trip purpose, time and destination, but also because two-thirds of their riders are people who can drive. The fact that they do *not* drive points again to their

[14]Figures 30 and 43 are constructed to the same vertical scale; both are considered as vehicle trip models. Person trip models (Figures 31, 41 and 42) are all constructed to an identical scale, different from the vehicle trip scale.

TABLE 12

CHARACTERISTICS OF RESIDENTS USING EACH MODE OF TRAVEL IN THE STUDY AREA

Resident Characteristics	Per Cent of Total By Mode				
	Auto Driver	Auto Passenger	Bus Passenger	Subway-Elevated Passenger	Suburban Railroad
Male	75.0	33.0	43.0	50.0	61.0
Auto Drivers	100.0	36.0	27.0	48.0	66.0
Under 14 Years of Age	...	23.0	12.0	2.0	1.0
Over 65 Years of Age	3.0	5.0	8.0	6.0	4.0
Going to and from Work	47.0	16.0	46.0	70.0	82.0
Going to and from School	1.0	5.0	13.0	4.0	2.0
Trips in Four Peak Hours	30.0	25.0	39.0	56.0	72.0
Going to or from Central Area	13.0	13.0	39.0	80.0	83.0

FIGURE 41—MODEL OF BUS TRIP DESTINATIONS

The destinations of 1,686,000 person trips using buses are shown on this model. Most of these destinations lie within seven miles of the Loop. The highest blocks represent 35,600 destinations and lowest 5,000, while the shaded areas have values of 2,500 to 5,000 destinations per quarter square mile grid. Figures 31, 41 and 42 have the same vertical scale.

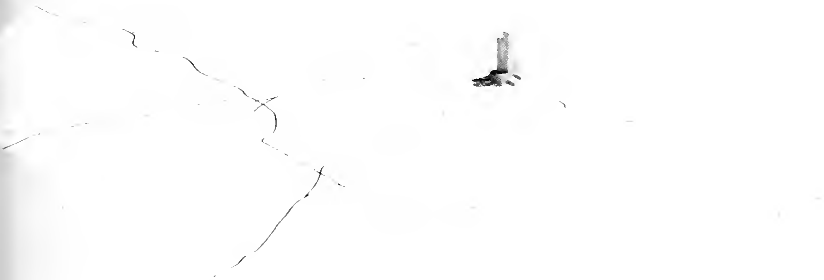


FIGURE 42—MODEL OF RAPID TRANSIT TRIP DESTINATIONS

The Loop stands out as the focus of person trips made on suburban railroads and subway-elevated trains. Elsewhere, destinations are so scattered that they do not show, except for a few shaded quarter square mile grids representing 2,500 to 5,000 destinations. The highest point represents 75,500 destinations. Altogether, 745,000 trips are made on rapid transit facilities on the average weekday, to destinations within the Study Area.

long average journeys and concentrated destinations in the Loop.

Bus users appear to be more restricted in their capability to drive. Of all mass transportation users, they have the highest proportion of non-drivers, of women, and of the very old and very young. Subway and elevated passengers have characteristics more like those of suburban railroad passengers than those of bus passengers.

This evidence partially destroys the idea that people choose their mode of travel. Clearly, a very great number of transit users do not have any alternate choice. If careful examination of car availability were added, additional persons who can drive would also be found to be "captive" users. It appears that choice operates to the greatest extent for suburban rail users and the obvious costs of driving and parking in the Loop would suggest that the rail mode is the better choice.

In contrast with mass transportation, Figure 43 shows the destination of all internal person trips made by auto drivers. This model is remarkable for the evenness of distribution of automobile trip destinations, not only in the suburban areas where there are very few mass transportation trips, but also within the inner area. Even the peaks are not extreme; the highest single quarter square mile in the Loop is the target of 28,500 auto driver trips per day. Elsewhere, there are somewhat lesser but still substantial concentrations. The highest quarter square mile in the Oak Park shopping center receives 15,400 such trips, that in Evanston, 11,100 and the shopping center at 95th and Western 8,500 trips.[15]

The evenness of auto driver trip destinations implies a dispersed travel pattern and this is the case as may be seen in Figure 22, page 44. Mass transportation is less dispersed and far more oriented toward the Central Area. Automobile trips can be dispersed because the automobile is an individual means of travel. Mass transportation must be more concentrated because it can serve efficiently only where there

[15]These trips, of course, are not all shopping trips, and are affected by the other activities which happen to be grouped in a particular quarter square mile.

FIGURE 43—MODEL OF AUTOMOBILE TRIP DESTINATIONS

Automobile drivers made 4,945,000 trips (internal and external) with destinations in the Study Area. These destinations are quite evenly spread; the highest block represents 28,500 destinations, while the lowest stands for 2,000 destinations. Shaded areas have from 1,000 to 2,000 destinations per quarter square mile grid. Figures 30 and 43 have the same vertical scale.

are sufficiently large groups of persons having common origins, common destinations or common alignments of their journeys. So the extent of urban centralization versus dispersion will have its effect upon mode of travel.

In sum, the choice of mode of travel is one of the most critical choices which groups of people make regarding transportation. But it is not a free choice, and the data which have been obtained by survey indicate that decisions are made within tight limitations. The demand for mass transportation service is, above all, a function of the number of people living and working in an area. If there are many people, then mass transportation can operate effectively. If the level of population density falls below 25,000 persons per net residential square mile (and similar densities for nonresidential uses) it appears that mass transportation services and usage decline. Suburban railroads are exceptions to this rule; they depend upon a specialization of living place tied to a highly concentrated work place like the Central Business District. Automobile ownership is linked with density in affecting usage of mass transportation; the higher the automobile ownership, the lower the mass transportation usage. The two basic limits set by density and car ownership appear to be so reasonably related to mass transportation usage, economically and practically, that predictions can be based upon them.

SUMMARY

Land use is the key to understanding trip making because it is the best available index to the activities which people undertake. These activities demand that travel be performed, both by persons and vehicles. The relationships between land use and trip making have been presented here in numeric form, calculated from data obtained from the inventories of land use and travel.

The dominant characteristic of trip generation rates, both for residential and nonresidential land, is the decline in rates from the peaks at the Central Business District. This is the result of lower density of land development with greater distance from the Loop, whether measured by population or floor area per acre.

While decreasing density reduces the total amount of trip making, it operates in the other direction to increase the amount of trip making per family. Those families living farther from the Loop own more cars, make more trips, and make them for different purposes. Understanding the trip making potential and characteristics of resident families is useful in the operations of predicting future travel.

Land use is not only a determinant of the amount of travel, but also the connections which are made by trips between different parts of an urban area. The predominant type of person trip is from residential to nonresidential land. Vehicle trips make this kind of movement to a lesser extent, because trips made by trucks and taxis mostly have nonresidential uses at both origin and destination. As the land use structure of the Chicago area changes, the patterns of trip making will adjust themselves to the new structure.

The split of person travel between automobile and mass transportation is related closely to density of land development. The present situation, where one-quarter of all person trips are made by mass transportation, is the result of an historical development in which mass transportation and high density buildings reinforced one another. High correlations were obtained between mass transportation usage and density. It appears that high density, and also low car ownership, provide a favorable environment within which mass transportation can operate. Since 1930, the patterns of growth in the region have emphasized low density development and increasing average rates of car ownership. This has operated steadily to change the relative usage of passenger cars and mass transportation—the former an increasing proportion and the latter declining. Extension of the trends of land development and of car ownership will undoubtedly continue to affect the relative usage of private, as opposed to mass transportation.

Chapter VI

SUPPLY AND USE OF TRANSPORTATION FACILITIES

To prepare a transportation plan for the Chicago area, detailed knowledge of the existing supply of transportation facilities is essential. An inventory was taken, therefore, of 2,900 miles of defined arterial streets and expressways and of 1,900 miles of mass transportation routes. The inventory identified and measured those basic factors which relate to the amount, location and quality of the service rendered by these transportation systems to the traveling public.

To measure the amount of service, careful definitions had to be prepared of the carrying ability of streets, bus lines and rapid transit lines. These definitions had to reflect a desirable and attainable quality of service. When carrying ability was defined, the first and most basic goal of the inventory was accomplished: the existing supply of transportation service could be put in quantitative terms. Supply then could be related to present demand—as measured by the travel inventories—to reveal the general locations and amounts of surpluses and deficits in carrying ability. This provides an indication of present needs for additional facilities. These measures of present supply remain as the base for comparison with future demands and hence for the estimation of needs for future improvements.

TABLE 13
MILES OF STREETS AND MASS TRANSPORTATION FACILITIES IN THE STUDY AREA BY TYPE

Type of Facility	Length in Miles
Local Streets	7,400a
Arterial Streets	2,796
Expressways	66
TOTAL	10,262
Bus Routesb	1,561
Elevated Subwayc	70
Suburban Railroadc	283
TOTAL	1,914

aEstimated.

bOne-half of round trip route distance; all routes are counted even though they fall on the same street. Includes the Clark-Wentworth streetcar line which, since 1957, has been converted to bus operation.

cRight-of-way length.

Existing travel patterns are affected both by congestion and by the locations of high-speed, high-capacity facilities. The second function of the inventory of transportation facilities, therefore, was to determine the properties of the transportation system which affect travel. Knowing these properties, relationships could be developed between supply and use and these relationships, in turn, could be used to estimate future loads on the area's transportation system.

This chapter considers the location and size of the supply of street and mass transportation services as well as the relationship between supply and use. Streets are considered first, then the systems of mass transportation. The use of these inventories in developing predicted loads on future highway and mass transportation systems will be taken up in the second and third volumes of this report.

THE SUPPLY AND USE OF STREET SERVICES

The Inventory

Before the inventory of streets could be conducted, a choice had to be made as to which streets should be included in the survey. In making this choice, streets were considered as falling into a range of types in accordance with the services they are intended to provide. These services, in turn, can be divided into service to traffic and service to land use.

As was shown in Chapter IV, there is a regular hierarchy of trip lengths, with most trips being short, and with progressively fewer trips being made as lengths increase. This hierarchy is useful in describing the several street systems in the entire street network. Trips generally begin on local streets, which provide access to land uses. Traffic moves from local streets to collectors and then, depending on trip length, onto arterials. If the length is sufficiently great, the trip may use an expressway for part of its journey.

Service to land use also varies with these four types of streets. Local streets are designed primarily to provide access to land; carrying traffic is their secondary task, as indicated by the fact that the average load on local streets in the Chicago area is less than 900 vehicles per day. Collector and arterial streets have the dual function of carrying traffic and of providing access to abutting properties. As traffic volumes increase, traffic and land use come into greater and greater conflict. This is a major planning problem. Expressways were designed to eliminate this conflict by concentrating exclusively on the traffic carrying function, with no land access permitted. This enables them to carry very large volumes at high speeds with increased safety.

Since local streets are designed principally to serve land and not to carry large volumes of traffic, they were excluded from the inventory and from all subsequent plans to provide additional capacity. Collector streets in some cases were considered as local streets and in other cases were grouped with arterials. Hence the inventory included only two classes of streets: arterials and expressways.

To identify the class of each street, the responsible traffic engineers of the City, County and State were consulted and their advice was used. Within the city of Chicago all of those streets which were part of the preferential street system approved by the Bureau of Street Traffic and Parking and the Department of City Planning, were inventoried as arterials. This system included the boulevards which were formerly under the jurisdiction of the Chicago Park District. For the most part, the preferential street system is a grid at one-half mile intervals with some radial streets superimposed.

Outside of the city of Chicago, all numbered state and federal routes, plus the more important secondary roads which County and State engineers identified, were taken as the arterial system. This suburban system, as inventoried, forms a rough grid at one mile intervals, with additional radials superimposed. A map of the arterials and expressways which were inventoried is shown on page 103 in the Appendix.

For arterials and expressways, information was obtained for each route section. A route section is defined as a length of arterial street or expressway lying between intersections of routes in the inventoried system. There were, in all, 4,300 such route sections and 2,300 intersections in this system. The information obtained included the location of the two terminal intersections, the length of the route section, route type, street width, abutting land use, parking, geometric design and the estimated 1956 traffic volume by vehicle type. These data were selected from many facts because they bore on the ability of the roadway to serve vehicles.

Additional studies were made to examine the use of the inventoried system. Using traffic volume data obtained from the City of Chicago, the County of Cook and the State of Illinois, plus data from the Study's own machine counters, vehicle flow maps, showing traffic volumes in the defined network of streets, were prepared. (See Pages 122, 123, and 124 in the Appendix.) Other special studies related the speed of moving vehicles to the volume and density of traffic on streets,[1] estimated the capacities of intersections[2] and estimated the vehicle miles of travel on the average weekday in the Study Area.[3]

Defining Street Capacity

The supply of service which is provided by a street network is generally measured in terms of capacity, or carrying ability. The word "capacity," unfortunately, carries with it the idea that there is a maximum flow of vehicles for

[1]Campbell, E. Wilson, Keefer, Louis E. and Adams, Ross, *A Method for Predicting Speeds Through Signalized Street Intersections*, a paper presented before the 38th Annual Meeting of the Highway Research Board, Washington, D.C., January, 1959.

[2]*Intersection Capacity Manual* (11,401). (Chicago: CATS. 1957.)

[3]Keefer, Louis E., "Estimating Vehicle-Miles of Travel," *CATS Research News*, Vol. 1 (1957), No. 19.

each street which should be attained if at all possible. When such maximum capacity (or rate of flow) is attained, the route is congested, lines of cars form behind signal lights, all vehicles slow down and every driver suffers delays. Hence "capacity" has to be defined very carefully, bearing in mind the purposes for which the measure will be used.

The intended use of "capacity" in this report is to provide a measure of the amount of service which a street can supply *at a certain specified quality level*. By applying these measures to individual parts of the street network, worthwhile comparisons can be made between capacity and use, street by street or area by area. To attain such a measure, the procedure here will be to define an "average maximum capacity" and then to impose conditions which will reduce this to a "design capacity." Design capacity is the measure which incorporates the important idea of quality of service. Detailed considerations leading to these definitions are given on Page 104 in the Appendix.

Basically, roadway capacity is determined by the physical characteristics of a route, of which street width, cross section design, and intersection design and spacing are the most important and most permanent factors. However, capacity is affected also by variables such as signal timing and spacing, turning movements, number of commercial vehicles, parking, bus stops, pedestrian interference and types of adjoining land uses. Pedestrian movement, parking and even signal timing may vary during the day and are apt to change substantially over a period of ten or twenty years. Since all the factors which affect capacity cannot be predicted exactly for the future, an approximate or generalized definition of capacity had to be employed.

The average maximum number of vehicles which can pass a point on a roadway in an hour is defined as the average maximum hourly capacity. The conditions under which this number can be obtained are: no parking, ten per cent left turns, ten per cent right turns, and green lights for 50 per cent of the time at intersections. Since street width or number of expressway lanes is a controlling factor, separate capacity figures are provided for different street widths, as reported in Table 14. The side frictions such as bus stops, cars stopping to unload passengers and pedestrian interference, have been generalized for three different types of areas — downtown, intermediate and outlying or rural. Clearly, the greater these side frictions, the smaller the capacities. All these are approximations, but they are necessary because of the tremendous size of the Chicago area and the length of the planning period, and they have provided useful and reasonable results.

TABLE 14
AVERAGE MAXIMUM CAPACITIES IN VEHICLES[a] PER HOUR

Arterial Streets By Type of Area	½ Pavement Width		
	10′	20′	30′
Downtown[b]	480	1,080	1,800
Intermediate[b]	600	1,320	2,160
Outlying and Rural[b]	660	1,440	2,160
Expressways	2,100 vehicles per hour per 12′ lane		

[a]Expressed in automobile equivalents.

[b]Assuming no parking; 50 per cent green time; 10 per cent left turns; 10 per cent right turns.

The capacities shown in Table 14 are called "average maximum" hourly capacities. They are rarely exceeded. They are not affected by speeds of vehicles because they are actually based on the discharge rates of vehicles through signalized intersections. (This does not apply, of course, to expressways.) Although intersection capacities are not affected by speed, they do themselves affect speed of travel. When many automobiles, within short time periods, try to use an arterial with a limited capacity, average speeds decline because queues are formed at intersections. Even during the less heavily traveled parts of the peak hour, queues will sometimes form behind traffic lights because vehicles tend to arrive in clusters. On expressways, drivers respond to the increased danger of accident by slowing down when volumes exceed critical levels.

Thus, even though a street is not used to its full capacity, there is a reduction in average speed as volumes begin to approach the capacity figure. Studies indicate that average speeds on arterial streets begin to decline when volume is near 60 per cent of capacity and on expressways when volume approaches 80 per cent of capacity. The relationship between speed and the ratio of volume to capacity is shown in Figure 44.

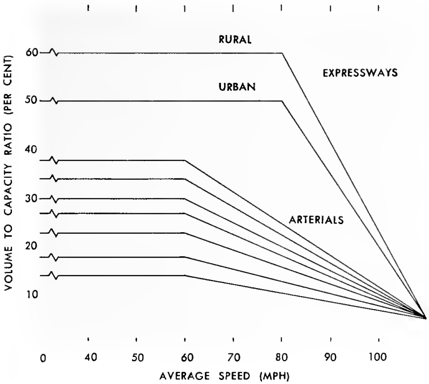


FIGURE 44—RELATIONSHIP BETWEEN SPEED AND THE RATIO OF VOLUME TO CAPACITY

AVERAGE SPEEDS INCLUDE DELAYS ON ARTERIALS DUE TO SIGNALIZATION
AT 100% THE VOLUME EQUALS THE AVERAGE MAXIMUM CAPACITY

These relationships provide the means for introducing a measure of quality into the definition of capacity. The use of an average maximum capacity would set a poor standard of service to the driving public; it would imply a continuation of congestion and would understate the need for improvements. On the other hand, to assume that drivers should travel at the posted speed limit on each street during the peak hour would set a high standard of service and thereby overstate the need for new facilities. Consequently it was decided that a compromise figure, equal to 70 per cent of average maximum capacity (85 per cent for expressways), would be set, and this capacity standard is called a "design capacity."

If tests show that higher volumes are likely to use certain routes in the future, then the delays on these routes can be estimated from the relationships shown in Figure 44. At that time, a determination can be made as to whether these delays are tolerable or whether additional capacity must be built, i.e., whether the standard is reasonable in light of the costs. In a sense, then, "design capacity" is a standard which, when applied to all streets in the region, will measure their traffic carrying ability. If present or future use exceeds design capacity, then the delays in average speed resulting therefrom can be calculated and evaluated and the needed additional facilities can be determined.

For operating purposes, design capacities are most conveniently expressed in 24-hour terms.[4] The conversion from peak hour to 24-hour is based upon the known, repetitive daily cycle of traffic volumes shown earlier in Figure 14. The design hour was taken as equivalent to 11 per cent of the 24-hour design capacity, a ratio which implies sufficient carrying ability for all except the thirty most heavily traveled hours in the year. The resulting 24-hour design capacities are shown in Table 15.

TABLE 15
DESIGN CAPACITIES EXPRESSED AS 24 HOUR TRAFFIC VOLUMES[a] BY STREET WIDTH AND AREA TYPE

Area Type	Street Width		
Arterials[b]	20′	40′	60′
Downtown	5,100	11,400	19,100
Intermediate	6,400	14,000	23,000
Outlying and Rural	7,000	15,300	23,000
	Number of 12′ lanes		
Expressways[c]	4	6	8
All Areas	54,000	81,000	108,000

[a] Volumes are in auto equivalents—i.e., trucks are weighted so that comparable volume counts on roads would be about 10 per cent less.

[b] Assuming: No parking, 50 per cent green time; 10 per cent left turns; 10 per cent right turns; 60-40 directional split; and 11 per cent of daily travel in peak hour.

[c] Assuming: 60-40 directional split and 11 per cent of daily travel in peak hour.

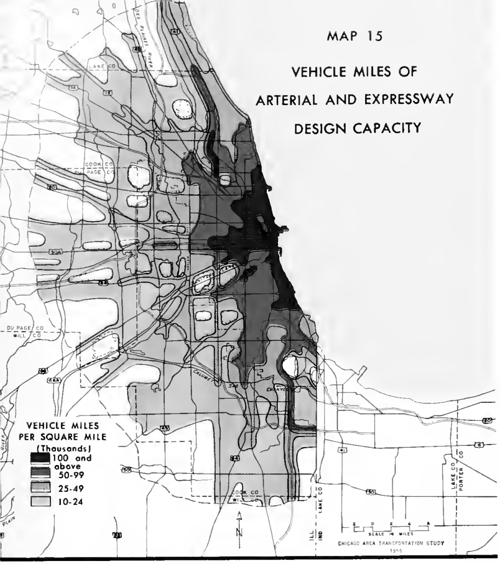
The Supply Of Street Services

Twenty-four hour design capacity is a volume or rate of flow measure. It can apply only to a single point on a street or expressway since it measures the number of vehicles which pass that point in a given time period. In order to

[4] For detailed reasoning, see Appendix page 104.

MAP 15

VEHICLE MILES OF ARTERIAL AND EXPRESSWAY DESIGN CAPACITY



The 36.5 million vehicle miles of arterial and expressway capacity in 1956 were distributed as shown above. Colors are used to indicate areas having the same range of capacity per square mile.

add up design capacities for a whole system of streets, it is necessary to relate the design capacity of a street segment to its length, and this is done by multiplying design capacity by length. The resulting measure — vehicle miles of design capacity — expresses the ability of a street system to hold as well as to deliver vehicles. It can thus be compared directly with vehicle miles of travel.

The 1956 design capacity of all streets surveyed in the inventory of transportation facilities was 36.5 million vehicle miles, expressed in automobile equivalents. Expressways provided 5,457,000 vehicle miles of capacity, an average design capacity of 83,000 vehicle equivalents per day over 66 miles of expressways. Similarly, arterials had an average capacity of 11,000 vehicle equivalents per day over 2,796 miles of streets, for a total arterial design capacity of 31,016,000 vehicle miles.

Arterials thus provided 85 per cent of the total design capacity of the inventoried street system and expressways about 15 per cent. Expressways (including most of the Outer Drive) provided their share of the capacity with only 2.3 per cent of the total length of inventoried streets. This is expected because expressways are able to move about 3.5 times as many vehicles per hour, per lane, as the typical urban arterial street, and generally they have more lanes.

Map 15 shows the distribution of design capacity within the Study Area.[5] This distribution is related to the form of the urbanized area. The location of major expressways stands out. The Outer Drive and the Congress Street Expressway show up clearly. The Edens and Kingery Expressway can also be identified to the north and south. These data are for the base year 1956 and do not include the Illinois Toll Roads, the Calumet Skyway, or the latest additions to the Congress Street Expressway.

TABLE 16
VEHICLE MILES OF TRAVEL AND DESIGN CAPACITY BY STREET TYPE, FOR THE STUDY AREA

Street Type	Weekday Travel	Per Cent	24-Hour Design Capacity	Per Cent
Arterials	29,800,000	90	31,016,000	85
Expressways	3,361,000	10	5,457,000	15
TOTAL	33,161,000	100	36,473,000	100

The amounts of street capacity per square mile (in other words, the density of capacity) are similar to the population densities shown on Map 12. Hence there appears to be a relationship between street capacity and population density, both declining with distance from the Central Business District. Within limits this must be true, because for people to reach densely developed land there must be sufficient street capacity to get them there. Even buses, which carry two-thirds of all mass transportation riders, require street space. Likewise, in low density areas a lesser amount of capacity is

[5] This and other maps of capacity and travel were prepared from data summarized by analysis zones (see page 102 in the Appendix). Analysis zone sizes are of two sizes: one square mile in the city of Chicago and nearby suburbs, and four square miles elsewhere. Hence these maps are more generalized than the land use and population maps shown in Chapter III which were prepared from data summarized by quarter square mile. The rules of the inventory of transportation facilities prescribed that capacities and usage should be summarized to zones where defined intersections existed; hence there exists a certain accidental lumpiness in these maps, especially in the outer parts of the Study Area.

needed; major streets can be narrower and more widely spaced.

The precise relationship between capacity and distance from the Central Business District is shown in Figure 45. This graph also shows the decline in net residential density with distance.[6] Net residential density is very close to employment density, and can be considered as a good index of over-all land development intensity.

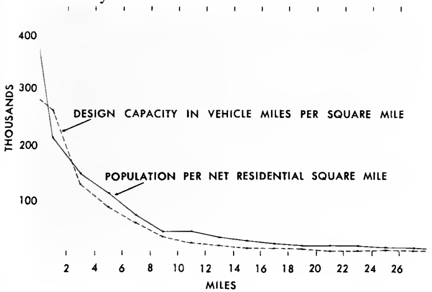


FIGURE 45—DESIGN CAPACITY AND DENSITY OF POPULATION BY DISTANCE FROM THE LOOP

It might be speculated that there is a normal amount of street capacity associated with a given population or employment density. Of course, this never can be strictly true because the demands for capacity are not completely conditioned by the local traffic; the potential through traffic or the number of vehicles wishing to pass through the area must also be considered.

The concept of a normal amount of capacity related to density is interesting because it may indicate that there are ceilings to the amounts of street service which need to be provided. People cannot travel all the time, nor can they own an unlimited number of cars; hence there is a finite amount of vehicular travel which they can produce. It seems clear that there are limits also to the number of persons who can be crowded onto the land. Except for through trips, therefore, and the conversion of mass transportation users to auto drivers, there are likely to be ceilings to the amounts of travel which will take place in any given area. This applies especially to those older areas which are more deeply imbedded in the urbanized territory. Part of the planning task is to find these limits and to use them in working out the best plan for new facilities.

The Use of Street Services

The use of streets, like the capacity of streets, can be measured in vehicle miles of travel. In several ways, vehicle miles is a more satisfactory measure than the number of trips. It weights trips by their length and hence is an indication of their actual impact on a road network. Moreover, it permits the use of streets to be compared directly with street capacity.

The inventory of travel provided one means for measuring the total vehicle miles of travel in the Study Area on the average weekday in 1956. Knowing the origin and destination of each vehicular trip, the desire line miles of travel between origin and destination can be computed. Desire line miles of vehicle travel can then be translated into over-the-road travel by factors obtained from empirical studies.[7] By these means, 28,700,000 desire line weighted vehicle miles of travel were estimated to have been driven on non-local streets on the average weekday or approximately 34,500,000 weighted vehicle miles of over-the-road travel.

A second and more exact technique for measuring street usage was to count the number of vehicles using each arterial or expressway route section during an average weekday and to multiply this number by the length of each such route section. Using this technique, 33,161,000 weighted vehicle miles of travel were estimated on the defined street network.[8] This figure checks closely with that calculated

[6]The coefficient of correlation between design capacity and net residential density, both plotted by mile rings from the Central Business District, is +0.95—an unusually high correspondence.

[7]The relationship of desire line travel to over-the-road travel in the Chicago area is approximately 1:1.2. This is computed from actual routing of a cross section sample of trips.

[8]For arterials and expressways, the unweighted vehicle miles of travel in 1956 was approximately 30.2 million. It was also estimated that six million vehicle miles were driven on local streets, for a grand total of 36.2 million unweighted vehicle miles within the Study Area.

from the travel inventory data and, being made from actual ground counts, it is used for control purposes.

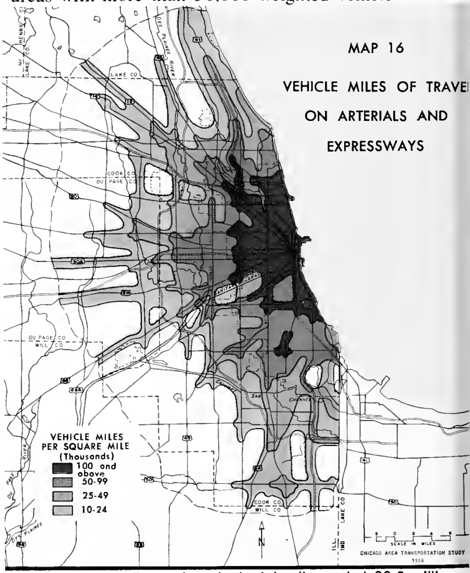
Table 16 shows the weighted vehicle miles of travel computed by this method, by street type. The distribution is similar to the distribution of capacity by street type: 90 per cent of the vehicle miles is driven on arterials. The explanation for the lesser proportion of travel (ten per cent) driven on expressways than capacity provided by them (15 per cent) is due largely to the location of certain expressways, such as Edens and Kingery, in outer parts of the Study Area. In these locations they are not used to their full capacity — yet.

Total vehicle miles of travel (unweighted), measured by traffic counts and including both local and arterial streets and expressways, was estimated at 36.2 million as of 1956 — 2.5 million by non-local and 33.7 million by locally registered vehicles. This last figure can be divided by the 1.6 million vehicles registered in the area. The result is 21 miles of over-the-road travel per weekday per vehicle—that is, 21 miles of actual usage each day. Since the average vehicle registered in the Study Area (trucks included) makes 3.7 trips per day, this means that the average over-the-road trip length is 5.7 miles.

Looking at this another way, the average registered vehicle drives 21 miles of over-the-road distance per weekday inside the cordon line or 7,500 miles per year.[9] Since vehicles in Illinois generally drive 9,700 miles per year,[10] this indicates that about 80 per cent of the vehicle miles traveled by the average registered vehicle is driven within the Study Area and 20 per cent outside the Study Area. This seems quite reasonable since one vacation trip and a few weekend journeys could account easily for 2,000 miles for the average passenger car.

Map 16 shows the distribution of the 33.2 million weighted vehicle miles of arterial and expressway travel within the Study Area. This map compares closely with the Cartographatron display of all vehicle trips (Figure 29) despite the difference in technique of presentation. There is a very heavy concentration of travel close in around the Central Business District, and then gradually decreasing amounts as distance from the Loop increases. Travel in the suburban fingers is evident but is not as sharp as the Cartographatron display, due to the more approximate presentation technique used here.

Comparison of the map of travel with the map of street capacity (Map 15) produces some differences. The map of travel is generally more compact and more closely related to the shape of the urbanized area. Yet at the same time, the areas with more than 50,000 weighted vehicle



Automobiles and trucks (weighted) traveled 33.2 million vehicle miles daily on arterials and expressways. Areas of heavy travel are extensive in Chicago and nearby suburbs. The areas of light travel do not extend much beyond the urbanized area.

[9]Twenty-one miles per day times 250 weekdays per year plus 115 weekend and holidays days, assuming daily weekend or holiday traffic in the Study Area at 90 per cent of weekday traffic.

[10]State of Illinois, Division of Highways, Bureau of Research and Planning, Table M.F.C., Motor Fuel Tax Collected and Motor Fuel Consumed (1930-1958) 1 sheet.

miles of travel per square mile are more extensive than comparable areas on the capacity map. These comparisons, as will be shown, are most important because they begin to delineate the places where congestion is great and, therefore, where improvements are needed.

Comparing the Supply and Use of Street Services

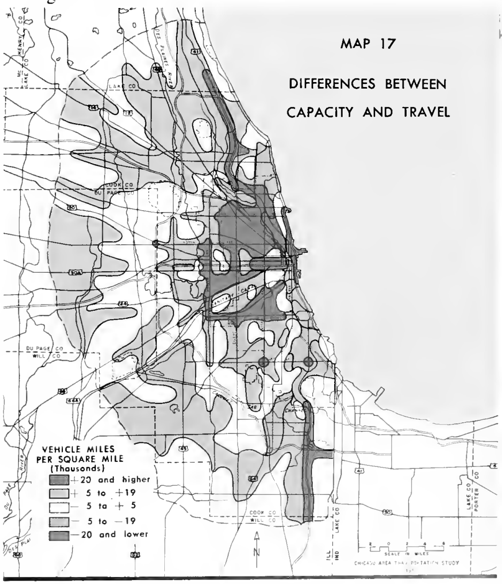
For the Study Area as a whole, the vehicle miles of design capacity were roughly in balance with the vehicle miles of travel (Table 16). There were 36.5 million vehicle miles of design capacity available in 1956 on major streets and expressways contrasted with about 33.2 million miles driven on these types of roads.

The fact of balance between supply and use is not the crucial point being made, since the total amount of supply is dependent upon the way in which design capacity is defined. More important are the geographic variations in the differences between supply and use. The reason, of course, is that these indicate where usage is great in relation to capacity and, therefore, where congestion is heavier. Since the defined design capacity has been used consistently for the entire area, the relationship of needs between one part of the Study Area and another is correct, even though the actual amounts of needs are relative.

Map 17 shows the differences between supply and use for all parts of the Study Area as of 1956. This map was prepared by subtracting use from design capacity in each of 582 analysis zones. Negative values indicate deficit capacities and are tinted red, while positive values indicate surpluses of capacity and are tinted blue. Those areas in which capacity and use are approximately in balance have a neutral grey shading. The average analysis zone has five miles of streets and over seven route sections. For the most part, these will be alike in being either overloaded or underloaded, but there are some exceptions in which one or two streets, because of their size, will stamp a whole area as being over or under capacity.

The greatest deficits of street carrying ability are not at the Central Business District, but in a wide belt starting some three miles out from the Loop. This deficit belt extends over the densely built up parts of the region to a distance of about 13 miles from the Loop. Beyond this there is a large region of surplus capacity which extends clear to the cordon line.

Cutting through the regions of deficit are the high capacity expressway facilities. The influence of the Congress Street Expressway is seen clearly. The Outer Drive also provides an excess of capacity over use, especially nearer to the Loop. At its southern end, between 47th and 51st Streets, the Outer Drive narrows, and it is here that congestion is most marked. At the northern end of the Drive, the capacity remains at a high level (although slightly reduced north of Irving Park). It is not the Drive itself which causes back-ups in this area but rather the deficiencies of the arterial system into which its higher volumes drain.



This map shows relative 1956 needs for additional facilities. Although needs indicate congestion, local points of congestion may occur where needs are not numerically great.

This basic pattern is familiar to most residents of Chicago and is quite reasonably explained. The rural and suburban parts of the Chicago area have a great deal of capacity, especially where expressways or numbered State and Federal routes pass through relatively undeveloped areas. With low density land development, this capacity is not fully used. Closer in, however, the prevailing movements of traffic from suburbs to city begin to accumulate a great many vehicle miles of travel. This travel suddenly hits a region of higher densities with its own heavy traffic requirements and a limited number of arterial streets. The result is congestion. This sudden transition is most noticeable along the line of the Des Plaines River and Harlem Avenue to the west, along Devon Avenue to the north and 63rd Street to the south.

The Central Area itself, however, is the target of, rather than the passageway for, travel. Partly, this is because it is positioned next to Lake Michigan. High percentages of trips made to this area use mass transportation. And finally, a very high proportion of streets in the Loop and vicinity are arterials and expressways. These facts explain the surplus of capacity in the Central Area.

Another way of viewing this pattern is to sum up capacities and use by distance from the Central Business District. Since each successive distance ring encompasses a larger area, the design capacity and vehicle miles of travel in each ring have been divided by the land area in that ring, resulting in capacity and use densities. These density figures are presented in Figure 46.

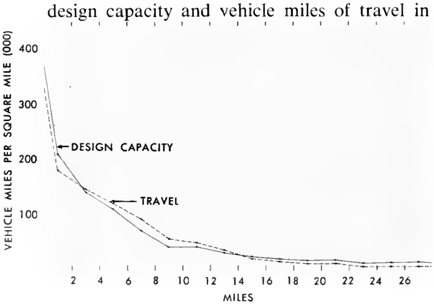


FIGURE 46—DESIGN CAPACITY AND WEIGHTED TRAVEL BY DISTANCE FROM THE LOOP

Travel is expressed in automobile equivalents.

Both capacity and use have curves which are very similar. They are very high at the Loop and decline rapidly with increasing distance. Yet it can be seen that the two curves cross each other twice. Where capacity is greater than use, there is a region of surplus capacity. Where use is greater than capacity, there is an indication of need for additional facilities.

To demarcate the comparison more clearly, the differences between the two curves have been extracted and are displayed in Figure 47. Comparison of this figure with Map 14 will show how closely the two agree. The region of greatest deficits lies between three and thirteen miles from the Loop. Near the Loop there is an excess of capacity, but it should be remembered that this excess is calculated upon a large base and percentagewise is not so great. From three to thirteen miles there are deficiencies in street services, with the greatest need shown at about six miles from the Loop. Beyond thirteen miles there is a region of excess capacity.

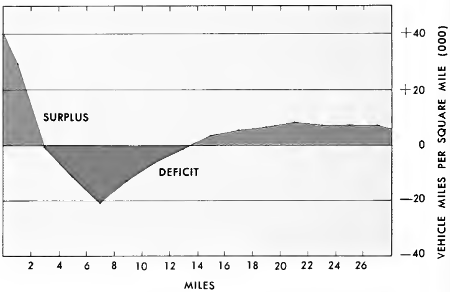


FIGURE 47—DIFFERENCE BETWEEN CAPACITY AND TRAVEL BY DISTANCE FROM THE LOOP

All this information is a beginning for planning. Those areas which have large deficits are areas which show a need for additional capacity. For example, several areas on the north side of Chicago have average daily deficits of the order of 35 thousand vehicle miles of capacity per square mile. Such deficits might be eliminated by the construction, in each square mile, of two miles of additional arterial streets, each with a design capacity of 17,500 vehicles per day. Or, existing streets could be widened. But since the resulting arterial streets would be at grade, with land access and many intersections and thus would provide a low level of service and safety, it may be more reasonable to consider building, in the vicinity, an expressway which could provide needed relief to this and adjacent areas. Since travel is increasing each year throughout the Study Area, these measured differences for 1956 will obviously be conservative figures.

It seems clear that the position of the areas of surplus and deficit is accurately marked only as of the date of inventory. As the Chicago Area grows, people will own more vehicles and will use the streets more intensely. Probably this additional use will increase the radius of the ring of deficit capacity, moving it outward from a distance of thirteen miles to as much as fifteen, eighteen, or even twenty miles.

The spread of congestion in the outer areas will be brought about by a number of factors. One of these is car ownership. The suburban areas, typically, have higher incomes — and resulting higher car ownership. This naturally adds more miles of travel for each family, particularly since suburban families are larger and thus have a greater potential for travel. Another factor is congestion, which affects travel in a number of ways. One is to reduce the total number of trips made. Another is to reduce trip length. Still other ways are by re-directing the route of travel around the congested area, or by shifting the choice of destination. In effect, congestion acts as a brake or self-limiting device and therefore it is more likely that there will be a spread of areas of deficit capacity rather than an intensification of congestion in existing deficit areas.

The spread of congestion is likely to be hastened by a lack of good land planning and roadside control. Much of the surplus capacity in the outer reaches of the Study Area is based upon rural conditions, with a minimum of signalization, roadside development, parking and pedestrian interference. As the Chicago region grows, the speeds and capacities of roads in suburban and rural areas will be *reduced* by extensive development of land abutting these roads. This reduction will come all the faster with parking allowed on streets, with buildings close to street lines and with multiple driveways. This is literally a "hardening of the arteries."

Summary

In summary, the inventory of arterial streets and expressways measured the amount of usage and of capacity of these facilities. A standard measure of service potential, called design capacity, was established. This was based upon a definition of capacity which was intended to reflect a desirable and attainable quality of service.

Using this definition, the total supply of street services in the Chicago Area appears to be in approximate balance with the use of streets. The distribution of supply and usage, however, is such that there are pronounced areas of deficit and surplus design capacity. There is a band of deficit capacity between three and thirteen miles from the Loop. This begins to measure the initial amounts and locations of needs to be met by highway improvements.

The creation of additional capacity for movement, however, selectively reduces travel frictions. To a certain extent, greater ease of movement may lengthen trips or re-direct travel along channels of high capacity, high quality service.

These effects must be carefully accounted for in preparing plans: shifts in travel caused by changes both in demand and supply must be estimated. An estimating device has therefore been developed which will be described fully in the second volume of this report. Using inventoried data, it "remembers" all inventoried or proposed route sections in a computer, and distributes trips from each origin to all destinations along a shortest time or cost path. The paths may be modified as different route sections become heavily loaded. By these means a more accurate simulation of future conditions can be obtained for planning and testing purposes.

THE SUPPLY AND USE OF MASS TRANSPORTATION SERVICES

The Inventory

Like the inventory of streets, the inventory of mass transportation was designed to determine the kinds and locations of mass transportation facilities serving the Study Area. Such an inventory permits the existing supply of service to be related to usage. Further, it is basic to the development of methods for estimating future usages, in turn a prerequisite for planning.

Mass transportation facilities, however, are not like highway facilities, and the amount of service they provide cannot be expressed in the same terms. The idea of capacity, which was used to measure the supply of street service (primarily a function of street width), cannot be used realistically to calculate the supply of mass transportation service. On rail facilities, it is the moving suburban or subway-elevated train which provides the service rather than the rails themselves, and on streets, it is the bus rather than the empty street.

Actually, of course, there are limitations to the physical capacity of rails to move trains and of streets to move buses. But these physical capacities are generally so great that they are unreal. Perhaps the only lines where the safe capacity of the physical facilities is even approached are the State Street Subway and the Illinois Central Railroad north of 71st Street. Both facilities operate trains with two minute headways during the rush hour periods.[11] Elsewhere, the problem is generally not one of the physical capacity of rights-of-way, but rather a problem of intermediate level: the service produced and the extent to which customers use that service.

Instead of measuring capacity, therefore, only the amount of service actually provided by mass transportation vehicles in 1956 was measured in the inventory. The unit of measure is the "seat mile." For example, a typical bus with 50 seats, traveling 10 miles, supplies 500 seat miles of service.

All bus, suburban railroad, and rapid transit lines operating in the Study Area were included in the survey.[12] Data obtained for each system included such items as length of each mass transportation route section, headways between buses or trains during the peak hour, number of vehicles and seats in the peak hour, speed of scheduled operation and the numbers of vehicles scheduled during the day on each route section. From this information, the quantity, location, and some characteristics of the quality of service supplied by mass transportation systems could be calculated.

The Supply of Mass Transportation Services

The results of the inventory are shown in Table 17. Buses provide about two-thirds of the 32.4 million seat miles produced by all mass transportation systems, whereas rapid transit (both subway-elevated and suburban railroads) supplies about one-third. Subway and elevated trains, with their more frequent service, have a greater number of seat miles scheduled per day than do the suburban railroads, despite the fact that the suburban trains move over greater distances.

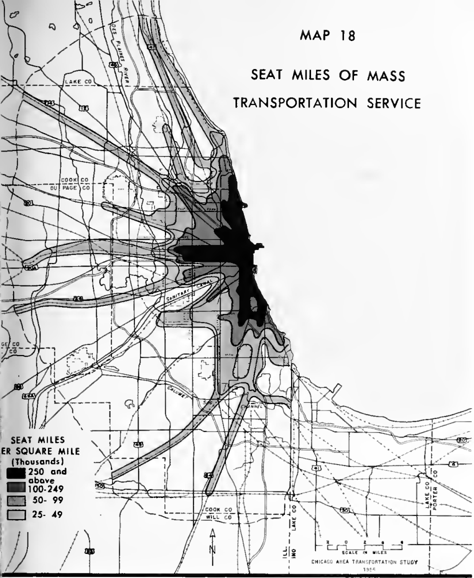
[11]Actually, some Illinois Central trains are scheduled one minute apart, but they use separate tracks.

[12]Long distance, interstate train, bus, and air passenger transportation systems were excluded because they either use separate means of entering the urban area (e.g., interstate trains and airplanes) or they are so few in number (e.g., interstate buses) that they do not affect the stream of vehicles on streets.

TABLE 17
WEEKDAY SUPPLY AND USE OF MASS TRANSPORTATION SERVICES IN THE STUDY AREA

Type	Scheduled Seat-Miles of Service	Per Cent	Person-Miles of Travel*	Per Cent	Ratio of Supply to Use
Bus	20,060,000	62	7,950,000	51	2.5
Subway and Elevated	7,244,000	22	3,444,000	22	2.1
Suburban Railroad	5,048,000	16	4,127,000	27	1.2
TOTAL	32,352,000	100	15,521,000	100	2.1

*Buses have been adjusted upwards to include the miles of bus travel which connect with subway-elevated trains (600,000 person miles). Bus miles of usage are also computed making adjustment for indirect travel whereas miles of travel for subway, elevated and suburban rail travelers is set equal to the desire line length of the entire journey from doorstep to doorstep.



The seat miles of mass transportation service available per square mile in 1956 are shown here. Most of 32.4 million seat miles of service are in the city of Chicago with the service provided by rail facilities standing out as ridges.

The distribution of the supply of all mass transportation service is shown in Map 18. Each station or bus stop was credited with the number of seat miles of service provided by mass transportation vehicles which stopped there on the average weekday.[13] The values for all the stations or stops in an analysis zone were accumulated and then divided by the area in that zone, to provide a uniform measure of service per square mile.

As might be expected, the greatest amount of service lies along the rapid transit lines near the Loop. The supply gradually diminishes with increasing distance from the Loop. The area of continuous supply at the level of 50,000 or more seat miles per square mile corresponds to the area served by the Chicago Transit Authority and by a few independent bus companies in nearby suburbs. This particular area can be compared with the Cartographatron display of all bus trips (Figure 20); they are almost identical.

Along the lines of the suburban railroads, the supply of service continues at the rate of 25,000 seat miles per square mile until the cordon line is reached. These finger-like extensions of railroad service compare very closely with Figure 19, which shows the desire lines of all trips made by rapid transit in the Study Area.[14]

Over-all, the decline in mass transportation service is extremely rapid with increasing distance from the Loop. Figure 48 shows the relationship between the density of service, as measured in seat miles per square mile, and net residential density. The level of mass transportation service declines faster than population density; this is the result principally of the tremendous amount of service needed to bring people to the Loop. Beyond 12 miles from the Loop the level of mass transportation service is very low—of the order of three or four thousand seat miles of service per square mile. (This is about the amount of service provided by one bus route with fifteen minute headways.) Of course this is an average figure, grouping some suburban areas having good rail service with other areas having no mass transportation at all.

[13]The seat miles of service in both directions on each route section were assigned to stations or stops at the south or west ends of each route section.

[14]An exception is the Chicago, Rock Island and Pacific Railroad in the southwestern part of the Study Area. Here the wide separation of stations and the rules of the inventory procedure slightly exaggerate the service provided, since a few cars, traveling longer distances between stations, credit a few stations with a seemingly large supply of service.

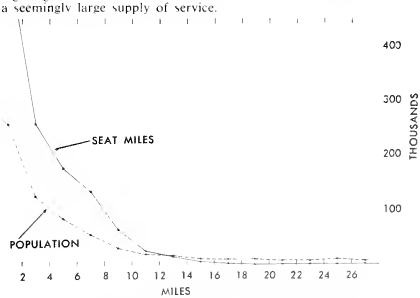


FIGURE 48—POPULATION DENSITY AND SEAT MILES OF MASS TRANSPORTATION SERVICE BY DISTANCE FROM THE LOOP

More and more, these facts indicate the specialized nature of mass transportation. It is not a service which competes over a wide area with the automobile, nor can it compete successfully with automobiles in low density areas. At the same time, it provides a means of moving people in high density areas where it is quite efficient and the automobile less so. Planning, therefore, requires an understanding of the situations in which the several specialized kinds of transportation can operate successfully. For the future of mass transportation, a very important consideration will be the level of rider demand and this, in turn, will be determined largely by the density of land development.

Comparing the Supply and Use of Mass Transportation

Working with data obtained from the inventory of travel, the use of mass transportation facilities was computed by summing desire line distances between origin and destination for all person trips, using the three modes of mass transportation. Desire line distance is very close to the true distance traveled by railroad and, to a somewhat lesser degree, by subway or elevated trains. For bus travel, however, a factor had to be used to expand desire line travel to an approximation of actual route miles of travel. The results of these computations are shown in Table 17.

There were 15.5 million seat miles of mass transportation used on an average weekday in 1956. This compares with 32.4 million seat miles of mass transportation which were scheduled. It appears, therefore, that there were more than twice as many seat miles of mass transportation scheduled as there was use of such service. Yet to the commuter going home during the rush hour, these figures will seem completely wrong. To him the demand for mass transportation services far exceeds the supply, otherwise why should he be standing up most of the way home?

One reason for this is the tremendous concentration of use of bus and especially of rapid transit systems during the morning and evening rush hours. Figure 24 on Page 48, showed that suburban railroads, subway and elevated trains, and buses, in that order, carry the highest percentage of their own daily travel during the two peak periods. This is an inefficient pattern from the viewpoint of the operating companies, because equipment and employees are not producing enough revenue during the off-peak hours. This is one reason why mass transportation management must count on loading vehicles at 1.5 times seating capacity during the rush hours; otherwise, these systems would lose money.

There are other inefficiencies which are inherent in the mass transportation system itself. Directional usage of vehicles during the peak hours is uneven; although buses and trains are crowded in one direction, those going in the opposite direction are generally lightly loaded. Furthermore, all seats in the vehicle move over the entire length of the route, whereas most passengers do not go to the end of the line. These reasons explain why mass transportation systems must provide more seat miles than are used.

The relationship between supply and usage, however, varies by mode of travel. Elevated and subway trains, and particularly suburban railroads, show a greater adjustment of seats to passenger usage. This is to be expected since they are scheduled to meet peak demands and are largely kept idle during the off-peak hours. Furthermore, trains of different lengths can be developed to adjust to carrying loads. Table 17 shows that suburban railroads provide only 1.2 times as many seat miles as there are passenger miles of usage, while subway and elevated trains provide 2.1 times as many seat miles of service as there are passenger miles of usage.

Buses seem to be the least efficient mode of mass transportation, with 2.5 times as much supply as there is use. One reason for this is that buses cannot increase and decrease in size, nor can they be combined in trains. Furthermore, because of public demands, they are often forced to provide a regular service in off-peak hours and in the "thinnest" passenger territory; this is highly inefficient.

These figures accent the perishable nature of the supply of mass transportation service. Once a bus or train has passed a particular point with empty seats unused, that amount of service can never again be used. And this perishability of mass transportation, in turn, accents the economic nature of the relationship between supply and use of mass transportation. Where there is no use of or, in effect, no demand for mass transportation, then economic pressures are created for a reduction in the supply of service. Only a strong public policy to maintain service despite financial loss, in order to achieve certain objectives, can prevent eventual curtailment of service as the natural result of a decline in demand. Such public action may be desirable, provided its full implications are understood.

Without a change in public policy, the supply of mass transportation services will probably continue to be very sensitively adjusted to the level of demand. In a sense, an equilibrium exists in which demand, fare rates, costs, practical operating requirements and public pressures for service are balanced. This equilibrium is adjusted also to land use patterns and density and to rates of car ownership.

The planning problem, assuming no change in public policy, is to estimate what the demand will be in the future, having a regard for the structure of the future city and for car ownership. Then determinations can be made as to whether the capacities of existing rail lines or bus routes need to be increased and what the levels of service shall be in view of costs and public pressures for service.

Summary

To summarize, mass transportation is different from street transportation, and the supply of mass transportation services cannot be dealt with in comparable capacity terms because capacities of rights-of-way alone are so great as to be unreal. Therefore, the actual production of seat miles of service was measured in the inventory of mass transportation facilities.

The results show that while the gross supply of service is double the use, this is the result of peculiar operating requirements and of the highly peaked demands on the mass transportation systems. The relationship between use and supply for buses, subway-elevated trains and suburban railroads are probably as good as can be obtained within economic, political and operational requirements and within the kind of demands which existed in 1956.

Because mass transportation service is a perishable commodity, supply is determined primarily by the demands of riders. Both use and supply have similar patterns of location and intensity within the Chicago area.

There is a very high relationship between use and supply on one hand and density of population and employment on the other hand. In particular, the Central Business District is the focus of mass transportation systems. This obviously is true because these facilities must have concentrated demands in space, and in time, to justify their bulk carrying characteristics.

Planning the mass transportation system of the future will depend, more than anything else, upon a careful estimate of the level of demand likely to exist for those services in the future. This level of demand is affected singularly by the densities at which land is used in the several parts of the urban area.

CONCLUSION

Like the inventories of travel and of land use, the inventory of transportation facilities measured an existing situation in order to provide a base for estimating and planning. The existing situation in this case was the capacity of arterial streets and expressways for moving automobiles and trucks, and the supply of service provided by mass transportation vehicles for the movement of people. The facts which were obtained permitted the supply of service to be described graphically and in quantitative terms, permitted supply to be compared with demand, and provided base information for use in estimating future travel on streets and mass transportation facilities.

Arterial streets and expressways were inventoried in terms of design capacity, a measure of service related to a reasonable quality of service. The total design capacity of major trafficways in the Study Area was calculated at 36.5 million vehicle miles, expressed in automobile equivalents. If all of the vehicle miles of actual travel had been distributed properly, there would have been no parts of this region where congestion could be identified, i.e., where usage was greater than the design capacity of the streets. But the distribution of supply and use was such that there were pronounced areas of both surplus and deficit capacity. The capacity deficit exists in a wide belt, beginning about three miles from the Loop and extending to a distance of thirteen miles. Beyond this band and, to some extent, at the very center, there is greater total capacity than there is usage.

The capacity of buses, subway and elevated trains, and suburban railroads was measured in terms of the seat miles of scheduled service provided during the average weekday. Over 32.4 million seat miles of service were provided in 1956. This compares with 15.5 million miles of passenger travel on those facilities. The large difference is explained by low, off-peak use of mass transportation vehicles, inefficient directional usage, and the fact that seats move over the whole length of a route, whereas the average passenger does not. The service provided by transportation of this type is specialized in location and time, and is geared to serve high density residential and employment centers.

Inevitably, comparisons will be made between the system of mass transportation facilities and the system of streets—both as to use and carrying ability. The use of buses, subway and elevated trains, and suburban railroads can be compared with the use of street services because both can be expressed in exactly the same terms: person miles of travel. As indicated in Chapter IV, 35,481,000 person miles of desire line travel by automobiles and taxis were measured in 1956, while 13,683,000 person miles of desire line travel were counted on all types of mass transportation combined. In other words, about two and one-half times as many miles of person travel were made by automobile as by mass transportation.

But no comparison can be made between the carrying ability of streets and mass transportation. Most simply, the carrying ability of mass transportation was not measured; the service actually rendered in 1956 was measured, not capacity to serve. Even if a calculation of maximum carrying ability could be made, the enlarged potential of mass transportation to move people would not be of significant interest without a corresponding demand for usage. This level of demand is conditioned by the present and expected future patterns of land use in the Chicago area, as well as by the income level of people and the nature of existing transportation services.

Actually, comparison is not to be desired. Transportation systems are planned to serve an urban region; the urban region is not planned so that a particular type of transportation will be able to operate economically. The urban region is not necessarily planned even to achieve the cheapest over-all transportation cost. To do so would be to have the tail wag the dog, for local transportation consumes only about one-tenth of the average Chicago area family's expenditures, and about the same proportion of the area's fixed capital investment.

Perhaps a better statement of a single objective is to maximize total urban productivity with a given capital investment. This capital investment consists of both investment in buildings and investment in transportation. In turn, the investment in transportation may be divided between mass transportation and streets. The total investment ought to be planned to provide the greatest production of goods and services and good living for the population of the Chicago area.

With this view, streets and mass transportation fall into place as components of the total supply of transportation, each having a particular task to perform. These tasks depend greatly upon the land use and density of patterns of the urban area because each type of service operates best in a certain environment. This, then, points to the need to estimate accurately what the form of the city of the future will be.

Chapter VII

SUMMARY AND CONCLUSION

As more people come to live in the Chicago area in the coming decades, more houses, stores and schools will be built for them, and there will be more factories and offices in which they will work. These new activities will fill up great areas of land, at a rate estimated to be twenty square miles per year. As a direct result of growth, more travel will be undertaken by persons, but existing patterns of travel will not grow uniformly. Travel patterns will shift as the total population adjusts to the new arrays of land uses where their daily needs can be satisfied. Growth, in effect, means change for transportation.

Planning a transportation system, therefore, requires very careful studies to define the transportation problems of the future—how much travel, where it will take place, and by what modes and routes. Forecasts of urban growth permit estimates to be made of the volumes of future travel. Then it is possible to plan for facilities in the right amounts and places so that the improved transportation network will be best adjusted to future travel requirements.

Large scale inventories of travel, land use, and transportation facilities are needed to provide a factual basis for such forecasting and planning. These inventories, requiring substantial investments of time and money, cannot be repeated regularly. Therefore, the procedures for gathering data, forecasting, and planning were designed so that data could be kept current, at reasonable cost, for the continuing reappraisal of plans.

The travel inventory was designed to collect all significant data on the travel of persons and of vehicles on an average weekday. These records were obtained by visiting a sample of all dwelling places and by sampling all commercial vehicles registered locally. In addition, travelers from outside the survey area were intercepted at entering roads and at outer suburban railroad stations to insure complete enumeration of daily travel.

These inventories disclosed that the average resident made two trips per day and the average truck about six. All told, on an average weekday there were 10.5 million one-way trips made by people riding in automobiles or on public transportation facilities. Moreover, there were 6.1 million vehicular trips traveling some 36,000,000 miles on the streets of the area.

Of more significance than total size is the characteristic pattern of these trips. They are predominantly short—the average journey being nearly six miles long (over-the-road distance) with half of all trips being less than three miles in length. Being short, the trips are bunched near the major land developments and travel density is greatest in the areas where land is most intensively used.

Trips reflect the stable activities of people and institutions within the cycle of a day. For any small part of the region, the number of persons starting trips will equal the number ending—i.e., origins will equal destinations. Also, it is a virtual rule that in the course of a day the trips moving from one point to another will tend to be balanced by equal reverse movements.

The variation in trip making by hour of the day is one of the most significant factors of urban travel. The hours of peak usage in the morning and evening determine, in large measure, the requirements for facilities.

Mass transportation is most heavily patronized during the peak hours. These trips are mainly work oriented. The very heavy peak demand on mass transportation facilities is one cause of financial difficulty. There is strong evidence of increasingly specialized use of mass transportation during peak travel hours. Travelers to the Loop appear to choose rapid transit because it provides superior service—no parking is required and service in the peak hour is most frequent. Off-peak mass transportation users, on the other hand, appear to be made up of "captive" riders. These are the car-less families—in Chicago four out of ten and in the suburbs one out of ten—and the non-drivers—women, children going to school, and older persons.

Trucks, in contrast to transit users or even auto drivers, do not show the same tendency towards peak hour use. Instead, they travel mainly during the working hours of the day between 9:00 A.M. and 5:00 P.M. Their patterns of travel origin and destination are similar to those of all travelers. This suggests that truck travel can be well served if adequate facilities to serve the peak demands of all vehicles are planned.

Trips made by persons are in response to the needs of living. The number of trips made daily shows a tendency to be greater for persons of higher income, for persons living in less dense residential areas and, naturally, for those who own cars. Since travel uses up about an hour and a half of the time of the average traveler each day,[1] it can be seen that there are limits to the amount of travel time allotted by the family or personal time budget. Since about ten cents of every consumer dollar spent goes for local travel, and this has been true for the last twenty-five years, it is obvious that travel cannot be extended greatly in the future unless there are substantial relative reductions in the cost of travel.

One of the final limiting factors on travel is the distribution of places to which trips can be made. If the spacing of stores and factories, churches and schools is designed for convenience to their "customers," this tends to reduce the distances people have to travel to accomplish their necessary purposes. Actually, the uses of land are the underlying mosaic that determines the origin-destination linkages of travel.

[1]Of the 4,595,000 persons age five or more, 2,825,000 reported making trips on an average weekday. Since there were 4,379,600 hours consumed in travel by these persons, this averages a bit more than an hour and a half per person traveling.

Since land use is important as a determinant of travel in many respects, an inventory of the use of land was made as the basis for explaining current travel patterns. Moreover, it was reasoned that, being relatively stable and slow changing, land use could be predicted and would provide a more accurate basis for an estimate of future travel.

Comparison of land use information with travel showed that there was great correspondence in their metropolitan patterns. Where there was vacant or sparsely developed land, there were few trips. Where the land was intensively used and buildings were densely packed, travel was correspondingly greater. The very large volumes of trips made daily to the Loop are better understood when the amount of floor area in this small center is known. With just about 0.2 per cent of the developed land, it contained nearly four per cent of the floor area. About one of every eleven trips made by people either began or ended in the Loop.

Besides indicating the volumes of trips expected, land use is of significance in determining the linkage of origins to destinations—that is, in explaining the entire journey. Land uses of different kinds have different degrees of affinity in travel linkage with other land uses. A dominant movement of people is from residential to nonresidential places and back. In the morning, people leave homes to go to work, to school and to shop. These dominant linkages—residential to nonresidential land—account for about three out of every four person trips. Of the remaining 25 per cent, fifteen per cent are between residential land uses. These are generally social and recreational trips. The final ten per cent of trips is between nonresidential land uses—the trips from work to store or store-to-store. For trucks, the opposite is true. Trucks link nonresidential uses mainly, delivering and picking up goods. Thus, land use is doubly significant as the base for estimating future travel—it defines not only the volumes of origins and destinations but the linkage which produces travel.

Of special concern are the facilities over which this travel takes place. These are the targets for improvement. Travel in an urban area flows along the channels provided. In the case of mass transit, this is along rail lines or bus routes. For automobiles and trucks, however, the streets and highways are the channels. The distribution of facilities and their capacity and quality are, in many ways, the measure of effective intercommunication that determines the smoothness of operation of the daily life of the community.

These facilities support and serve the land uses. If the transport facilities are too small in capacity, it is difficult to develop intensive land uses. The network or systems of facilities should be adjusted to the land uses and to the travel demands of the public. Because these facilities are fixed, there are bound to be some points of congestion or insufficient capacity as well as places with surplus capacity. This will occur because travel habits and even land uses change more rapidly than the transportation facilities.

The task of the future is one of providing facilities in the right amounts and locations to supply land development with adequate transportation services. This must be achieved through supplemental building and additions to the present system. The additions must be made with limited financial resources. There is, therefore, much room for ingenious design in the establishment of a development plan for these facilities. There are many possibilities in type of facility as well as in location. Whatever the solution may be, it must be one that comprehends the entire urban community and that meets its very complex travel demands.

The seemingly independent facts obtained through the major inventories represent, in truth, only parts of one great functioning whole —the urban community. Each is related to the other because each is a part of this whole. Each represents an orderly array of human activities because they are expressions of a purposeful, living community. Not only do these inventories detail orderly behavior but behavior that is essentially rational. This must be so for it is not likely that a society of a competitive type, with limited resources, will waste energy or effort if things can be accomplished with greater economy.

A large community of people like the Chicago region is constantly discarding the old and trying the new. It is always adapting to change. Changes are forced by new people, by new technology and by the competition of other metropolitan places. In this process of continual adjustment, whereby the regional community seeks to increase productivity and enhance the qualities of livability, the planning and programming of a transportation system is of great importance.

Technically, the point has now been reached where the entire circulation system of the community can be comprehended. Whole systems of streets and transit facilities, of spatial locations of activities, and of interchange of persons and vehicles, can be dealt with. Careful planning with this enlarged scope offers greater certainty of acting in the public interest than the method of making piecemeal adjustments in response to local pressures.

With these capabilities, a longer look may be taken at the expected future and at the various ways in which the community's travel requirements might be met. Sharpness of forecasting and careful measures of the consequences of alternative lines of action allow reduction of chance in arriving at improvements which will be most likely to serve the future metropolitan community.

Appendix

GEOGRAPHIC IDENTIFICATION OF SURVEY DATA

The value of the information collected in the inventories of travel and land use is, in part, dependent on the ease with which it can be related to the geographic area from which it was taken. Uniform geographic identification of all data collected is essential. Further, a system of identification which permits rapid summarization by machine methods is required.

To meet these specifications, the Study adopted a plane-coordinate grid as the primary unit of geographic identification. Using State and Madison Streets in Chicago as base lines the grid was constructed at one-half mile intervals to cover a 90 mile by 90 mile area. Map 19 shows the entire grid system plotted, and the numbering system used. This map, however, does not show the close alignment of the grid with the street system in the city of Chicago and several suburban communities. A nearly coterminous arrangement of grid and streets exists in this more densely developed portion of the Study Area.

The one-half mile grid, as such, is a unit too large to be used in the collection of travel and land use data. The home interview required a specific street address. Similarly, trip ends were recorded to a street address, and the land use inventory measured land areas within blocks. The conversion of street address and block identification to the Study grid system for the city of Chicago was accomplished by machine with a minimum of map work. Figure 49 shows a quarter square mile grid and the block numbering system.

Survey data for the Study Area (see Map 22) were collected and recorded to the combination of street address and block. The blocks were then summarized to the quarter square mile grid.[1] Survey data outside the cordon line were recorded to political unit. As shown on Map 20, the degree of detail for geographic identification of trip data decreased with distance from the Study Area. Cities, townships, counties and, finally, entire states were used.

To provide an analysis unit larger than the quarter square mile grid, and to decrease the number of geographic units for which forecasts were to be made, the analysis zone was created. In the Study Area, a zone is defined as being one or more quarter square mile grids. Three zone sizes were used in the Study Area: quarter square mile units were used in the Loop, one square mile units for the city of Chicago and a few adjacent suburbs and four square mile zones for the remainder of the Study Area. In the external area (outside the cordon line) zones were established in a band approximately ten miles in width. With the exception of northern Lake County, Indiana, where four square mile zones based on the grid were used, all external zones were based on townships. Each zone is numbered and further identified by the grid coordinates of its center. In total there are 582 zones in the Study Area and 45 in the external area.

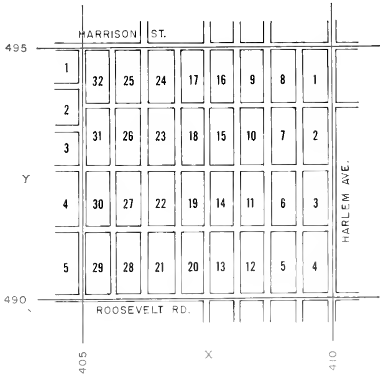


FIGURE 49—BLOCK NUMBERING SYSTEM WITHIN QUARTER SQUARE MILE GRID

[1]Just as the grid is too large for data collection, the block is too small for summarization. The 49,481 blocks in the Study Area are summarized to 5,111 grids.

The largest geographic unit used by the Study for analysis purposes was a system of *rings* and *sectors*. Ring and sector lines, used separately or together (to form districts), define a group of zones, as shown on Map 21. Sector lines were extended beyond the zoned area and *sector points of entry* were established. The sector points of entry are used in mapping as a starting point for all trips with one end falling beyond the outer ring of zones. Descriptions of this and other mapping procedures follow.

GRAPHIC PRESENTATION OF SURVEY DATA

Three methods have been used in this report to present the geographic distribution of survey data. Floor area and trip destination data have been shown in three dimensional models. Land use, population, automobile ownership and capacity maps used the isoline method. The photographs of trip desire lines are examples of the Cartographatron operation. The first two methods are used wherever grid or zone summaries are to be presented. The Cartographatron, however, portrays the movement (trip) between two points, in this case, between two grid squares. Each of these methods starts with data punched into cards and identified geographically by the grid coordinate system.

Isoline Maps and Models

In the case of isoline maps and models, the data to be presented are printed directly from the punched cards onto maps. This is accomplished by arranging the cards in such order that the data will print out in the proper grid square. The resulting map is made up of four strips, each covering a width of ten miles, or twenty grid squares. Figure 50 shows the relationship of four strips to the Study Area. The four strips are joined and photographically reduced to one-half their original scale, or 1″ equals two miles. This reproduction then becomes the base manuscript for preparation of models or isoline maps. Models are constructed of wooden blocks placed directly on this manuscript and later positioned on a map for presentation.

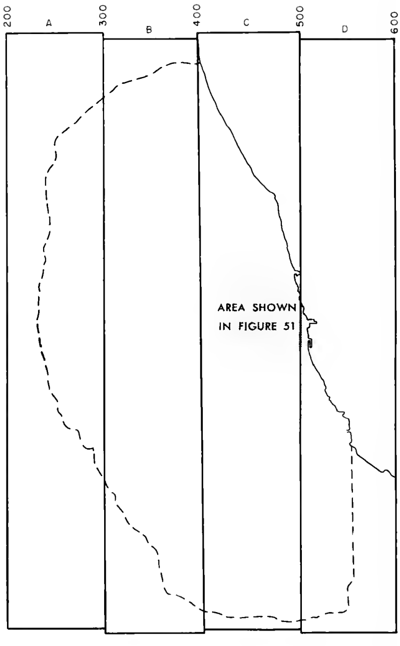


FIGURE 50—LAYOUT OF MACHINE PRINTED STRIP MAPS

Isolines are compiled on the manuscript in a manner similar to the "logical contouring" of relief features. This is a process of compiling contour lines[2] by interpolation of known elevations and interpretation of drainage features. Ideally, the compilation of contour lines would be the simple connection of an infinite number

[2]A contour line by definition depicts equal elevation above sea level. The word 'isoline' is a general term defined simply as a line of equal value.

of elevation points of equal value. The isoline as used by the Study, however, is compiled by enclosing areas (one quarter square mile grids) of similar value. A typical example is demonstrated in Figure 51. It will be noted from this example that the grid lines are not followed rigidly in isolining. In fact, knowledge of the area being isolined is essential if the isolines are to depict the pattern in a realistic fashion. After the isolines have been compiled and checked against other maps, they are drafted in final form either on or as an overlay to a base map.

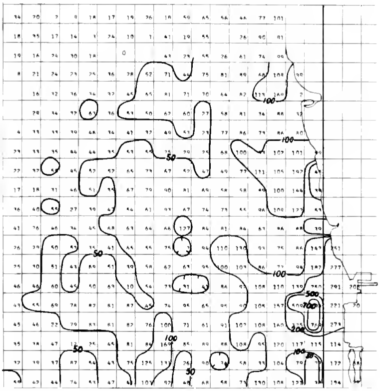


FIGURE 51—EXAMPLE OF ISOLINED MACHINE PRINTED MAP

The Cartographatron

The mapping of *trip desire lines* has always been difficult. To trace a line from the point of origin to the point of destination, for every trip occurring in an urban area on an average day, is impractical. Further, if such a map were drafted, it most certainly would not be legible. Several methods have been used to bypass this problem. The first, and perhaps still the most commonly used, was to group trip ends geographically into zones. The procedure then is to draft lines from each zone center to all other zones where interchange occurs. The use of variable line weights has been the usual method of displaying the volume of trips.

A second method, used extensively in California studies and later by the Detroit Metropolitan Area Traffic Study, is to trace trips from origin to destination through a grid system, by machine. In this method each grid square becomes a zone comparable to those used in the earlier method. By computing the direction in which a trip moves on the grid, a card can be punched for each grid square traversed by the trip as it moves from origin to destination. The cards were then summarized for each grid and maps were prepared in the same fashion as the land use maps in this report.

A third method is that used by the Chicago Area Transportation Study. Two factors forced the development of this method: the large geographic area involved in the study and the enormous number of trips occurring in the area. The alternatives were simple: either increase the size of the geographic unit (one quarter square mile grid), to decrease the number of zones, or develop a new method. The first seemed to be inconsistent with detail of the *travel* and *land use data* to be collected. Therefore, a contract was entered into with the Armour Research Foundation of Chicago to design and construct a device which would automatically map trip desire lines. The result of this contract was the construction of the Cartographatron.[3]

In the simplest of terms, the Cartographatron is a combination of an electronic computer, a television picture tube, and a camera. The equipment is pictured in Figure 52.

Before the Cartographatron could be operated, travel data had to be prepared for its use. The traval data were transferred from punched cards to magnetic tape and in the process of making this conversion, the desire line length and direction of each trip were computed. The completed magnetic tape contained information on the origin, direction, and characteristics of each trip. This magnetic tape could then be read by the Cartographatron.

The panel of this machine contains selectors which permit an operator to select for display

[3]A detailed description of the Cartographatron and its operation is presented in the *CATS Research News*, Vol. 2 (1958), No. 6.

only those trips having desired characteristics. Thus trips can be selected according to their length, purpose, time of arrival, land use, zone of origin, direction, mode of travel or any other of a total of twenty-two trip characteristics.

For any trips so selected, the Cartographatron converts the numerical data on the tape into voltages which then generate a blip of light on the face of a cathode ray tube, moving it precisely at the correct angle from the trip's origin to its destination. The speed at which this blip of light moves is a function of the trip's factor—that is, the number used to expand that sampled trip to its correct proportion of the total universe of travel. The slower the speed, the greater would be the amount of light generated on the face of the tube and hence the greater number of trips represented.

In the Study Area, all of the trips are traced between quarter square mile grids. Trips with origins and/or destinations outside the cordon line are traced either from the centers of the political unit to which they are coded or, in the case of trips starting outside ring "8", the trace starts at the sector point of entry. See Map 21, page 102.

At all times during the running of a tape, a camera with its lens open is focused on the face of the cathode ray tube. Each blip of light is recorded on a photographic plate, the weight of each line being directly related to the speed of the moving blip. The photographic plate ac-

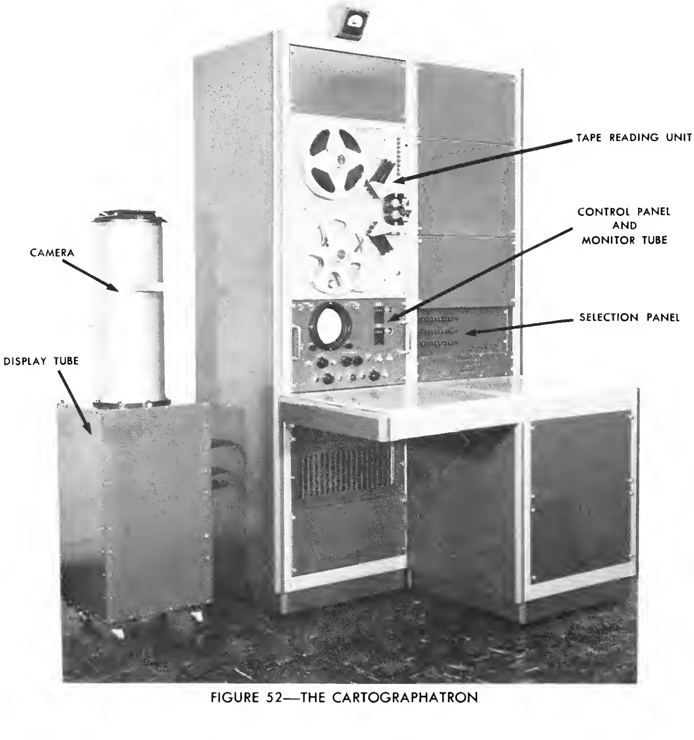


FIGURE 52—THE CARTOGRAPHATRON

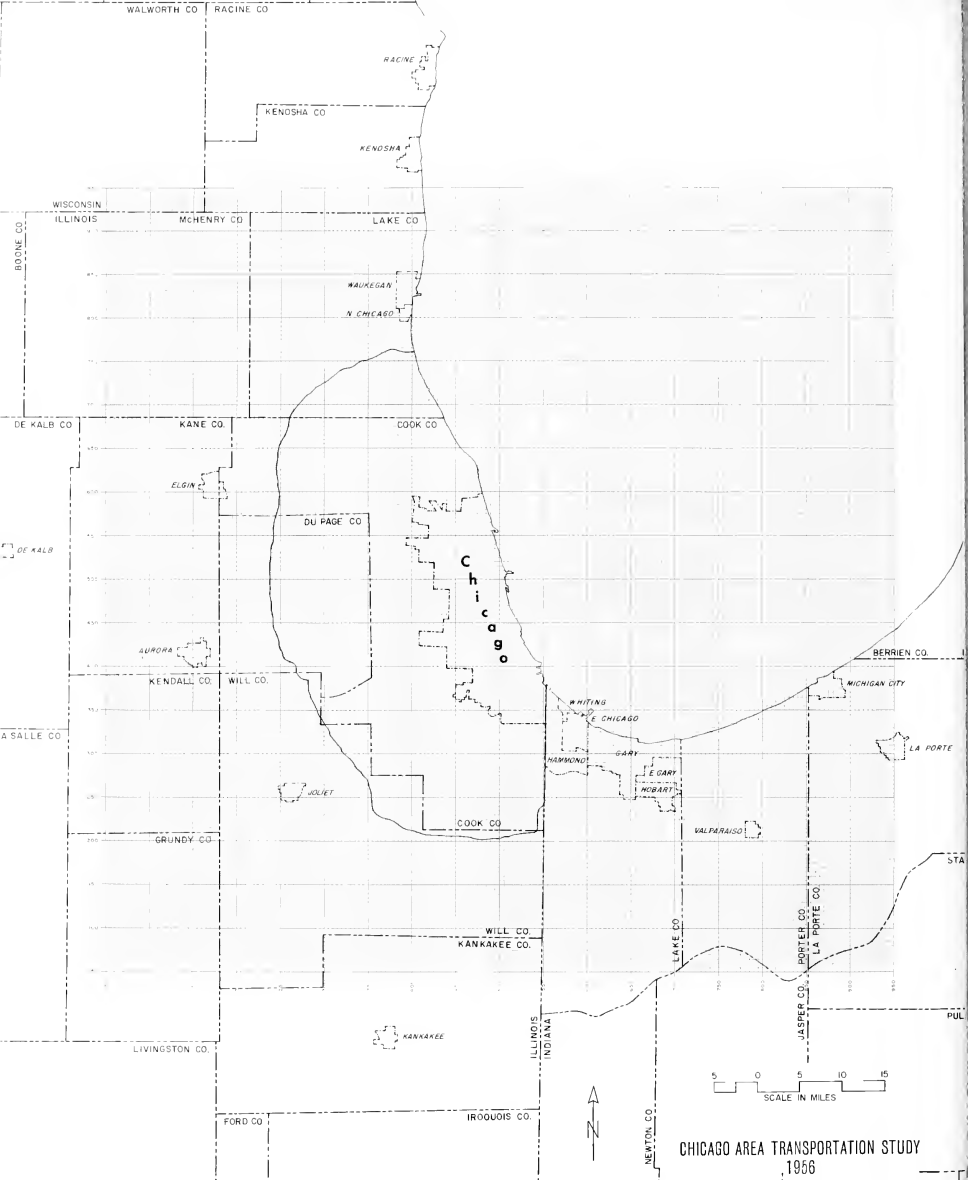
cumulates the records of thousands of trips, with varying *densities* of desire lines as more of these lines accumulate in some places than in others.

Before the plate is removed from the camera, one operation must be performed to complete the map. This is to display a *calibration wedge*, or scale. The scale consists simply of lines of known trip value. With this scale it is then possible to translate a density on the map to a value in terms of trips. The plate is then processed in the photo-lab and prints, such as those used in this report, are prepared.

The scaling of Cartographatron displays is accomplished by examining the plate with a densitometer. A density reading is made of a known trip mile value on the calibration wedge. Profiles may be run in which the density value is plotted for each point inspected and later converted to trip mile values by use of the calibration wedge. If isolines are required, they may be obtained by preparing a series of special prints in which the exposure time in printing is varied with each print. The resulting prints will depict patterns in relation to the density of the plate and the amount of light transmitted (exposure). The outer limits of the pattern on each print are then scaled by using the densitometer.

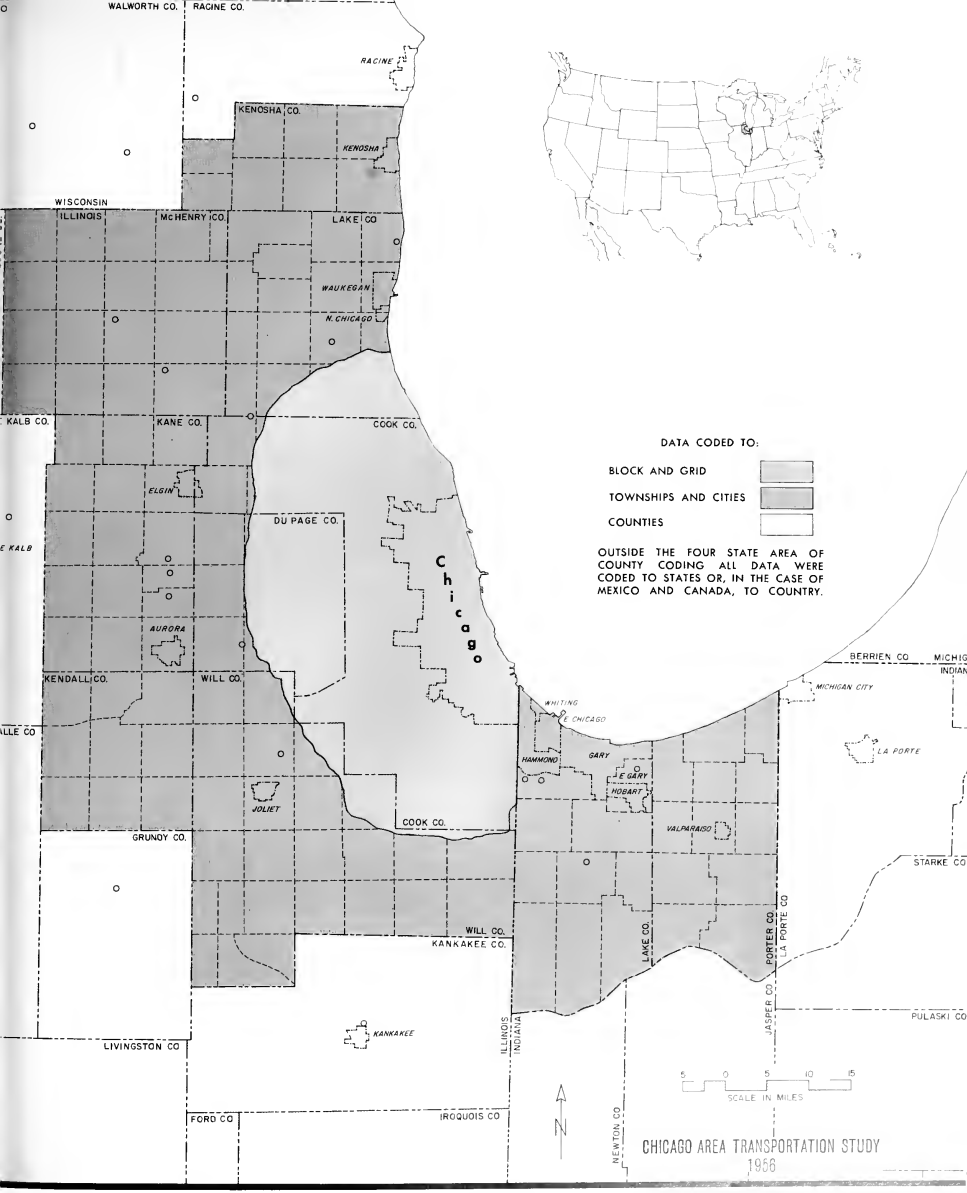
The Cartographatron, in processing data as described above, completes a single trip desire line in one ten thousandth of a second, or 20,000 trips in seven minutes. By other methods, this would have required many hours of machine processing and additional hours of cartographic work. Further, the Cartographatron permits the selection of trips to be mapped. All of the characteristics of a trip (mode, purpose, time, etc.) are recorded on the same tape. By use of the selection panel on the Cartographatron, it is possible to select only those trips of immediate interest, and to map them.

To place the Cartographatron operation in its proper perspective, the size of the travel inventory must be considered. Trip records from all surveys combined require more than 378,000 punched cards. In terms of magnetic tape, this equals nineteen reels. This is the travel inventory file which, when expanded, accounts for each of the 10,500,000 daily trips. Allowing time for the changing of reels, it takes about 7 minutes to run one reel. A map of the entire file can be prepared in approximately four hours.



MAP 19
GRID COORDINATE SYSTEM

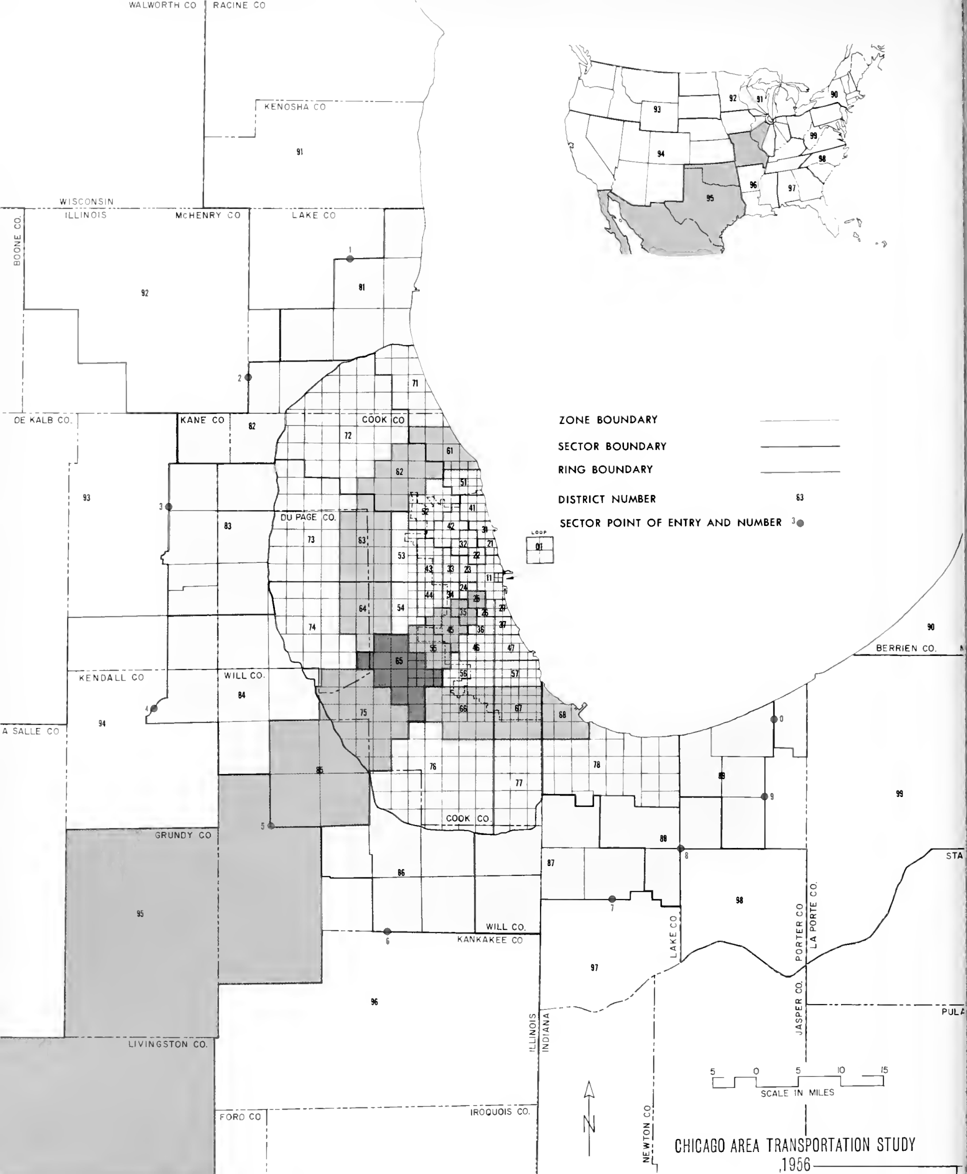
A grid system with lines spaced one-half mile apart provides the basis for systematic geographic identification of data for small areas within and adjacent to the Study Area.



MAP 20

DEGREE OF GEOGRAPHIC CODING DETAIL

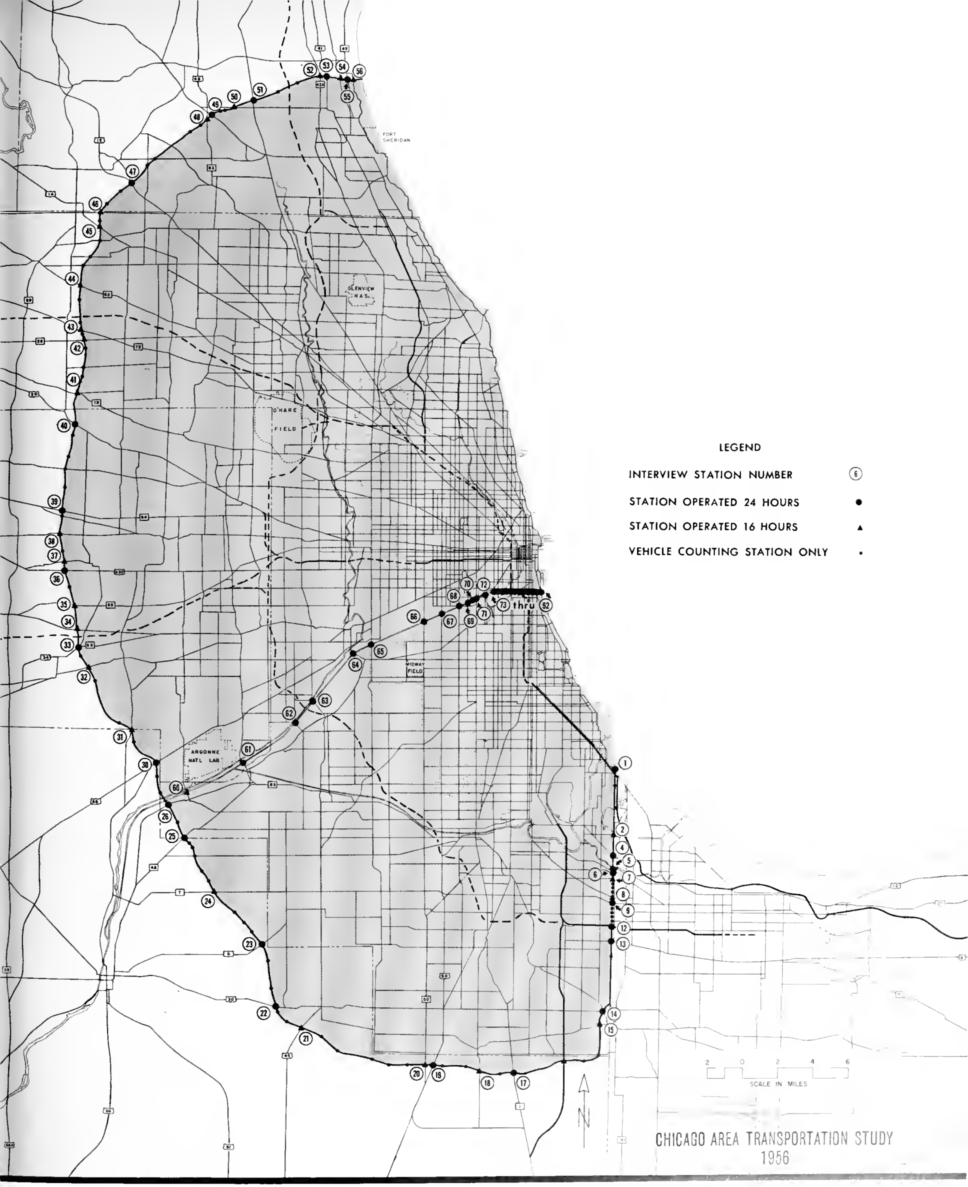
Travel data were coded in different degrees of detail, depending on proximity to the Study Area. Within the cordon line, all data were coded to block and grid coordinates. Within the adjacent counties, travel data were coded to townships and, at successively greater distances, to counties and states.



MAP 21

ANALYSIS ZONES, RINGS, SECTORS AND DISTRICTS

For easier study, block and grid data were summarized inside the Study Area to 582 analysis zones of one-quarter, one and four square mile areas. These were numbered to permit further summarization by ring or by sector. Ring 6 is shown in blue and Sector 5 in red on this map.



MAP 22

CORDON AND SCREEN LINE INTERVIEW STATIONS

The Study Area is defined by the cordon line. Interview stations numbered 1 through 56 were located along this line; vehicles entering and leaving the area were interviewed at these points. A screen line marked by stations 60 through 92 and located along the Sanitary and Ship Canal was used for special interviews to check the accuracy of travel inventories.

Highway capacity has been the subject of much study by many capable persons over the past forty years. The work of the Highway Research Board Committee on Highway Capacity has made the most significant contribution in this field. The Highway Capacity Manual[1] published by the Committee is used as a guide to capacity calculations throughout the United States and in many foreign countries.

Intersection capacities used by the Chicago Area Transportation Study are not the same as those which would be obtained from the Highway Capacity Manual. It is the purpose of this appendix to show why the Highway Capacity Manual was not used and to describe how the Chicago Study capacity measures were obtained.

Intersection capacity has many connotations. In an attempt to standardize terminology, the Capacity Committee defined three levels of capacity for urban arterial streets. These are—basic capacity, possible capacity and practical capacity. Basic capacity is a kind of theoretical number, being the greatest number of vehicles that, under ideal conditions, can pass a point on a roadway in an hour. Possible capacity is less than basic capacity. Possible capacity is a figure calculated to represent maximum intersection output, given a normal mixture of turning movements, commercial vehicles, variation in drivers, etc. Practical capacity is defined as "the maximum number of vehicles that can pass a given point on a roadway or in a designated lane during one hour, without the traffic density being so great as to cause unreasonable delay, hazard or restriction to the driver's freedom to maneuver under the prevailing roadway or traffic conditions."

Practical capacity is an attempt to develop an operating standard. The designation of practical capacity is a recognition that traffic does not flow at a uniform rate for an hour. Traffic flow equal to the possible capacity is attended by severe back-ups, congestion and traffic delays. Traffic flow at practical capacity values thus allows a tolerable amount of congestion and provides a reasonable quality of service.

Practical capacity, by its very definition, is a subjective value. What is more important is that this definition does not give a precise impression of the number of cars that are delayed, how long they are delayed or how much the speed is reduced. Thus, a positive assessment of the quality of service or the measure of inconvenience afforded at these practical capacity values is not possible under this definition.

The capacity figures presented in the Highway Capacity Manual were developed from a series of vehicular volume observations at intersections throughout the United States. Data were grouped in a manner that relates observed volumes to the particular physical and roadway conditions at the time of observations. Counts taken under similar conditions were grouped to add stability to the results. The results were displayed by graphs indicating the relationship of observed volumes to physical and traffic conditions for intersection approaches.

There are two difficulties with this approach. One is that the resulting figures show relationships which are, in effect, average observed volumes representing a range of points. The use of averages, when the range of events is not shown, can be a questionable statistical device.

The second difficulty is that observed volumes do not necessarily equal capacities. For observed volumes to equal possible capacity, an intersection must be under a continuous backlog for an hour. Observations in Chicago indicate that very few intersections have this continual pressure for an hour. It is likely, therefore, that observed volumes would be less than possible capacity. For example, the Highway Capacity Manual reports a decline in capacity per ten feet of width as width of roadway increases. In other words, roadways are less efficient for each additional increment of width. Within the range of typical street widths the

[1]*Highway Capacity Manual* (U.S. Department of Commerce, Bureau of Public Roads) Washington, D.C., Government Printing Office, 1950.

opposite effect is more likely true because left and right turning vehicles or slow moving commercial vehicles have less total effect on wide than on narrow roads. Most likely the relationship reported in the Highway Capacity Manual results because there was insufficient traffic pressure to load the wider streets completely. Across the country many streets have been observed to carry higher volumes than were considered possible by the Highway Capacity Manual. Local traffic engineers in the Chicago area have recently used a factor of 1.4 to expand the capacities derived from the Highway Capacity Manual.

To account for differences resulting from the kind of area in which a street is located, the Highway Capacity Manual grouped and averaged observed volumes for four different area types. These were downtown, intermediate, outlying and rural. The capacity values indicate a decline outward from downtown to rural areas. This may be questioned. More likely the reverse is true because the impedances of pedestrians and of parking activity tend to increase as downtown areas are approached. This may not have been observed from volume counts because of progressively declining volumes from downtown to outlying areas. Recent releases by the Highway Capacity Committee bear out this observation.

Chicago being one of the larger metropolitan areas and, therefore, less likely to be typical, it was concluded that intersection capacity observations should be made locally and that standards based on these observations be set. This viewpoint was supported by the Technical Committee of the Study. Moreover, in 1956, when the Chicago Study started its capacity work, the Highway Capacity Manual was being revised by the Highway Research Board Committee on Highway Capacity. The results of the new study were not ready for public release and it appeared that they would not be available in time for use by the Chicago Study.

The first capacity study by the Chicago Study was made according to instructions issued by the Committee on Highway Capacity. Field sheets similar to those prepared by the Committee were used to record the observations at intersections in the Chicago area. Two crews of six men each made counts of vehicles and pedestrians at 102 selected interesections. Separate counts were made for each green signal indication, on each approach to every test intersection, for 90 consecutive minutes. Each recorded count included a record of vehicle types and turning movements. An inventory of the fixed features of the roadway was taken at the same time.

Counts were made only at two-phase, fixed time signal controlled intersections of which the majority were four legged, allowing two-way movement on each leg. A few three, five and six legged intersections were included, some with one way movement on one or more approaches.

Observers marked with a check all green intervals which were considered "loaded," i.e., all approach lanes fully utilized. In the event of doubt, the cycle was considered "not loaded."

A multiple linear correlation analysis was made of this data. Estimating equations were developed and tested against the observed data. Equations developed for similar conditions, using one group of intersections, gave poor results in estimating capacities for a second group of intersections.

While the results of this study did not produce estimating equations for capacities, they indicated that, under certain conditions, such an equation might be developed. First, it would be necessary to obtain observed data that were truly representative of a particular intersection. Second, the observations would have to be precise, made, preferably, by a team of well trained engineering technicians. Third, all cycles used in the calculations would have to be truly loaded.

Some interesting results were noted in addition to the conclusions stated in the preceding paragraph. For a group of intersections where the approaches were loaded 70 per cent or more of the hour, the observed volumes ranged from

107 per cent to 195 per cent of possible capacity as stated.

Note that some of the approaches were only 70 per cent loaded in the Highway Capacity Manual. Another significant observation was that capacities increased per 10′ of width, as street width increased, when the approaches were fully loaded.

On the basis of these observations, additional studies were carried out on Chicago Park District boulevards which had turn restrictions, to obtain observations of the effect of the elimination of trucks and turns. Minimum headways were obtained for green signal intervals, with the intersection approach legs fully utilized. Observations taken at the 102 intersections previously mentioned were used to develop modifying factors to account for average conditions of ten per cent left and ten per cent right turns. These data were then used to compute maximum hourly discharge rates for typical intersections in the Chicago area. These were termed capacity standards. Capacities were computed in passenger car units for a signal split of 50-50.

As yet, no account had been taken of the impedances due to pedestrians or to parking maneuvers. Since these impedances are related to the type of area in which the street is located, capacity standards were computed for four area types comparable to those defined in the Highway Capacity Manual, i.e., downtown, intermediate, outlying and rural. These impedances are more prevalent in central areas than in outlying and rural. Chicago Study standards, therefore, showed increasing capacities outward from downtown to rural areas for similar conditions, instead of decreasing as indicated by the Manual.

The capacity standards also show the effect of street width on capacities—the wider the street, the greater the capacity per unit of street width. Here again, this differs from the Highway Capacity Manual in that the Manual shows decreasing capacity per unit of street width as width increases.

These capacity standards, stated in passenger car units, represented the best judgment as to the capability of streets to discharge vehicles at typical intersection approaches in the Chicago area. These standards are shown in Table 14, page 78.

These capacity standards represent maximum hourly capacities. They can be achieved only if there is a continual backlog at the signal. This means that *all* vehicles approaching would be delayed. Moreover, since vehicles do not arrive at a steady hourly rate, some vehicles would be delayed through several signal cycles. Under these conditions, delays would be very great and congestion intolerable.

It is obvious that traffic delays increase as volume increases. If it were possible to relate speed and volume, it would be possible, then, to select a volume (i.e., capacity value) equal to a volume which would permit a route section to operate at an acceptable speed. A study indicated that volume has no appreciable effect on speed of urban arterial streets until approximately 60 per cent of the capacity is reached. From that point on each increment of volume causes a decrease in the average speed of all drivers. Curves relating speed to the ratio of volume to capacity are shown on Figure 44, page 79 of this report.

Using these curves it was possible to establish a figure which represented a reasonable capacity for use in design. This was called "design capacity" and it represents the hourly volume which is judged to be sufficiently great to prevent the waste of street space, yet not so great as to cause extensive driver delays. It is a subjective decision but it represents a measurable standard.

This design capacity is analogous in use to the Highway Capacity Manual's "practical" capacity. It has the virtue of being able to measure the sacrifice of speed for each additional increment of traffic volume. Thus it is a valuable test in benefit cost appraisals.

To compare travel with capacity, both must be stated in the same units of time, i.e., either in hourly or 24 hour terms. Origin-destination data is commonly stated in the latter fashion. To predict traffic volumes for some future time period in smaller increments would be very difficult and would not be very accurate. Thus, a comparison of capacity with trip desire requires that capacity be stated in 24 hour terms. To convert hourly approach capacity to 24 hour two-way capacities, all that is required is to determine their relationship and the percentage of traffic flowing in the direction of heavy flow, during the peak hour.

Peak traffic is a stable function of the 24 hour traffic and is determined readily from volume counts. In this report, peak hour capacity was set at 11 per cent of 24 hour capacity. This is comparable roughly to the thirtieth highest hour for urban streets. The directional split during the peak hour was set at 60-40. This was based on manual counts at over eighty locations, scattered throughout the Chicago area, for which the heavy direction of flow was 58 per cent of the two directional flow during the peak hour.

Further study is needed to be more certain of the capacity characteristics of urban streets and especially towards the designation of capacity standards. It is believed that this approach has merit. More precise evidence on speed-volume relationships would be helpful, however, not only in refining standards but in evaluating alternative improvement plans. This last is particularly important because assigned volumes can be converted directly to estimates of travel time, for evaluating costs as opposed to time savings, in testing plans for new facilities.

SAMPLING VARIABILITY

To estimate the sampling variability, the "standard error" is used. Two-thirds of the time, the difference between the total obtained by expanding the sample and the total which would be obtained by complete enumeration will fall within one standard error. Ninety-five times out of 100 this difference will fall between two standard errors. Table 18 shows the standard error for trip totals of different sizes.[5]

This table can be used to estimate the standard error of trip volumes. For example, if there are 5,000 internal vehicle trips from one area to another, Table 18 may be entered at 5,000 and the standard error read as 448. This means that two times out of three, the sample estimate of 5,000 would differ from a complete count by less than ± 448 or ± 9.0 per cent.

[5]Ground counts indicated that trips reported by residents averaged about 85.6 per cent of the trips crossing the 'screen line' and the trip data were factored up to these ground counts. The effective sample rate was therefore about 2.5 per cent. The sampling variability has been assumed to approximate that of a 2.5 per cent random sample using the formula $\sigma_p = \sqrt{\frac{pq}{N}}$

The sampling variability would be lower for trips from the truck and taxi, and external surveys, in which the sampling rates were higher.

TABLE 18

APPROXIMATE STANDARD ERRORS FOR INTERNAL TRIP TOTALS OF VARIOUS SIZES AS EXPANDED FROM SAMPLE HOME INTERVIEWS

Expanded Trips	Standard Error	Standard Error as a Percentage of Expanded Trips
100	63	63.4
250	100	40.1
500	142	28.4
750	174	23.2
1,000	201	20.1
2,500	317	12.7
5,000	448	9.0
10,000	634	6.3
25,000	1,002	4.0
50,000	1,415	2.8
100,000	1,996	2.0
250,000	3,132	1.3
500,000	4,371	.9
1,000,000	6,015	.6

TABLE 19—1956 POPULATION, DWELLING PLACES AND AUTOMOBILE OWNERSHIP BY DISTRICT[a]

District	Total Population[b]	Occupied Dwelling Places[e]	Total Dwelling Places	Autos Owned	Auto Drivers Licensed to Drive
01	4,954[c]	9,306	12,756	1,298	6,451
11	317,557	125,811	137,811	48,871	90,886
21	137,010	56,961	59,631	29,455	44,232
22	115,974	37,013	38,723	23,175	29,194
23	161,881	50,684	53,564	29,987	44,615
24	99,488	27,932	28,832	17,732	26,418
25	59,744	18,955	19,825	11,931	17,755
26	43,298	13,182	13,842	8,673	13,163
27	128,217	40,207	42,577	15,061	29,269
31	160,772	69,160	71,830	40,976	61,613
32	159,425	54,819	56,559	41,955	55,309
33	145,172	48,967	50,347	36,803	50,012
34	110,415	31,701	32,631	23,070	35,090
35	70,781	21,842	22,592	15,933	21,828
36	100,072	29,800	30,670	19,474	27,953
37	216,070	77,467	81,787	37,332	68,270
41	189,986	70,412	72,092	58,668	85,806
42	178,490	58,599	59,889	50,078	69,084
43	207,982	67,808	68,558	62,669	90,011
44	122,504	39,362	39,692	37,995	54,585
45	82,827	23,966	24,386	21,769	29,513
46	214,550	66,084	67,524	54,141	81,616
47	290,070	100,915	103,975	68,297	115,161
51	100,176	36,081	37,371	33,509	53,575
52	132,057	37,926	38,676	41,952	60,082
53	114,588	31,732	32,152	34,952	49,541
54	70,418	20,006	20,306	23,548	33,965
55	71,752	19,265	19,595	20,040	26,855
56	123,856	35,088	35,778	38,510	56,373
57	141,674	41,032	42,232	37,106	57,719
61	65,564	19,395	20,145	25,148	37,276
62	92,474	25,352	26,552	32,303	46,267
63	117,647	32,153	33,023	38,434	53,742
64	79,283	22,049	22,499	27,815	41,839
65	46,587	12,448	12,988	16,298	22,039
66	145,867	40,501	41,101	43,416	63,665
67	107,036	30,516	31,356	26,883	40,856
71	57,013	16,019	16,709	20,649	30,214
72	79,623	21,364	22,174	26,443	39,104
73	58,858	16,148	16,838	20,025	29,507
74	59,097	16,786	17,086	19,987	29,848
75	11,948	3,741	3,801	4,239	6,131
76	121,220	33,976	35,176	38,126	58,267
77	55,686	14,715	15,015	16,920	24,667
TOTAL	5,169,663[d]	1,667,246	1,730,666	1,341,646	2,009,366

[a]For a more detailed presentation of population data, see *Home Interview Data on Population and Related Trip Making Characteristics* (31,210), (Chicago: CATS, 1959).

[b]Does not include institutional population.

[c]Does not include 5,514 out of area visitors.

[d]Does not include 46,463 out of area visitors.

[e]A "dwelling place" is any form of sleeping quarters for individuals or families. Thus a hotel room or a bed in a large dormitory may be defined as a "dwelling place." A dwelling unit, on the other hand, corresponds to the U.S. Census Bureau definition and indicates separate quarters with working facilities and private entrance. A dwelling place, in this survey, is the basic sample and interview unit.

TABLE 20

FLOOR AREA BY DISTRICT AND BY TYPE
(In Millions of Square Feet)

District	Residential	Manu-facturing	Trans-portation**	Commercial Retail	Commercial Service	Commercial Wholesale	Public Buildings	Total
01	6.8	4.5	4.0	13.7	43.8	10.6	8.9	92.3
11	77.5	58.1	33.7	17.7	22.5	32.1	28.0	269.6
21	51.8	4.6	1.2	4.2	3.5	1.9	5.9	73.1
22	31.8	14.9	2.9	4.2	2.4	2.1	3.4	61.7
23	40.0	11.8	2.2	4.9	2.4	1.8	4.9	68.0
24	24.6	5.4	3.2	6.2	2.2	1.1	3.9	46.6
25	13.8	16.6	8.0	2.5	2.0	1.8	1.5	46.2
26	11.4	19.8	5.3	4.5	1.5	1.7	2.9	47.1
27	28.2	4.7	3.0	2.2	1.9	1.4	6.2	47.6
31	55.7	3.5	1.1	3.3	4.1	.8	5.8	74.3
32	52.4	11.7	1.3	3.9	2.7	1.0	3.8	76.8
33	46.3	18.9	3.0	4.9	2.9	1.2	3.2	80.4
34	28.5	11.6	5.3	3.1	1.8	1.0	2.0	53.3
35	18.8	14.5	7.6	2.5	1.2	1.0	3.3	48.9
36	26.5	12.4	1.0	3.0	1.7	.8	2.9	48.3
37	70.3	1.8	1.1	3.7	5.3	.8	9.7	92.7
41*........	70.9	2.6	1.3	5.0	6.2	1.2	5.2	92.4
42*........	61.6	4.7	1.0	5.2	3.5	1.3	5.4	82.7
43	75.9	7.4	1.2	5.7	3.6	1.0	7.2	102.0
44*........	36.7	12.9	.9	3.1	1.5	.5	3.0	58.6
45*........	23.5	8.5	2.8	1.2	.6	.4	1.2	38.2
46	64.3	6.6	1.7	6.3	3.5	1.0	4.6	88.0
47	93.9	7.0	2.9	5.9	6.3	1.8	9.8	127.6
51*........	31.0	3.4	1.9	2.1	1.7	.4	5.4	45.9
52*........	33.4	1.7	.5	1.7	.9	.6	1.9	40.7
53*........	25.3	5.8	.6	1.7	.9	.3	2.8	37.4
54*........	9.8	.3	.2	.6	.3	.1	1.3	12.6
55*........	8.9	.2	.2	.5	.5	.2	.2	10.7
56*........	35.8	1.3	.4	2.2	1.0	.6	2.5	43.8
57	39.3	13.8	1.6	4.0	1.3	.9	3.8	64.7
61*........	18.1	.1	.3	.7	.7	.1	2.0	22.0
62*........	2.7	.5	.1	.5	.6	.1	.3	4.8
63*........	4.2	.4	...	.5	.4	.1	.7	6.3
64*........	11.1	.1	...	.5	.3	...	1.3	13.3
65*........	.8	...	...	.1	.1	...	.1	1.1
66*........	30.4	3.0	.4	1.8	1.1	.6	3.0	40.3
67*........	19.7	11.1	.8	2.4	1.4	.5	1.9	37.8
71*........	...	...	...	...	...	...	...	...
72*........	1.8	.2	...	.3	.2	...	.2	2.7
73*........	1.8	.1	.1	.3	.2	...	.4	2.9
74*........	1.9	.1	.1	.4	.3	.1	.8	3.7
75*........	...	...	...	...	...	...	...	...
76*........	10.8	2.2	.6	1.3	.8	.3	.9	16.9
77*........	3.0	.7	...	.2	.1	.1	.3	4.4
TOTAL	1,301.0	309.5	103.5	138.7	139.9	73.3	162.5	2,228.4

*Districts with incomplete floor area coverage.

** Includes communications and public utilities.

District[b]	Total Area in Sq. Miles	Land In Use					
		Residential	Manufacturing	Trans.[c] Commun. and Utilities	Commercial	Public Buildings	Total[d] Developed Land
01	1.2	11.4	9.6	117.0	147.4	26.5	311.9
11	12.4	1,071.5	549.7	1,400.8	913.5	347.4	4,282.9
21	3.7	866.6	63.8	59.8	240.7	106.1	1,337.0
22	4.0	750.8	297.3	152.9	270.9	85.0	1,556.9
23	4.9	960.1	228.1	242.7	277.0	90.4	1,798.3
24	3.0	569.3	98.6	178.1	181.5	77.2	1,104.7
25	4.0	396.2	425.6	555.8	286.0	36.9	1,700.5
26	3.0	359.2	422.2	379.3	160.7	47.1	1,368.5
27	3.5	545.7	82.8	170.4	176.4	213.6	1,188.9
31	5.0	1,135.7	62.4	59.3	247.4	214.2	1,719.0
32	7.0	1,825.0	282.4	137.5	301.1	136.1	2,682.1
33	7.0	1,574.7	392.7	443.8	306.9	83.2	2,801.3
34	5.0	894.9	324.9	417.8	278.2	47.9	1,963.7
35	6.9	884.9	527.3	857.6	239.1	137.5	2,646.4
36	4.9	1,001.0	322.0	351.6	235.6	65.6	1,975.8
37	5.4	1,052.8	27.0	174.0	295.9	255.8	1,805.5
41	9.6	2,282.8	198.6	186.4	464.6	266.9	3,399.3
42	13.0	3,174.5	144.6	185.3	442.6	590.2	4,537.2
43	14.2	4,505.0	234.8	219.4	452.5	292.3	5,704.0
44	11.2	2,805.7	440.4	443.4	275.2	138.2	4,102.9
45	13.2	1,895.3	600.3	1,955.0	204.1	85.1	4,739.8
46	11.9	3,031.6	252.9	545.7	425.9	155.5	4,411.6
47	11.9	2,771.8	282.3	432.0	466.2	231.4	4,183.7
51	12.4	2,511.9	231.1	391.8	218.5	275.5	3,628.8
52	23.0	4,312.5	535.7	193.1	347.2	350.0	5,738.5
53	23.0	3,748.6	756.8	336.9	449.0	294.9	5,586.2
54	18.3	2,632.2	1,091.1	445.8	173.5	435.9	4,778.5
55	18.2	2,045.9	992.5	976.6	181.5	150.0	4,346.5
56	17.8	4,092.3	72.3	242.4	290.0	324.8	5,021.8
57	16.5	2,615.1	812.4	1,622.0	378.0	143.4	5,570.9
61	24.2	4,630.2	99.1	379.5	216.9	432.5	5,758.2
62	48.0	4,560.4	292.2	1,795.5	473.4	448.7	7,570.2
63	51.4	5,902.7	470.1	6,751.5	485.6	329.2	13,939.1
64	40.7	4,810.2	106.7	144.8	317.6	575.9	5,955.2
65	51.7	2,757.1	291.6	1,126.6	232.1	272.1	4,679.5
66	44.1	4,559.4	622.9	1,535.4	390.8	362.6	7,471.1
67	33.6	2,293.5	1,637.9	1,962.9	287.1	148.8	6,330.2
71	42.6	3,581.1	129.2	475.3	191.8	1,025.0	5,402.4
72	146.0	5,917.2	205.7	578.8	350.1	347.2	7,399.0
73	103.2	5,314.6	219.4	602.6	287.4	211.1	6,635.1
74	79.8	5,042.6	190.3	258.0	273.5	863.7	6,628.1
75	79.8	1,359.9	34.7	815.1	55.8	3,267.8	5,533.3
76	140.3	6,117.2	288.9	1,546.4	451.8	707.3	9,111.6
77	56.0	2,403.7	440.0	577.7	160.5	107.9	3,689.8
Total CATS Area	1,236.5	115,574.8	15,790.9	32,424.3	13,501.5	14,804.4	192,095.9
68	23.1	1,730.7	5,825.8	1,630.9	435.5	176.3	9,799.2
78	110.8	11,793.8	3,677.9	3,230.8	938.3	689.5	20,330.3
Indiana Area Surveyed[e]	133.9	13,524.5	9,503.7	4,861.7	1,373.8	865.8	30,129.5
Total Land Surveyed[a]	1,370.4	129,099.3	25,294.6	37,286.0	14,875.3	15,670.2	222,225.4

[a]The procedures of the land use survey are given in detail in the *Land Use Survey Manual* (15,210), (Chicago: CATS, 1956). Details concerning the classification of land use will be found in *Land Use Categories* (15,100), (Chicago: CATS, 1957).

[b]See Map 21 page 102 for district identication.

[c]Includes a small amount of land in extractive industries, gravel quarries, etc.

[d]This is a subtotal of land in Residential, Manufacturing, Transportation, Commercial and Public Building. The sum of these land uses has been used as a base for the compilation of the developed land area map which appears on page 12.

CHICAGO STUDY AREA BY DISTRICT—IN ACRES

Public Open Space	Parking[e]	Streets and Alleys	Total Land in Use	Vacant Land: Residential[f]	Vacant Land: Manufacturing	Vacant Land: Commercial	Vacant Land: Waterways and Unusable	Total Land
86.0	65.6	210.1	673.6	....	......	4.0	55.8	733.4
424.6	195.9	2,530.9	7,434.3	143.4	158.9	49.9	150.2	7,936.7
331.6	7.0	667.1	2,342.7	29.2	1.5	9.8	...	2,383.2
6.4	7.5	837.5	2,408.3	32.6	42.5	12.6	40.5	2,536.5
216.6	7.0	1,026.4	3,048.3	55.2	21.8	15.5	...	3,140.8
150.8	15.4	575.6	1,846.5	37.8	3.8	6.6	...	1,894.7
12.6	38.8	603.5	2,355.4	48.5	41.4	21.5	121.5	2,588.3
17.7	22.3	375.5	1,784.0	56.3	51.9	6.3	16.1	1,914.6
136.8	29.8	700.8	2,056.3	154.9	9.7	8.3	...	2,229.2
521.7	16.6	864.0	3,121.3	32.9	1.0	18.7	7.3	3,181.2
224.1	23.7	1,362.2	4,292.1	62.1	42.1	29.8	31.3	4,457.4
147.2	38.1	1,321.1	4,307.7	100.0	45.7	40.4	...	4,493.8
88.9	51.2	881.7	2,985.5	85.7	87.9	33.8	...	3,192.9
135.9	26.4	966.4	3,775.1	97.1	459.9	25.4	73.3	4,430.8
113.3	8.5	881.2	2,978.8	133.3	38.6	19.9	...	3,170.6
506.1	16.2	1,020.7	3,348.5	84.0	8.8	14.8	...	3,456.1
607.9	15.7	1,618.8	5,641.7	310.9	102.6	79.2	20.5	6,154.9
1,029.1	23.8	2,282.9	7,873.0	292.1	14.8	106.2	28.0	8,314.1
339.5	22.8	2,628.6	8,694.9	230.5	50.3	88.9	...	9,064.6
412.3	11.2	1,871.5	6,397.9	570.7	63.0	102.1	2.3	7,136.0
253.6	47.0	1,669.9	6,710.3	932.8	611.4	126.1	80.7	8,461.3
399.6	37.9	2,035.1	6,884.2	434.8	200.3	97.5	4.8	7,621.6
827.8	49.1	2,255.4	7,316.0	225.1	29.1	73.8	...	7,644.0
588.9	12.4	1,835.5	6,065.6	1,361.0	249.0	219.3	59.3	7,954.2
2,131.6	7.0	3,284.2	11,161.3	3,060.4	396.7	143.9	10.1	14,772.6
3,613.4	18.6	2,708.0	11,926.2	2,239.5	402.6	112.1	53.3	14,733.7
1,995.4	1.9	1,925.2	8,701.0	1,699.4	569.2	70.8	643.6	11,684.0
203.3	93.3	1,655.4	6,298.5	2,684.6	2,194.9	95.2	339.2	11,612.4
987.6	17.6	2,607.9	8,634.9	2,403.6	155.9	207.9	...	11,402.3
295.1	11.8	2,516.2	8,394.0	828.9	1,082.9	122.9	121.7	10,550.4
2,717.5	9.0	2,144.2	10,628.9	4,622.4	138.8	55.7	40.2	15,486.0
4,600.8	.7	3,330.6	15,502.3	14,469.8	225.1	439.8	64.0	30,701.0
1,522.6	2.5	4,025.1	19,489.3	10,748.9	2,177.0	235.8	225.1	32,876.1
3,675.3	3.7	3,508.1	13,142.3	11,440.2	1,041.6	272.7	185.0	26,081.8
7,300.0	.3	2,983.1	14,962.9	15,692.3	1,063.9	109.2	1,293.4	33,121.7
3,093.5	22.1	4,099.8	14,686.5	11,126.8	1,760.5	159.5	474.4	28,207.7
1,142.4	55.9	2,125.8	9,654.3	3,852.4	5,053.0	133.9	2,817.9	21,511.5
2,936.8	...	2,506.3	10,845.5	15,882.4	197.7	140.2	220.8	27,286.6
6,644.7	3.6	5,100.8	19,148.1	72,686.9	300.9	351.7	950.0	93,437.6
2,939.7	.9	3,796.1	13,371.8	48,651.4	3,301.3	55.9	685.0	66,065.4
2,389.8	5.5	3,794.0	12,817.4	37,385.5	415.5	141.3	339.4	59,099.1
7,246.5	...	1,761.3	14,541.1	34,507.3	511.3	24.3	1,464.6	51,048.6
5,978.7	8.4	6,152.3	21,251.0	67,605.2	538.3	124.2	253.7	89,772.4
4,549.9	...	2,504.6	10,744.3	22,939.1	1,165.7	50.5	901.8	35,801.4
73,543.6	1,052.7	93,551.4	360,243.6	390,037.9	25,029.0	4,257.9	11,774.8	791,343.2
669.5	...	1,388.4	11,857.1	352.5	1,416.0	94.1	1,101.1	14,820.8
1,906.7	...	7,360.6	29,597.6	35,024.8	3,319.0	1,633.7	1,367.3	70,942.4
2,576.2	...	8,749.0	35,377.3	35,377.3	4,735.0	1,727.8	2,468.4	85,763.2
76,119.8	1,052.7	102,300.4	401,698.3	425,415.2	29,764.0	5,985.7	14,243.2	877,106.4

[e]Parking lots with areas of 10,000 square feet or more, were measured for that part of the survey area for which floor area measures were obtained (all of the City of Chicago, Oak Park, Cicero, Berwyn and portions of other suburbs. Total land area covered equaled about 295 square miles). Beyond this area, parking was included with the use served.
[f]Includes agriculturally used land.
[g]See Map 23 for definition of Indiana land use survey area.

TABLE 22

ALL PERSON TRIP DESTINATIONS BY MODE BY DISTRICT

District	Auto Driver	Auto, Truck-Taxi Passenger	Suburban Railroad	Elevated and Subway	Bus	Total Person Destinations
01	78,556	57,168	84,134	126,678	119,645	466,181
11	256,266	132,175	33,243	65,363	211,564	698,611
21	84,516	49,972	886	13,361	68,554	217,289
22	70,590	37,276	862	6,865	42,386	157,979
23	88,020	41,737	1,660	8,806	58,190	198,413
24	51,948	28,720	979	4,648	38,275	124,570
25	45,173	17,334	601	3,867	25,535	92,510
26	38,849	16,418	212	2,905	25,743	84,127
27	52,544	33,676	869	10,916	49,016	147,021
31	105,883	59,580	1,399	24,267	54,946	246,075
32	127,984	75,445	1,581	13,949	59,495	278,454
33	132,011	70,155	1,449	11,558	61,472	276,645
34	75,679	40,103	1,692	9,212	38,220	164,906
35	63,023	32,884	67	2,186	32,221	130,381
36	62,195	37,787	341	4,474	34,197	138,994
37	96,060	55,854	8,637	22,061	81,070	263,682
41	162,793	87,522	1,662	29,254	46,232	327,463
42	155,936	84,640	2,174	14,569	64,170	321,489
43	219,061	142,272	1,670	22,550	54,796	440,349
44	130,514	80,636	2,140	10,271	21,843	245,404
45	77,397	45,540	167	1,895	27,490	152,489
46	178,813	102,649	3,363	12,498	80,274	377,597
47	207,428	112,367	19,105	25,416	98,323	462,639
51	137,508	74,328	3,420	11,325	27,566	254,147
52	156,287	82,550	5,390	4,068	29,283	277,578
53	132,017	93,105	2,293	3,550	20,449	251,414
54	92,263	52,261	2,690	1,473	4,789	153,476
55	82,048	48,107	404	601	17,154	148,314
56	143,771	89,259	6,947	1,710	23,822	265,509
57	148,594	79,790	7,246	2,830	38,058	276,518
61	111,898	72,552	5,775	2,599	7,281	200,105
62	126,021	71,901	4,199	343	14,149	216,613
63	139,313	77,766	6,799	1,067	10,061	235,006
64	124,319	64,506	7,248	523	5,245	201,841
65	55,799	39,052	465	...	4,665	99,981
66	181,153	100,719	6,622	965	27,463	316,922
67	127,610	81,954	5,237	395	24,606	239,802
71	91,755	50,929	5,017	94	4,342	152,137
72	101,541	55,112	6,639	326	9,748	173,366
73	79,481	45,499	4,452	217	1,630	131,279
74	79,199	44,095	4,883	62	2,425	130,664
75	16,212	12,305	67	...	1,232	29,816
76	189,661	113,156	10,213	63	12,950	326,043
77	67,693	44,789	685	...	5,432	118,599
TOTAL	4,945,382	2,835,645	265,584	479,780	1,686,007	10,212,398

TABLE 23

ALL PERSON TRIP DESTINATIONS BY LAND USE BY DISTRICT

District	Residential	Manufacturing	Transportation Communications and Public Utilities	Commercial	Public Buildings	Public Open Space	Total Person Destinations
01	24,524	35,447	31,957	313,425	52,358	8,470	466,181
11	240,179	133,502	51,736	172,296	88,673	12,225	698,611
21	130,577	15,377	2,399	44,965	17,804	6,167	217,289
22	87,552	28,243	2,200	29,980	7,807	2,197	157,979
23	122,120	22,139	3,907	33,068	14,351	2,828	198,413
24	66,747	12,226	3,047	29,150	12,425	975	124,570
25	41,859	22,794	8,716	14,867	3,080	1,194	92,510
26	34,353	22,182	4,018	19,059	3,773	742	84,127
27	82,836	6,543	3,345	23,505	21,808	8,984	147,021
31	156,397	8,804	2,304	49,510	16,555	12,505	246,075
32	169,230	31,306	2,403	48,458	13,299	13,758	278,454
33	149,316	43,640	5,585	61,525	13,249	3,330	276,645
34	89,319	37,512	5,299	20,900	3,933	7,943	164,906
35	62,988	27,547	6,094	23,278	8,296	2,178	130,381
36	87,182	15,994	1,994	24,598	6,889	2,337	138,994
37	174,061	3,613	2,740	44,531	32,451	6,286	263,682
41	214,166	12,297	2,636	73,349	17,548	7,467	327,463
42	182,776	16,845	3,547	88,862	22,554	6,905	321,489
43	243,255	17,432	3,466	134,990	29,327	11,879	440,349
44	143,746	27,654	2,559	54,813	12,873	3,759	245,404
45	89,145	11,684	21,779	23,905	3,920	2,056	152,489
46	221,899	13,563	6,298	106,574	20,858	8,405	377,597
47	302,674	10,263	10,536	97,648	29,553	11,965	462,639
51	145,845	9,649	4,110	59,809	27,021	7,713	254,147
52	163,705	17,708	3,619	61,763	20,349	10,434	277,578
53	137,777	24,550	3,605	52,517	17,991	14,974	251,414
54	86,985	13,828	1,783	29,681	12,203	8,996	153,476
55	81,071	26,190	3,723	25,952	7,311	4,067	148,314
56	158,752	2,678	2,165	79,089	16,437	6,388	265,509
57	169,175	25,556	5,212	55,381	13,416	7,778	276,518
61	116,513	1,349	4,490	49,116	20,382	8,255	200,105
62	135,244	5,218	7,092	40,673	17,736	10,650	216,613
63	147,178	10,176	6,758	47,120	17,945	5,829	235,006
64	120,288	1,408	5,245	47,658	18,284	8,958	201,841
65	62,550	4,180	956	16,587	6,666	9,042	99,981
66	196,282	13,781	6,379	62,645	25,265	12,570	316,922
67	141,321	19,002	5,284	54,823	13,471	5,901	239,802
71	85,163	1,778	4,832	34,350	17,739	8,275	152,137
72	105,950	2,773	6,550	33,003	14,119	10,971	173,366
73	84,285	2,239	3,819	25,017	10,573	5,346	131,279
74	79,084	1,620	4,648	27,185	12,697	5,430	130,664
75	17,020	917	228	4,487	5,154	2,010	29,816
76	181,946	9,794	9,406	86,723	26,949	11,225	326,043
77	73,492	8,339	1,801	22,633	6,868	5,466	118,599
TOTAL	5,606,527	779,340	280,270	2,449,468	781,960	314,833	10,212,398

TABLE 24

INTERNAL PERSON TRIP DESTINATIONS BY TWO DIGIT LAND USE CLASSIFICATION

Land Use Code	Description	Person Trip Ends	Total
0	**RESIDENTIAL**		5,437,858
1	**AGRICULTURE, FORESTRY AND FISHERIES**		14,061
2	**MANUFACTURING, DURABLE**		
20	Lumber and Wood Products	7,091	
21	Furniture and Fixtures	16,952	
22	Stone, Clay and Glass Products	11,226	
23	Primary Metal Industries	65,339	
24	Fabricated Metal Products	85,836	
25	Machinery, Equipment and Supplies	197,556	
27	Transportation Equipment	46,052	
28	Professional and Photographic Equipment and Watches	15,018	
29	Miscellaneous Manufacturing Industries	36,789	
	TOTAL		481,859
3	**MANUFACTURING, NON-DURABLE**		
30	Food and Kindred Products	89,325	
31	Tobacco Manufacturers	571	
32	Textile Mill Products	8,082	
33	Apparel and Other Fabricated Textile Products	22,079	
34	Paper and Allied Products	21,034	
35	Printing, Publishing and Allied Industries	72,044	
36	Chemicals and Allied Products	32,952	
37	Petroleum and Coal Products	7,536	
38	Rubber Products	5,295	
39	Leather and Leather Products	10,151	
3R	Manufacturing, Unknown	221	
	TOTAL		269,290
4	**TRANSPORTATION, COMMUNICATION AND OTHER INDUSTRIAL NON-MANUFACTURING**		
40	Railroads (other than Local and Interurban)	54,688	
41	Local and Interurban Mass Transportation	68,127	
42	Trucking	33,336	
43	Warehousing	22,681	
44	Air Transportation	25,462	
45	Water Transportation	3,285	
46	Highway Transportation	2,862	
47	Utilities and Communication	57,259	
48	Mining	582	
49	Other Non-Manufacturing Industrial	125	
	TOTAL		268,407
5	**COMMERCIAL—RETAIL**		
50	Food and Drugs	388,958	
51	Eating and Drinking Places	309,397	
52	General Merchandise	267,212	
53	Apparel and Accessories	62,207	
54	Furniture House Furnishing and Household Appliances	35,313	
55	Motor Vehicles and Accessories	49,203	
56	Gasoline Service Stations	55,573	
57	Lumber, Building Material, Hardware and Farm Equipment Dealers	41,852	
58	Liquor Stores	18,772	
59	Miscellaneous Retail Stores	70,586	
5R	Retail Store, Unknown	10,214	
	TOTAL		1,309,287
6	**COMMERCIAL—SERVICE**		
60	Finance—Insurance—Real Estate	195,607	
61	Personal Services	152,351	
62	Miscellaneous Business Services	37,197	
63	Automobile Repair Services and Garages	55,905	
64	Miscellaneous Repair Services	16,209	
65	Indoor Amusement and Recreation Services	180,512	
66	Medical and Health Services	172,452	
67	Legal Services	15,311	
68	Office Building N.E.C.	77,978	
69	Miscellaneous Services	14,956	
6R	Services, Unknown		
	TOTAL		918,478
7	**COMMERCIAL—WHOLESALE TRADE AND CONTRACTING**		
70	Wholesale Distributors with Storage Facilities	15,874	
71	Wholesale Food Dealers and Jobbers	19,502	
72	Salvage Firms and Offices	2,680	
73	Other Wholesalers	38,028	
74	Building Construction and Special Trade Contractors	33,521	
75	General Contractors Other Than Building Construction	6,709	
76	Vacant and Temporary Commercial Building		
77	Construction Projects	42,384	
79	Other Commercial N.E.C.	346	
	TOTAL		158,044
8	**PUBLIC AND QUASI-PUBLIC BUILDINGS**		
80	Postal Service	43,971	
81	Military Service	9,361	
82	Other Federal Administration	14,680	
83	State, County, City or Local Administration	68,400	
84	Educational Services—Schools	348,484	
85	Museums and Art Galleries	6,359	
86	Churches	98,315	
87	Hospitals, Sanatoria and Mental Institutions	122,509	
88	Non-Profit Membership Organizations	56,692	
89	N.E.C.	640	
	TOTAL		769,411
9	**PUBLIC AND QUASI-PUBLIC OPEN SPACE**		
90	Public Parks and Forest Preserves	68,015	
91	Golf Courses	23,415	
92	Swimming Pools	20,548	
93	Botanical and Zoological Gardens	8,060	
94	Race Tracks and Stadia	21,510	
95	Outdoor Amusement N.E.C.	71,735	
96	Joy or Pleasure Rides	15,846	
97	Non-Usable Land—Flood Control, Etc.	152	
98	Other Open Space N.E.C.	21,602	
99	Bus Stop, Elevated and Subway Stations, Taxi Stand or Automobile Pickup Point	52,734	
RR	Land Use Unknown	1,326	
	TOTAL		304,943
	TOTAL PERSON TRIP DESTINATIONS		9,931,638

TABLE 25

ALL VEHICLE TRIP DESTINATIONS BY LAND USE BY DISTRICT

District	Residential	Manufacturing	Transportation Communications and Public Utilities	Commercial	Public Buildings	Public Open Space	Total
01	14,541	8,740	10,495	94,589	11,501	4,331	144,197
11	98,836	75,088	55,852	140,407	36,008	8,687	414,878
21	52,987	9,313	1,235	31,402	7,198	3,026	105,161
22	40,852	18,727	2,302	28,493	2,991	1,294	94,659
23	52,587	16,378	3,655	28,493	5,654	3,567	110,334
24	27,636	8,154	3,551	18,975	5,038	1,275	64,629
25	18,737	14,683	14,164	14,449	1,663	1,620	65,316
26	15,676	14,689	5,704	14,545	1,920	1,244	53,778
27	27,297	4,736	4,089	18,476	7,780	3,514	65,892
31	69,309	6,806	1,511	37,393	7,459	6,334	128,812
32	82,164	19,138	2,275	39,202	4,869	5,633	153,281
33	72,395	29,294	4,182	44,628	6,027	2,051	158,577
34	40,697	22,423	5,877	19,494	2,320	4,069	94,880
35	29,961	19,333	6,724	21,344	3,847	2,684	83,893
36	39,577	9,914	2,277	19,064	2,984	2,017	75,833
37	65,257	3,245	2,168	29,739	13,760	2,980	117,149
41	114,486	9,538	2,023	55,893	7,816	6,253	196,009
42	95,599	13,330	3,544	62,940	8,691	4,878	188,982
43	124,567	13,243	2,519	86,663	13,184	7,752	247,928
44	80,665	19,612	2,950	40,050	6,689	2,555	152,521
45	44,470	9,056	18,276	19,247	1,981	3,187	96,217
46	109,521	9,941	4,641	69,623	7,569	6,517	207,812
47	138,545	7,966	6,681	70,953	11,058	6,156	241,359
51	83,191	8,028	3,727	45,778	14,436	5,310	160,470
52	98,439	13,601	2,933	50,848	9,184	8,166	183,171
53	77,712	20,837	4,209	37,983	7,765	8,092	156,598
54	53,546	11,572	2,853	24,381	7,527	3,872	103,751
55	44,901	19,832	4,035	18,898	2,355	1,797	91,818
56	88,059	2,348	1,960	53,847	7,651	3,977	157,842
57	91,580	17,027	4,639	43,566	6,286	5,068	168,166
61	67,521	1,270	3,936	34,541	10,874	5,124	123,266
62	82,899	4,340	5,364	33,218	8,145	6,017	139,983
63	93,609	9,152	6,840	36,058	9,929	4,950	160,538
64	77,387	1,431	4,990	37,939	10,997	5,886	138,630
65	37,999	3,280	1,549	13,049	3,120	4,403	63,400
66	114,580	11,051	5,990	49,318	10,432	6,102	197,473
67	75,349	14,007	4,578	38,653	5,788	4,130	142,505
71	53,870	1,383	4,025	27,219	9,885	5,145	101,527
72	68,338	2,359	5,505	29,760	5,711	6,210	117,883
73	52,226	1,500	3,114	20,760	5,721	2,795	86,116
74	50,989	1,252	4,272	22,045	6,922	3,243	88,723
75	10,066	804	490	3,813	2,268	868	18,309
76	108,079	7,570	7,907	63,376	13,078	7,119	207,129
77	41,951	6,222	2,228	19,154	2,741	2,759	75,055
TOTAL	2,928,653	522,213	251,839	1,710,266	338,822	192,657	5,944,450

TABLE 26

VEHICLE COUNTS AT PERMANENT STATIONS — SUMMARIZED BY WEEKS, SHOWING TOTALS FOR 5 DAY WEEK WITH DEVIATIONS OF WEEK ABOUT THE MEAN WEEK

Week Beginning	5 Permanent Stations[a]		3 Permanent Stations[b]	
	5-Weekday Total	Deviation From Mean	5-Weekday Total	Deviation From Mean
4-29-56	530,471	105.1	440,397	106.8
5- 6-56	514,787	102.0	431,898	104.8
5-13-56	516,033	102.3	427,890	103.8
5-20-56	539,394	106.9	449,708	109.1
5-27-56	484,407	96.0	390,690	94.8
6- 3-56	536,532	106.3	444,670	107.9
6-10-56	556,611	110.3	456,559	110.7
6-17-56	556,896	110.4	455,052	110.4
6-24-56	569,152	112.8	459,176	111.4
7- 1-56	545,856	108.2	432,761	105.0
7- 8-56	568,976	112.8	457,779	110.0
7-15-56	566,187	112.2	451,779	109.6
7-22-56	570,917	113.2	455,329	110.4
7-29-56	547,830	108.6	438,623	106.4
8- 5-56	546,257	108.3	434,607	105.4
8-12-56	565,596	112.1	461,732	112.0
8-19-56	549,816	109.0	447,445	108.5
8-26-56	551,481	109.3	446,008	108.2
9- 2-56	512,163	101.5	406,876	98.7
9- 9-56	526,457	104.3	429,571	104.2
9-16-56	502,817	99.7	412,970	100.2
9-23-56	514,226	101.9	417,711	101.3
9-30-56	523,951	103.8	424,633	103.0
10- 7-56	504,645	100.0	403,693	97.9
10-14-56	516,586	102.4	418,197	101.4
10-21-56	512,554	101.6	411,852	99.9
10-28-56	513,937	101.9	419,237	101.7
11- 4-56	491,423	97.4	399,077	96.8
11-11-56	496,719	98.4	394,922	95.8
11-18-56	471,298	93.4	375,358	91.0
11-25-56	450,538	89.3	378,734	91.9
12- 2-56	472,667	93.7	396,702	96.2
12- 9-56	483,134	95.8	418,697	101.6
12-16-56	480,086	95.1	399,624	96.9
12-23-56	449,023	89.0	366,535	88.9
12-30-56	457,763	90.7	376,116	91.2
1- 7-57	494,643	98.0	411,300	99.8
1-13-57	483,323	95.8	405,963	98.5
1-20-57	439,487	87.1	370,846	90.0
1-27-57	477,989	94.7	397,618	96.4
2- 3-57	484,301	96.0	402,351	97.6
2-10-57	477,729	94.7	394,292	95.6
2-17-57	451,505	89.5	370,173	89.8
2-24-57	466,656	92.5	380,790	92.4
3- 3-57	473,298	93.8	385,935	93.6
3-10-57	485,509	96.2	401,643	97.4
3-17-57	475,609	94.3	393,733	95.5
3-24-57	450,079	89.2	366,864	89.0
3-31-57	435,800	86.4	351,376	85.2
4- 7-57	476,387	94.4	387,920	94.1
4-14-57	492,545	97.6	400,649	97.2
4-21-57	474,674	94.1	383,265	95.4
Total	26,236,720		21,437,326	
Mean ...	504,552	100.0	412,256	100.0

[a]5 Permanent Stations

1. U. S. 14 (Northwest Highway) near Staples Rd.
2. U. S. 66 (Joliet Road) at County Line
3. Ashland Ave. near Cermak Rd.
4. U. S. 45 (LaGrange Road) near 67th St.
5. Ill. 42A (Harlem Ave.) near 47th St.

[b]3 Permanent Stations

1. Ashland Ave. near Cermak Rd.
2. U. S. 45 (LaGrange Road) near 67th St.
3. Ill. 42A (Harlem Ave.) near 47th St.

TABLE 27

COMPARISON OF SAMPLE SURVEY AUTO DRIVER TRIPS CROSSING THE SCREEN LINE WITH SCREEN LINE COUNTS

Type of Trip	Sample Survey Counts	Screen Line Counts	Per Cent Check[a]
Vehicle Garaged in Area:			
Both Trip Ends Inside Area..........	356,523[b]	416,524	85.6
One Trip End Inside Area, One End Outside..............	17,572[c]	14,968	117.4
Both Trip Ends Outside Area.......	149[c]	491	30.3
Vehicle Garaged Out of Area:			
Both Trip Ends Inside Area..........	....[d]	3,263	....
One Trip End Inside Area, One End Outside..............	17,572[c]	15,057	114.0
Both Trip Ends Outside Area	6,483[c]	4,031	160.8
TOTAL	397,896	454,334	87.6

[a]Survey Counts divided by Screen Line Counts.
[b]Source: Home Interview Survey.
[c]Source: Cordon Line Survey.
[d]No data available.

TABLE 28

COMPARSION OF SAMPLE SURVEY COMMERCIAL VEHICLE TRIPS CROSSING SCREEN LINE WITH SCREEN LINE COUNTS

Type of Trip	Sample Survey Counts	Screen Line Counts	Per Cent Check[a]
Vehicle Garaged in Area:			
Both Trip Ends Inside Area..........	76,055[b]	75,059	101.3
One Trip End Inside Area, One End Outside..............	4,604[c]	5,388	85.4
Both Trip Ends Outside Area.......	85[c]	195	43.6
Vehicle Garaged Out of Area:			
Both Trip Ends Inside Area..........	....[d]	1,561	....
One Trip End Inside Area, One End Outside..............	6,692[c]	6,579	101.7
Both Trip Ends Outside Area	2,196[c]	2,229	98.5
TOTAL	89,632	91,011	98.5

[a]Survey Counts divided by Screen Line Counts.
[b]Source: Commercial Vehicle Survey.
[c]Source: Cordon Line Survey.
[d]No data available.

TABLE 29

NUMBER OF PERSONS PER CAR BY LAND USE AND BY TRIP PURPOSE FOR INTERNAL TRIPS

Land Use	Persons Per Car*
Residential	1.6
Manufacturing	1.3
Transportation	1.3
Commercial	1.5
Public Buildings	1.7
Public Open Space	1.9
Average for all Land Use Types..................	1.56
Trip Purpose	
Home	1.6
Work	1.2
Shop	1.5
School	3.5
Social-Recreation	2.1
Eat Meal	1.8
Personal Business	1.6
Average for all Trip Purposes...	1.56

*Car loads computed by summing auto drivers and auto passengers according to trip purpose or land use and dividing totals by number of auto drivers in each category.

TABLE 30

DIFFERENCES BETWEEN INBOUND AND OUTBOUND TRAVEL TO DISTRICTS

District	District Origins	District Destinations	Percentage Differences
01	457,328	450,860	+1.43
11	683,129	683,991	— .12
21	214,191	214,761	— .26
22	156,475	155,712	+ .49
23	194,678	195,763	— .56
24	122,455	122,887	— .35
25	91,881	91,324	+ .61
26	83,091	83,005	+ .11
27	142,977	143,470	— .34
31	242,912	243,197	— .12
32	273,445	273,833	— .14
33	272,350	273,068	— .26
34	163,021	162,476	+ .34
35	129,256	128,772	+ .38
36	138,158	137,368	+ .58
37	259,434	259,537	— .04
41	321,979	323,173	— .37
42	317,095	317,147	— .02
43	432,875	433,902	— .24
44	242,086	241,756	+ .14
45	151,208	148,392	+1.90
46	371,025	372,209	— .32
47	456,944	454,803	+ .47
51	248,620	250,628	— .81
52	271,710	273,108	— .51
53	247,038	247,490	— .18
54	150,172	149,128	+ .70
55	146,034	146,676	— .44
56	262,141	261,645	+ .19
57	266,357	265,230	+ .43
61	196,094	197,436	— .68
62	211,904	211,315	+ .28
63	229,754	229,699	+ .02
64	196,900	197,923	— .52
65	97,707	97,629	+ .08
66	309,550	310,124	— .18
67	214,121	213,057	+ .50
71	141,346	140,633	+ .51
72	163,875	163,639	+ .15
73	124,399	124,851	— .36
74	120,316	120,295	+ .02
75	25,580	25,435	+ .57
76	310,302	309,233	+ .35
77	84,454	85,058	—0.71
TOTAL ...	9,936,367*	9,931,638	

*High by 4,729 trips (0.048%) as a result of using second card source.

TABLE 31

CHICAGO TRANSIT AUTHORITY TOTAL REVENUE PASSENGERS SUMMARIZED BY WEEK, SHOWING TOTALS FOR 5 DAY WEEK WITH DEVIATION OF WEEKS ABOUT THE MEAN WEEK

Week Beginning	5 Weekday Total	Deviation From Mean	Week Beginning	5 Weekday Total	Deviation From Mean
4-29-56	10,194,880	104.8	10-28-56	10,301,825	105.9
5- 6-56	10,005,470	102.8	11- 4-56	10,130,740	104.1
5-13-56	10,173,985	104.6	11-11-56	10,041,690	103.2
5-20-56	10,092,950	103.7	11-18-56	8,627,055[d]	88.7
5-27-56	8,849,382[a]	91.0	11-25-56	10,305,980	105.9
6- 3-56	10,121,150	104.0	12- 2-56	10,510,950	108.0
6-10-56	10,011,310	102.9	12- 9-56	10,527,180	108.2
6-17-56	9,964,875	102.4	12-16-56	9,564,790	98.3
6-24-56	9,825,755	101.0	12-23-56	7,541,902[e]	77.5
7- 1-56	8,104,045[b]	83.3	12-30-56	7,830,492[f]	80.5
7- 8-56	9,181,595	94.4	1- 6-57	10,096,565	103.8
7-15-56	9,037,325	92.9	1-13-57	10,096,835	103.8
7-22-56	9,157,285	94.1	1-20-57	9,941,800	102.2
7-29-56	9,140,730	93.9	1-27-57	9,903,690	101.8
8- 5-56	9,314,160	95.7	2- 3-57	10,125,710	104.1
8-12-56	9,320,335	95.8	2-10-57	10,027,695	103.1
8-19-56	9,212,310	94.7	2-17-57	9,982,705	102.6
8-26-56	9,248,035	95.1	2-24-57	9,967,370	102.4
9- 2-56	8,620,205[c]	88.6	3- 3-57	10,083,210	103.6
9- 9-56	10,164,535	104.5	3-10-57	9,856,730	101.3
9-16-56	10,199,290	104.8	3-17-57	9,871,490	101.5
9-23-56	10,215,505	105.0	3-24-57	9,764,810	100.4
9-30-56	10,329,415	106.2	3-31-57	9,781,535	100.5
10- 7-56	10,259,110	105.4	4- 7-57	10,053,720	103.3
10-14-56	10,347,375	106.3	4-14-57	9,998,025	102.8
10-21-56	10,290,265	105.8	4-21-57	9,621,460	98.9
			Total	505,937,231	
			Mean	9,729,562 = 100	

[a] Included Memorial Day
[b] Included July 4th
[c] Included Labor Day
[d] Included Thanksgiving
[e] Included Christmas
[f] Included New Year's

TABLE 32

MEAN AIRLINE TRIP LENGTH OF INTERNAL PERSON TRIPS BY LAND USE

LAND USE	MEAN TRIP LENGTH (Miles)
Residential	4.3
Manufacturing—Durable	5.0
Manufacturing—Non-Durable	5.3
Transportation, Communications and Public Utilities	5.3
Commercial—Retail	3.1
Commercial—Service*	4.8
Commercial—Wholesale	5.9
Public Buildings	3.6
Public Open Space	4.5
ALL LAND USES	4.3

*Includes Office Buildings.

TABLE 33

UNWEIGHTED VEHICLE TRIPS AND VEHICLE MILES OF TRAVEL

Vehicle Type	Unweighted Vehicle Trips			Unweighted Vehicle Miles of Travel (Desire Line)			
	Home Interview and Truck-Taxi Surveys	External Cordon Line Survey	Total	Home Interview and Truck-Taxi Surveys	External Cordon Line Survey	Total	Percentage
Automobile and Taxis....	4,982,364	269,107	5,251,471	19,281,000	3,219,000	22,500,000	87.7
Light Trucks	297,221	13,496	310,717	818,000	110,000	928,000	3.6
Medium Trucks	448,369	15,887	464,256	1,248,000	192,000	1,440,000	5.6
Heavy Trucks	56,361	22,661	79,022	259,000	537,000	796,000	3.1
All Trucks ...	801,951	52,044	853,995	2,325,000	839,000	3,164,000	12.3
Total Vehicles	5,784,315	321,151	6,105,466	21,606,000	4,058,000	25,664,000	100.0

TABLE 34

INTERNAL PERSON TRIPS BY PURPOSE AND MODE

(in thousands)

Purpose	Mode					
	Auto Driver	Auto Passenger	Suburban Railroad	Subway-Elevated	Bus	Total
Ride	...	105	...	...	...	105
Home	1,991	1,198	116	230	784	4,319
Work	1,130	239	102	166	396	2,033
Shop	295	149	7	19	77	547
School	21	54	2	10	106	193
Social-Recreation	527	567	10	19	142	1,265
Eat Meal	107	89	...	3	12	211
Personal Business	512	297	12	32	169	1,022
Serve Passenger	228	8	...	..	...	236
Total	4,811	2,706	249	479	1,686	9,931

TABLE 35

INTERNAL TRIPS—BY LAND USE LINKAGE WITHIN MODE
(In Thousands)

Land Use Linkage of Trips Between	Person Trips: Trips	Person Trips: Percentage	Vehicle Trips: Automobile*	Percentage	Taxis and Light Trucks	Medium Trucks	Heavy Trucks	Total Taxis and Trucks	Percentage	Total Vehicle Trips	Percentage
Residential and Residential..	1,654	16.7	724	15.0	107	65	3	175	18.0	899	15.6
Residential and Nonresidential	7,559	76.1	3,670	76.3	141	54	7	202	20.8	3,872	66.9
Nonresidential and Nonresidential	718	7.2	417	8.7	221	329	46	596	61.2	1,013	17.5
TOTAL	9,931	100.0	4,811	100.0	469	448	56	973	100.0	5,784	100.0

*Based on a sub-sample from the Internal Survey.

TABLE 36

INTERNAL PERSON TRIPS BY LAND USE AND PURPOSE
(In Thousands)

Land Use	Purpose: Home	Work	Shop	School	Social Recreation	Eat Meal	Personal Business	Serve Passenger	Ride	Total
Residential	4,319	157	...	1	696	41	165	43	15	5,437
Manufacturing	...	700	...	...	2	...	29	18	2	751
Transportation[a]	...	173	...	...	9	...	34	46	6	268
Commercial Retail[b] ..	...	327	543	...	93	166	115	28	52	1,324
Commercial Service .	...	326	...	1	168	2	392	21	9	909
Commercial Wholesale	...	134	4	...	1	...	16	1	2	158
Public Buildings	...	189	...	191	86	1	242	53	7	769
Public Open Space ..	...	27	...	...	210	1	29	26	12	305
TOTAL	4,319	2,033	547	193	1,265	211	1,022	236	105	9,931

[a]Includes communications and public utilities.
[b]Includes trips to agriculture, forestry and fisheries.

TABLE 37

EQUATIONS AND RELATED DATA USED TO PLOT GRAPHS SHOWN IN CHAPTER V

Figure Number	Data Unit	Item	Regression Line	r
32	Analysis Zone		Hand Fitted Curve	
33	District	Person Trips Total Vehicle Trips	$y_1 = 6.64 - 2.43 \log x_1$ $y_2 = 4.32 - 1.90 \log x_1$	–.95 –.96
34	District	Person Trips Total Vehicle Trips	$y_1 = .08 + 4.05 x_2$ $y_2 = -.83 + 3.19 x_2$	.96 .97
37	District	Person Trips Automobile Trips	$y_3 = 11.80 - 4.246 \log x_1$ $y_4 = 7.34 - 3.29 \log x_1$	–.97 –.96
38	District	Person Trips Automobile Trips	$y_3 = .35 + 7.076 x_2$ $y_4 = -1.60 + 5.545 x_2$	.98 .97
39	Home Interview Sub Sample		Hand Fitted Curve	
40	Analysis Zone		$y_5 = 15.5 + 21.745 \log x_3 - 16.72 \log x_4$	.87

Dependent Variables:
y_1 Person destinations per dwelling place.
y_2 Vehicle destinations per dwelling place.
y_3 Person trips per family (occupants of defined dwelling places).
y_4 Automobile trips per family (occupants of defined dwelling places).
y_5 Per Cent of all person trips using mass transportation.

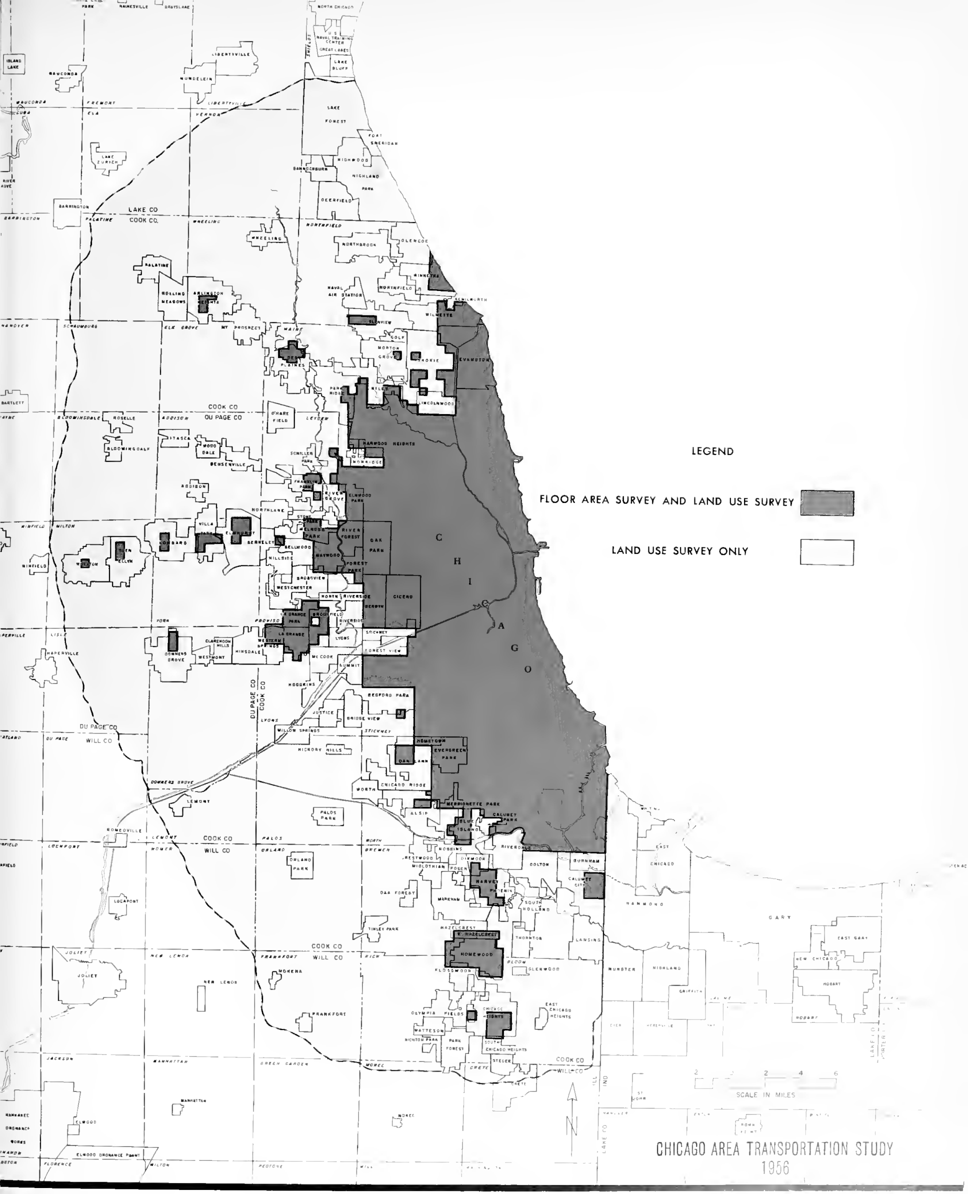
Independent Variables:
x_1 Dwelling places per residential acre.
x_2 Automobiles owned per dwelling place.
x_3 Population per 100,000 square feet of residential land.
x_4 Automobile per 1,000 population.

TABLE 38

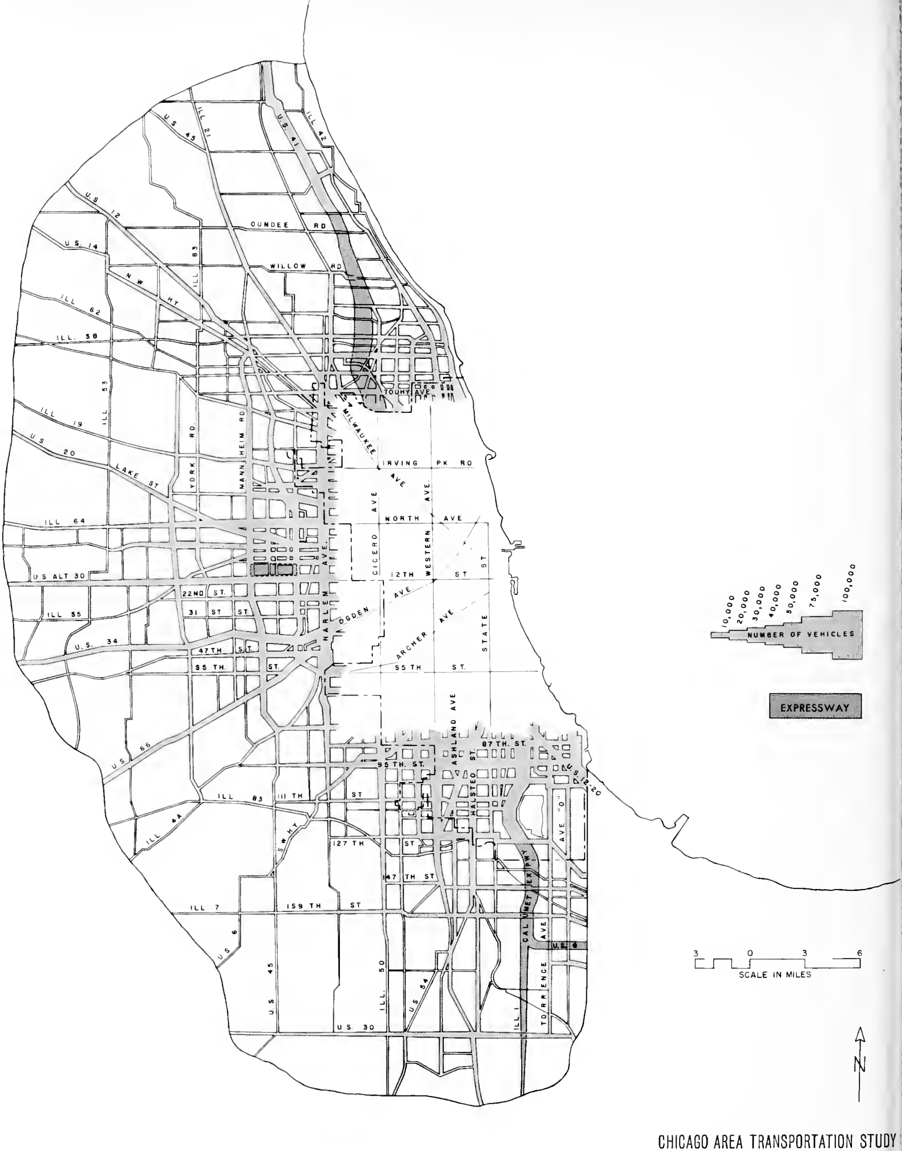
STUDY AREA POPULATION AND TRAVEL DATA SUMMARIES FOR 1956

Item	Number	Percentage
DWELLING PLACES		
Dwelling Units	1,609,977	93.5
Non-Dwelling Unit Quarters	111,269	6.5
TOTAL	1,721,246	100.0
Occupied Dwelling Places	1,667,246	96.9
Vacant Dwelling Places	54,000	3.1
TOTAL	1,721,246	100.0
POPULATION		
Age 16 and Over	3,701,761	71.6
Under 16 years	1,467,902	28.4
TOTAL	5,169,663	100.0
LICENSED AUTO DRIVERS	2,009,366	38.9
MOTOR VEHICLES		
Automobiles	1,341,646	84.0
Trucks	130,000	8.2
Taxis	5,600	0.3
Automobiles owned by Private Industry and Governmental Agencies (Est.)	120,000	7.5
TOTAL	1,597,246	100.0
PERSON TRIPS WITH DESTINATIONS IN STUDY AREA — BY PURPOSE		
Home	4,447,572	43.5
Work	2,098,728	20.6
Shop	557,813	5.5
School	194,266	1.9
Social-Recreation	1,306,611	12.8
Eat Meal	212,958	2.1
Personal Business	1,041,189	10.2
Serve Passenger	247,957	2.4
Ride	105,304	1.0
TOTAL	10,212,398	100.0

Item	Number	Percentage
PERSON TRIPS WITH DESTINATIONS IN STUDY AREA — BY MODE		
Auto Driver	4,945,382	48.4
Auto Passenger	2,835,645	27.8
Suburban Railroad Passenger	265,584	2.6
Subway-Elevated Passenger	479,780	4.7
Bus Passenger	1,686,007	16.5
TOTAL	10,212,398	100.0
PERSON TRIPS WITH DESTINATIONS IN STUDY AREA — BY LAND USE AT DESTINATION		
Residential	5,606,527	54.9
Manufacturing	779,340	7.6
Transportation Communications and Public Utilities	280,270	2.7
Commercial	2,449,468	24.0
Public Buildings	781,960	7.7
Public Open Space	314,833	3.1
TOTAL	10,212,398	100.0
VEHICLE TRIPS WITH DESTINATIONS IN STUDY AREA— BY TYPE		
Automobiles	4,945,382	83.2
Taxis	171,478	2.9
Trucks (Unweighted)		
Light Trucks 303,995 36.7%		
Medium Trucks 456,355 55.2		
Heavy Trucks 67,240 8.1		
TOTAL TRUCKS 827,590 100.0%	827,590	13.9
TOTAL	5,944,450	100.0
VEHICLE TRIPS WITH DESTINATIONS IN STUDY AREA — BY LAND USE AT DESTINATION (Trucks Unweighted)		
Residential	2,928,653	49.3
Manufacturing	522,213	8.8
Transportation Communications and Public Utilities	251,839	4.2
Commercial	1,710,266	28.8
Public Buildings	338,822	5.7
Public Open Space	192,657	3.2
TOTAL	5,944,450	100.0



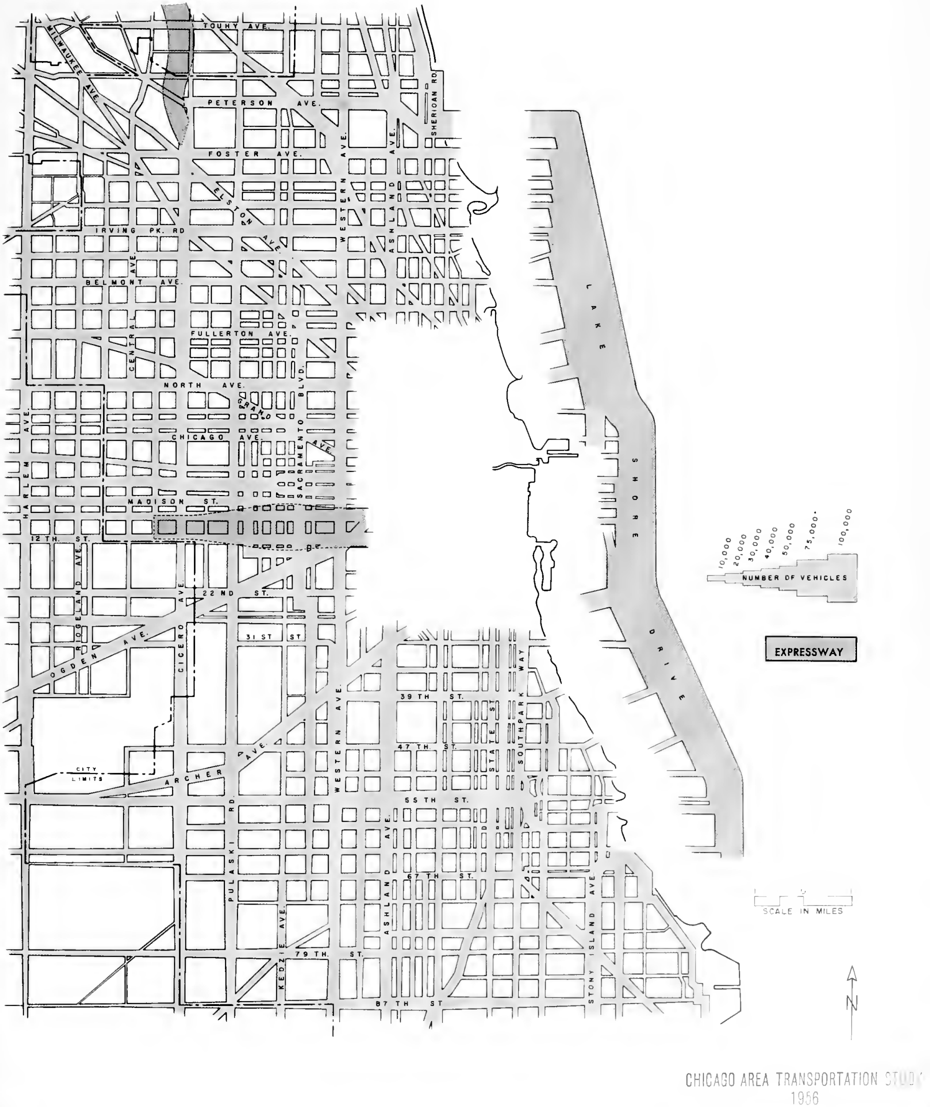
MAP 23
LIMITS OF LAND AND FLOOR AREA SURVEYS
Land use was surveyed in the entire 1,236 square mile Study Area and also in 134 square miles of Lake County, Indiana. Floor area was measured in 295 square miles within the Study Area.



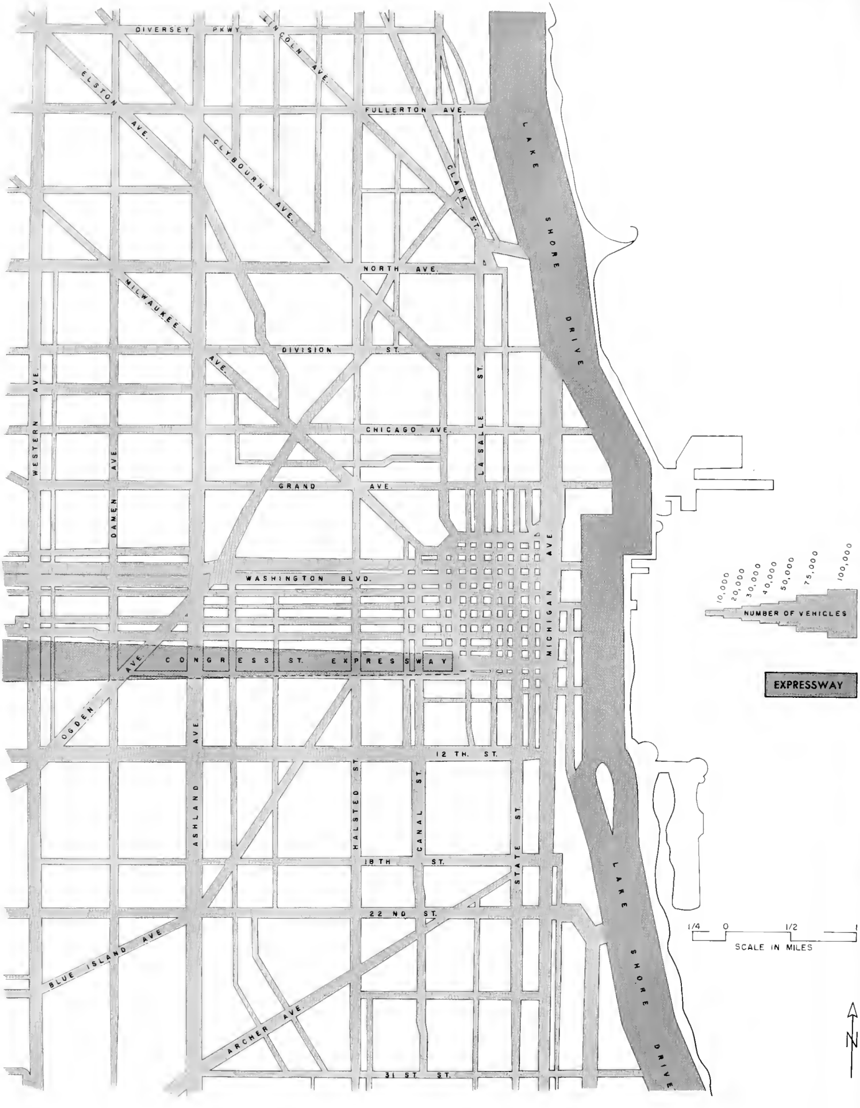
MAP 24

VEHICLE FLOW MAP—A

Maps 24, 25 and 26 were compiled in 1957 from existing traffic flow maps dated 1954 through 1956 and from traffic counts made in 1956 and 1957.

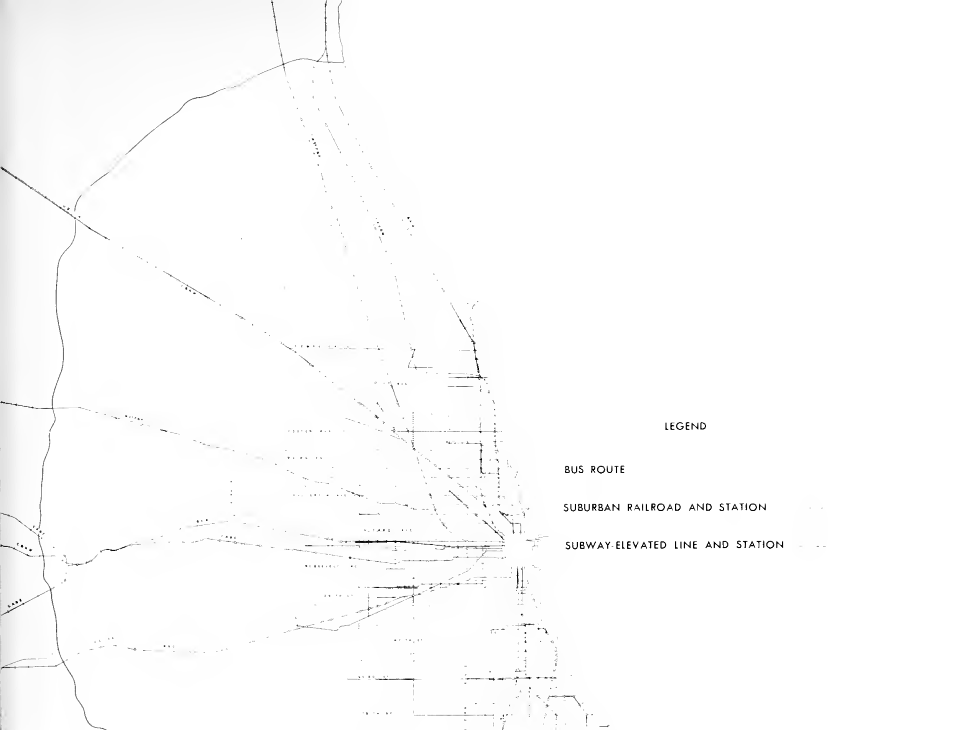


MAP 25
VEHICLE FLOW MAP—B

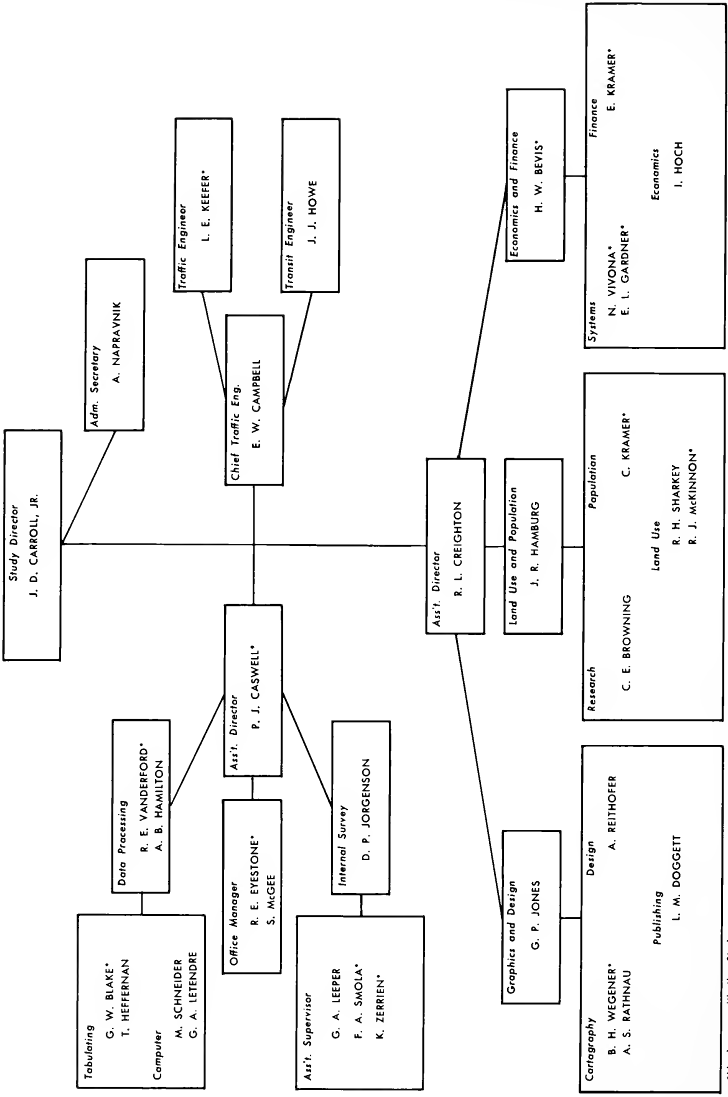


CHICAGO AREA TRANSPORTATION STU
1956

MAP 26
VEHICLE FLOW MAP—C



MAP 27
MASS TRANSPORTATION FACILITIES
This map shows the major portion of the mass transportation system inventoried in 1956. The system includes 1,560 miles of bus routes, 70 miles of subway-elevated rights of way, and 283 miles of suburban railroad lines.



*No longer with the Study.