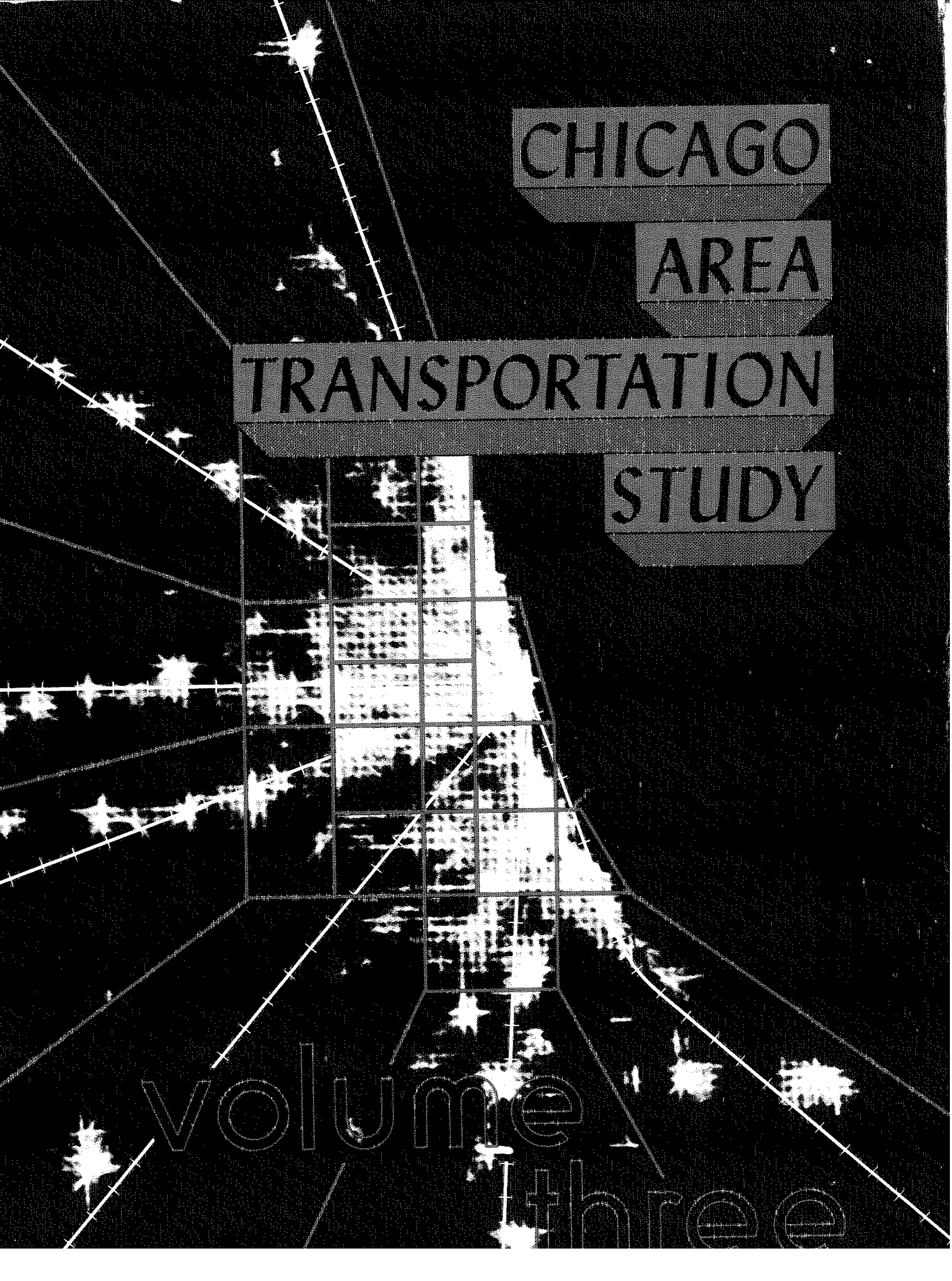
CHICAGO AREA TRANSPORTATION STUDY

volume three



COVER DESIGN

Defined by the desire line pattern of "short trips," the urban communities of the Study Area provide the background for an idealized design of transportation facilities. This abstract network design illustrates the main theme of the recommended regional transportation facilities plan—rail travel to serve the center and expressway grids to serve non-central needs.

Wies

Chicago Area Transportation Study

FINAL REPORT
In Three Parts

Volume III
Transportation Plan

APRIL 1962

STUDY CONDUCTED UNDER THE SPONSORSHIP OF

STATE OF ILLINOIS

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GOVERNOR

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DEPARTMENT OF PUBLIC WORKS AND BUILDINGS

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CITY OF CHICAGO

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IN COOPERATION WITH

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CHICAGO AREA TRANSPORTATION STUDY

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July 2, 1962

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Director, Department of Public Works and Buildings
State of Illinois

The Honorable John J. Duffy
President, Board of County Commissioners
Cook County

The Honorable Richard J. Daley
Mayor, City of Chicago

The Honorable Rex M. Whitton
Federal Highway Administrator
United States Department of Commerce

Gentlemen:

We have the honor to transmit the third and final volume of the report of the Chicago Area Transportation Study. It presents recommendations for meeting the future transportation needs of metropolitan Chicago.

The proposals contained herein have been developed from the base of a most thorough study. They are long range recommendations -- looking forward to the time period after 1980 when there will be nearly eight million people living within thirty miles of Chicago's Loop.

We respectfully recommend that these proposals be taken under study by each governmental authority. Such review will indicate how these regional proposals can best be adjusted to the long range community development policies of each jurisdiction. Transportation plans must be thoroughly meshed and coordinated with community development and renewal plans.

We sincerely trust that this volume, after thorough review by the governmental agencies of the region, will prove a significant help in fixing on common growth objectives and so carry forward the inter-governmental cooperation for which this area is noted.

Respectfully submitted,

Policy Committee

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Chapter I

INTRODUCTION

The story of metropolitan Chicago is a story of growth and change. Over the last hundred years the prairie shore of Lake Michigan has been changing from rural to urban with ever increasing speed. Grasslands have changed to crop lands and crop lands to land supporting an urban population and its institutions. The village has become the city; the city has given way to the metropolis; and the metropolis is growing out towards connection with other metropolitan areas to form an urbanized region around the southern and western shores of Lake Michigan.

The conversion from prairie to metropolis has created a new landscape and geography. Beneath the land surface there are endless networks of pipes, wires and cables providing the needed system of nourishment to support the new urban uses. And on the surface there is the expanding cover of concrete and steel, of roads and buildings. These are, all of them, the deposits of a growing population. Near the old center, the earlier dwellings and roads are now being torn out and rebuilt and, at the outer edges, urban development is rapidly replacing agricultural uses. Replacement of older urban forms and the peripheral extension of new urban growth are testimony of the continuing investments and changes which must be expected in a healthy, growing metropolis.

The urban physical environment is the setting in which more than five and one-half million people presently live and work. The nature and condition of this environment affects the life of all inhabitants. Just as the house is of critical importance to the family, so the urban environment is critical to the metropolitan community.

As population increases, approaching eight million persons in 1980, the physical environment must be enlarged and changed. And this environment will be of even greater significance, because it is the arena and environment within which so many more persons live, work and raise families.

One aspect of the metropolitan physical environment is the subject matter of this report. The task here is to spell out a plan for a future regional transportation network. The purpose of the work is to propose the nature, arrangement and location of future transportation facilities. This task distinguishes Volume III, in many ways, from the preceding two.

Volume I concentrated on the present system of transportation and how it is being used. It reported on factual and measurable phenomena and, therefore, required a scientific concern for measurement, objectivity and accuracy.

Volume II projected these measurable dimensions of travel forward to 1980. While this was a more speculative report, because it attempted to describe the unknown future, it, too, required the essential tools of the scientist. It reflected the scientific disciplines of measurement and objectivity.

This last volume is not scientific in the same way. Its special concern is not what is, or what will be, but rather with what *ought* to be. The questions of *should* or *ought* are questions concerned with values. These are resolved by judgment and choice—rational processes, but not coldly scientific. With the future spreading out in front, and with many public decisions to be made, the problem of planning is the problem of making better choices.

Making plans for the future is common. Families, businesses, governments—all are constantly looking ahead and making plans. Wherever there are limited resources and particular goals or desires, plans are made. This involves choosing among alternatives in the light of objectives. It is not possible to please everyone or simultaneously to achieve diverging objectives. The plan, then, can give direction to actions and can help to insure that the accumulation of a series of projects will fit together and provide the desired end result.

To plan for a metropolitan community assumes some knowledge of those things which are valuable to the entire metropolis. Before devising or testing plans, the report will consider what is valuable and, further, how this can be measured. It then is possible to prepare plans which appear to maximize the effects valued by the populace. Planning, after all, is for people.

Special Aspects of Plan Making

While there are common elements to the process, and need for making plans, there are special problems that make the development of transportation plans for the Chicago urban region unique.

The *size* of the area immediately places this task in a separate class. This is not alone because it is the country's second largest metropolitan area. It also contains more registered vehicles than any one of thirty-seven states, more people than any one of forty-two states, and more person miles of transit-riding than any other place in the country except New York City. These people and their activities are concentrated in a relatively small area, so that it is much more likely that travelers will compete for and crowd the available transportation facilities. Concentration within a limited area is a key reason why traffic problems are always most severe in the large metropolitan areas.

The current size of the region produces some awesome numbers, but it is going to grow much larger in the next twenty years. Table 1 gives growth measures of enlarged future travel demands as reported in Volume II. As the table shows, travel demands are expected to grow faster than population. Not only will the great metropolitan beehive become larger, but its citizens will increase in daily activity so that the tempo of action and movement will increase faster than the growth in population. This daily travel is necessary for effective metropolitan communities, because they depend upon intensive specialization of function, and this can be supported only by increased amounts of interchange.

Along with increases in population, in businesses, and in service establishments, there are increases in the number of units of government. Additional governments, like additional people and businesses, serve to multiply the number of particular interest groups or viewpoints within the metropolitan community. This proliferation of groups and viewpoints makes agreement on a single direction or action more difficult. Clearly, special interests must be adjusted in order to find solutions in the best interests of the larger community.

While there is a compounding of problems with increasing size, and an ever greater need for coordinated action, fortunately, there are also greater opportunities to obtain public benefits. The urban regional population of 7.8

TABLE 1
SUMMARY OF PROJECTIONS FOR THE STUDY AREA—1956 TO 1980

Item	1956	1980	Ratio (1980/1956)	Net Increase (1980-1956)
Population	5,169,663	7,802,000	1.51	2,632,337
Motor Vehicle Registrations	1,597,200	3,046,000	1.91	1,448,800
Person Trip Destinations in Study Area				
By Automobile	7,781,027	15,625,000	2.01	7,843,973
By Mass Transportation	2,431,371	2,456,000	1.02	24,629
Total	10,212,398	18,081,000	1.77	7,868,602
Vehicle Trip Destinations in Study Area				
Automobile and Taxi	5,116,860	10,193,964	1.99	5,077,104
Truck (weighted)	1,418,424	2,467,030	1.75	1,048,606
Total	6,535,284	12,660,994	1.94	6,125,710
Miles of Person Travel on Mass Transportation (over-the-road)	14,919,000	18,078,000	1.21	3,169,000
Vehicle Miles of Travel (over-the-road on arterials and expressways)	34,240,000	67,054,000	1.96	32,814,000

million persons projected for 1980 is expected, in that year, to spend about 3.1 billion dollars for local travel.[1] Added to this will be the cost of moving goods and other commercial traffic estimated at 2.2 billion dollars.[2] This represents a substantial allocation of community effort and presents a very real opportunity for economies and public benefits through carefully worked out public plans and policies.

The nation's metropolitan areas are, and will continually be, in competition with one another as places in which to work, to live and to engage in business. In large measure, the productive strength of a metropolitan area is affected by the design and operation of its internal transport system. Once again there is great need to secure a more efficient transport system, and there will be great rewards for those areas which do so most effectively.

Transportation facilities constitute one of the most important elements of public capital. Investments in highways, streets and transit system facilities within the Study Area have exceeded $100 million each year from 1956 through 1960. Nationally, in 1959, 6.8 billion dollars of capital investment went into highways, for an annual rate of ninety-five dollars per registered vehicle, or thirty-eight dollars per capita. Any reasonable manner of measurement indicates that the money to be spent on fixed, new transportation facilities and/or on the modernization of old facilities will be a substantial share of total capital investment and a major item of public investment. A conservative estimate of capital expenditures by governmental agencies for transportation facilities in the next twenty years would be over two billion dollars. It is of great importance that this money be spent wisely, and towards a satisfactory community objective—i.e., according to a plan.

The opportunity and the challenge are great. The task of this volume is to develop, test and display a plan that will cope with the problem ahead, yet will also be representative of the public interest.

[1]This is based on an estimated ten per cent of consumer income of Study Area residents being spent for transportation within the area.

[2]Based on estimates of industrial shares of net national product. The transportation industries contribute about seven per cent of total output.

THE PLANNING METHOD

This report, the third in a series, covers the final stages of the planning process. This process, illustrated in Figure 1, consists simply of fact gathering, forecasting and plan making. The two basic steps which precede plan making have been reported. This volume will cover the detailed steps employed in the construction, testing and evaluation of alternate plans.

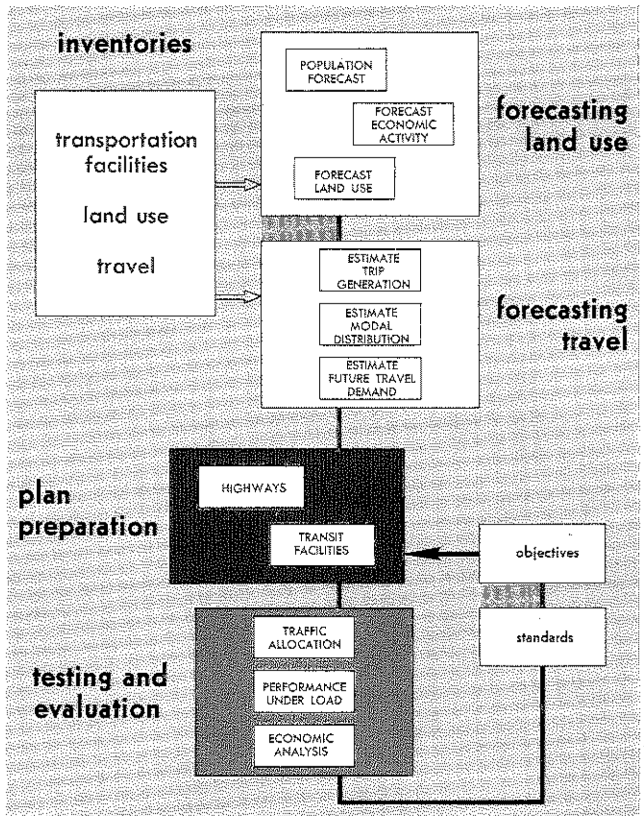

FIGURE 1—THE PLANNING PROCESS

This volume concentrates on the preparation, testing and evaluating of a transportation plan.

A first step, having been given the physical dimensions of the problem, is to be quite clear as to the objectives. What, in fact, are the criteria of goodness? To what end are we building? This problem is tackled directly in Chapter II, which is concerned with the establishment of objectives and the problems of dealing with those which turn out to be conflicting rather than mutually supporting.

After objectives have been set down, the next step is to determine exactly what elements can be assembled to make plans. This is covered in Chapter III. A particularly important part of this work is the development of standard types or modules which can be assembled into a complete system. In addition, it is necessary to prepare the rules which govern the assembly operation. This chapter describes the materials with which the planner can work in building toward the desired objectives.

In Chapters IV and V, plans for roadway and for rapid transit facilities are prepared and tested. The actual preparation of each plan is a complex synthesis of planning modules, estimates of future demand, and acknowledgment of the restraints imposed by existing expressways and rapid transit facilities. Plans for highways and transit facilities are tested by assigning estimated 1980 travelers to them and by appraising the extent to which objectives appear to be maximized. In this process the costs of travel and of construction are reviewed and system efficiency is measured.

When sufficiently revised and tested to be certain the plan is well adapted to 1980 needs, problems of financing and scheduling remain to be considered. Chapter VI considers the total costs, the size of the public pocketbook, and the best sequence or priority for adding the new improvements.

CONSIDERATIONS IN PLAN PREPARATION

In the search for a best solution to the long range development of the region's transport system, there is a virtually limitless array of different directions in which to explore. But it is the task of the planner to narrow and to focus his search. Certain requirements or self imposed choices provide outside boundaries or limits within which the solution must fall.

Four such limiting conditions are pointed out in the following sections. These do much to shape the initial direction of the search for a best solution.

Design of a Complete System

Highway and transit facilities are part of a large system. One roadway connects with another and each mode relates to and functions with others. Planning for a series of individual new routes or proposing a series of spot improvements will run the great danger of missing the forest because of concern with the trees. This would be planning for parts rather than for the whole.

In a system, changes in one part affect the action and function of other parts of the system. It is well known that new and improved travel routes not only change the paths of travel used, but that they may also change origin-destination patterns. In the longer range, changes can influence the character and intensity of land use.

Any plan must, therefore, be sufficiently extensive to provide a complete system of routes and be tested and appraised as a system—not as individual, incremental improvements.

Existing Conditions Limit Plans

Plans developed for the Chicago region are much more severely constrained than plans for a completely new city. Already in place is a substantial urban landscape containing networks of highways and transit facilities.

These existing facilities cannot, without very great losses to the community, summarily be torn up and replaced any more than the housing supply or any other accumulated capital can be disposed of and rebuilt. Some portions of transportation systems can be replaced and some new facilities can be added. Over time, changes can be wrought by both replacement and addition, so that the present networks can gradually be converted to those wanted in the future.

Thus, changes can be brought about through planning, but not all at once. The direction and degree of change depend upon the time period of plans, upon the seriousness of present deficiencies, and upon the extent of total productive capability. It is quite certain that any final plan must be carefully responsive to the great array of development already in place.

Limit of Time

As suggested earlier, the length of the planning period is very important. A planning target placed too far into the future suffers from the increasingly indistinct image of what to plan for. Yet, on the other hand, too short a time span suffers from lack of vision and incurs the risk of having no freedom to try to change the present situation. In this volume, a time period of about one generation was taken. This is a compromise between the long and the short possibilities. It is long enough to allow the sketching of large new regional systems, yet not so far reaching as to require forecasts of presently unknown technological changes.

Plans are subject to continual review, and to modification based on new evidence and unforeseen events. This in no way lessens the value of stating a target for the work of a generation. Such a statement clarifies objectives and provides the means for coordinating the work of many public jurisdictions towards common goals.

The forecast target year used in Volume II was about 1980, or that time when the population within the Study Area reaches 7.8 million. The planning target will reach somewhat beyond this point by considering the design of transportation facilities within the Study Area when all lands are devoted to urban uses.

Problems of Scale

A final consideration in plan preparation is one of working at the proper scale. A region of 7.8 million persons some twenty years hence does not allow the planner to be concerned with the timing of traffic signals or the headways on bus routes. These are important problems, but they are at too fine a level of detail. Likewise, final locations and geometric designs of specific facilities are not a proper task of this report. Instead, a metropolitan planning scale is maintained, spelling out the dimensions of the main elements of regional networks of express highways and rail transit lines.

Final locations of new routes require detailed study of buildings, soil conditions, location of utilities, and intimate correlation with neighborhood land use plans. All routes laid out on maps in this volume are on general rather than exact locations. Final locations will be worked out only when it is feasible either to acquire property or to begin construction. In short, the object of this study is to lay out and describe a full system or network as the base from which to work towards more detailed and exact locations.

ASSUMPTIONS

As in any planning work, certain assumptions are made in preparing plans. The broad assumptions—no war, no major depressions or other national catastrophes—are made by all who propose such plans.

In addition, however, there are assumptions that affect the nature of the proposals. These are listed before proceeding with more detailed development of a solution. These assumptions are:

1. Forecasts are reasonably accurate.
2. What people do reflects what they prefer to do and reflects the choices they value. Thus, to serve society well, the trend of choices is a critical guide as to future preference.
3. No major technological revolution will take place in transportation in the next twenty years which will radically change the planning requirements for the movement of people.
4. People, in making journeys, will behave in a predictable fashion. The number and length of journeys and their relationship to land use can be reliably estimated on the basis of trip characteristics observed today.

In conclusion, the task at hand is to prepare a system plan for roads and rails. As time goes on, more detailed studies of individual segments of the network can be prepared as these are scheduled for construction. But the design of the over-all system will still be the major concern of this report.

This approach recognizes that there are several levels of detail and generality for planning. The system plan is a general plan; it is also long range, but kept within the limits of a time span in which technological change is not a large factor. To go beyond this time would be to increase the haziness of any answer and, therefore, inhibit current action. In any case, it is recognized that plan making—which is decision making—is a continuous process.

In assembling this volume to trace out the steps and considerations in plan preparation, there has been one major test for writing and selection of material. This has been to share completely with the reader the evidence and the process of working and reasoning that have led to a specific proposal. The completeness of the record will, it is believed, be of great assistance in building certainty into the development and execution of public policy.

Chapter II
OBJECTIVES

Plans are designed to direct actions toward particular targets or goals. At the moment a public official makes a decision, there usually are several courses of action which might be taken. If one decision becomes part of a sequence of decisions extended over a longer time period, there is an increasing range of alternatives possible. Lacking a clear goal, each decision could reflect mainly the pressures of the moment. With the goal clearly specified, a course of action can be selected which will approach the desired result more directly. The definition of objectives is an essential task to be undertaken before preparing plans.

But simply stating goals is not sufficient. This is particularly true in the public realm. The goal or objective must be stated clearly, it must be a logically sound goal, and it must be measurable. This is the task of this chapter.

To undertake this larger task, an examination is made of those things the public will want from a transportation system. Land use development values also are examined. These disclose many different things that society values, but which are seldom stated in the hard, measurable terms needed to assess objectively the plan which is most likely to achieve them. So a series of six critical objectives is proposed. Four are measurable, but sometimes mutually opposing. How they can be blended into a single criterion for judging plans then is explored. The chapter is concluded by an examination of the kind of city which would result from the construction of a plan which is best in terms of this single criterion.

The General Goals of Planning

The over-all objective of planning transportation was stated in Volume I: *to secure a transportation system*[1] *for the Chicago area which will reduce travel frictions within the constraints of safety, economy and the desirable development of land use.*

It does not matter, basically, whether people in urban areas move by bus, automobile, suburban railroad or elevated-subway train, as long as the main purpose is achieved. The different modes are all part of a total transportation system. This system should be planned in a coordinated fashion so that each mode will complement the other modes—again, with the purpose of achieving the goal just stated.

Goals, however, cannot be restricted to those concerned just with transportation. The reason is that goals represent the imposition of community values. It would be narrow-minded to claim values for transportation and to disclaim values for such things as community design or the general welfare. Transport is a means to an end—not an end in itself.

The planning agencies of the region are responsible for the preparation of long term, comprehensive land development plans. The over-all community development objectives contained in such plans can be of great importance for evaluating transportation plans. If land development plans call for a significant change in the pattern of community growth, the location of travel requirements might be altered. This could produce a revision in transportation plans, since transportation facilities are designed to serve land uses.

The City of Chicago Department of Planning and the Northeastern Illinois Metropolitan Area Planning Commission presently are aiming at comprehensive land development plans by 1963. Work also is progressing on plans for adjacent counties and for many municipalities in the region. As city and regional development objectives become refined and clearly specified, the land use forecast will have to be reviewed. This is the normal requirement for reviewing of plans, and is a process that, in a vital community, should be going on as a regular activity.

Transportation system goals must also be consistent with the more general objectives of community welfare. The main transport aim

[1]The transportation systems of concern here consist of those facilities used for the movement of people within the Chicago area, and for the movement of trucks. Excluded are the special transport facilities for air travel, intercity movements of people by rail and bus, and those for freight movements by rail or water.

—increasing speed or reducing travel friction within certain limits—is intended to promote the general welfare by increasing productivity. The principle by which greater productivity is gained is the principle of the assembly line in a factory, which permits large tasks to be fractioned into smaller ones—these to become the specialties of certain workers. A transportation system is the assembly line of an urban society, and allows more efficient specialization of activities.

Transport systems, while aiming at efficiency, also must provide a variety of services to meet the needs of a variety of individuals. For example, many people are too old or too young or without the money to own and drive cars. Visitors also are often without cars. Unless society is to restrict the movements of these people, it must provide a good quality of public transportation service. In 1956, over forty per cent of the families in the city of Chicago did not own cars.[2] Although this proportion is declining, by 1980 there will still remain a fourth of the families in Chicago (sixteen per cent in the Study Area) who would not own cars. Clearly, for these people, for standby purposes, and for serving peak demands and special areas, reasonably priced public transportation services must be available and operative.

Public transportation services are presently provided by railroad or transit companies, or by taxis. These will use either exclusive rights-of-way (railroad, elevated-subway) or the surface street system, where public carriers will be mixed with private automobiles and trucks. In this volume, plans for public transportation facilities are developed mainly for rail services, because the planned road system improvements can readily accommodate any reasonable usage by buses.

With respect to rail services, it is quite clear that they are vital to the effective operation of the planned Central Area. A Central Area plan was completed in 1959 by the City of Chicago Department of Planning. This plan reflects the city policy of continuing intensive land development. Without the specialized passenger services of the suburban railroad and the rapid transit system, it is doubtful whether the workers, shoppers and customers could be delivered satisfactorily to this center in the morning and returned home at night. Without such service, the policy of intensive development probably could not be supported. So improvements in such rail services must be made. A goal of planning will, therefore, be to achieve improvements in rail services consistent with cost and reasonable consumer demand. Moreover, it will be an objective to concentrate on improved services using existing rail rights-of-way.

While public transit services are essential, the bulk carrier of people is, and will increasingly be, the automobile. The great flexibility of usage makes this the best general purpose tool for meeting individual travel needs. Additional urban goods movement will continue to be truck borne and will thereby add to the need for more and better roads. So the bulk of travel must move over the road. This means that the majority of projected improvements must be directed towards the road system.

By either means—roads or rails—the objective of transportation planning remains; to improve ease of travel within the constraints of safety, economy and land use requirements.

All this is commonly accepted, but, unhappily, very general. A dozen plans could be prepared and claims made that each achieved these objectives. What is needed is a means for measuring plan performance and for more rigorously defining what is good, better and best. This is absolutely essential when plans which will influence the expenditure of billions of dollars are being prepared. Consequently, attention is focused now on the conversion of these general values into specific measures so that an objective appraisal can be made of the expected performance of alternative plans.

CRITICAL OBJECTIVES

Objectives for a metropolitan region must be those of the people. Moreover, planning objectives should reflect the preferences of future people as well. This is a problem not easily solved. Personal, family or even corporate goals are easily isolated, but how are the objectives of a community of nearly eight million

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[2]Hamburg, John R., "Car Ownership and Trip Making in the CATS Area," *CATS Research News*, Vol. 3 (1959) No. 2.

future inhabitants to be known? While the problem is difficult, it is an essential step needed to avoid the easier assumption that the plan maker's preferences are those of the people.

It is fairly easy to provide word pictures of desirable transportation systems and their relationships to land use. Efficiency, speed, good design—these are valued words and rightly popular. But they do not help greatly when decisions must be made. They do not provide that kind of measured evidence which is needed for executive decisions, or for the objective testing and evaluation of plans.

A series of critical objectives must, therefore, be isolated. On the one hand, they must represent things which people want; on the other hand they must be measurable so that plan performance can be scaled. Opinion surveys are not too useful in this respect. Likewise, it is dangerous for the planner to assume he is typical of or wiser than the people. The best single source for identifying what is valued comes from the actions and choices of people—from the things they do as opposed to the things they do not do. Observations of survey data and of a whole series of contemporary and historical actions permit one to distill a series of essential human values. This has been done. The result is a list of six criteria which are presumed to be the popular ones toward which transportation planning should strive. They indicate the tests which must be applied to define an improved system. The six are:

1. Greater speed
2. Increased safety
3. Lower operating costs
4. Economy in new construction
5. Minimizing disruption
6. Promoting better land development

A careful examination of these criteria will reveal that they are important components of any larger statement of what people want.

These six were carefully developed and reviewed by the advisory committees of the Study and agreement was reached that this was a reasonable list. But being an acceptable list and providing a measurable means for plan evaluation are two different things. First, the planner must convert each objective to measurable units of value. How much is one unit of safety worth and how much is the value obtained from a minute of time saving? Until these objectives can be fitted to a scaled value parameter, purposeful measurement of improved performance is not possible.

But even with a measured value system for each criterion, another difficulty must be met. Some way must be found to deal with the fact that one criterion may be incompatible with another. For example, economizing on construction, if maximized, would mean building no new facilities. This would be the opposite of improving performance for the traveler. The planning idea is to achieve the best blending of all six objectives. This requires a measurable basis for comparing gains in one dimension—i.e., safety—with corresponding losses in another—desire to save construction dollars. For this reason, each objective is measured in terms of a single unit, dollar costs. This allows the measured objectives to be weighed against one another and also to be combined as estimates of total costs.

To develop this system of accounting, the following section discusses each criterion and its apparent scale of social worth or value.

Greater Speed

There is no doubt that people want faster transportation. While people realize the necessity of using up time in traveling from place to place, they would prefer to use as little as possible. It is only the occasional weekday traveler in an urban area who has the leisure or inclination to enjoy a trip for its own sake.[3]

The continuing search for faster travel has existed throughout history. The wheel, the clipper ship, the railroad, the automobile, the airplane, and now jets and rockets testify to the drive for greater speed. But desire for speed in and of itself would not have brought all these changes about; the compelling force is that increased speed produces economic gain. A salesman who can make more trips in the same time can earn more money; a truck driven faster can carry more goods in a given time period; and faster deliveries can reduce inventories.

[3]Unfortunately, there are few places where a trip is enjoyable in its own right. Attractive roadways, such as the Outer Drive, are all too rare. See the objective of promoting better land development, page 14.

That increased speed has value is attested each day in a variety of ways in the metropolitan area. Travelers show consistent willingness to pay more for the faster means of transport. Tolls on special high speed roads, higher fares for air travel, and even surcharges for jet travel are examples. Our whole society—probably the most productive in the world—is predicated on expensive, mechanized transportation rather than on inexpensive, slow foot travel.

It is difficult to assess the value of time and yet an estimate is necessary to scale the value of improvements in speed of travel. Some people are willing to pay more to save time than others. The wealthier a person, the more he tends to value his time. Also, time may be more or less valuable for any individual, depending on the circumstances—there may be a difference in his evaluation of time when going to work and when going to a movie in the evening. Despite these difficulties, several bases exist for estimating average values of time in dollars and cents terms.

There is no question about the value of time for commercial vehicles. Truck drivers are paid an average of $3.00 per hour. The time of the truck itself is worth about $1.00 per hour, yielding a total of $4.00 per hour for the unit of truck and driver.[4] This is a representative cost of truck time—and it is paid whether the truck is stopped in a traffic jam or speeding along an expressway.

While there are obvious and measurable values for time savings to commercial vehicles, there are also real and measurable values for time savings to auto drivers. Several examples will illustrate this point. At about forty miles per hour, the average automobile in urban areas has the low operating cost of about 2.3 cents per mile.[5] Yet, on unrestricted roads, the average speed of automobiles is currently reported as fifty-three miles per hour[6] and has been increasing somewhat each year. This speed increases vehicle operating costs to 3.0 cents per mile. For this additional 0.7 cents, the average driver saves 0.37 minutes per mile. At this rate, he is paying 1.89 cents per minute or $1.13 per hour for the time saved. Thus, while each driver does not count all these costs, there is measurable evidence that the typical driver values time because he is willing to spend money to save time.

Another method for illustrating the values that drivers place on time is to examine decisions to use toll rather than free roads. Careful studies have been made of the operating, accident and time costs of driving on alternate routes in relation to the costs and time of using toll facilities. Combining these facts with the proportion of drivers choosing the toll facilities, four studies compute values ranging from $1.14 to $2.45 per hour as the estimated value of time for the average passenger vehicle. (See Appendix Table 23.)

The typical traveler using public transportation facilities also values his time, although generally at a lower rate per hour than the average auto driver.[7] Yet, here again, this user will seek out faster routes as in the case of the diversion of riders from buses to elevated or subway routes. And the user will also pay more for express than for local service.

The preceding examples indicate that there are values to time, and that there are a variety of ways of estimating these values. Each person evaluates his needs differently, depending on trip purpose, income, whether he is traveling as part of his work, and many other considerations. There is no precise way of determining time values under such circumstances. Yet, a single average figure must be set—a sort of strategic reading which will permit plans to be evaluated.

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[4]See Cartage Agreement of Local 705, International Brotherhood of Teamsters, effective January 1, 1961, to December 31, 1961. The $3.00 figure is an approximation which includes fringe benefits. It is conservative in that it assumes driver's time only, without any helper.

[5]Operating costs are defined here to include only the costs of gasoline, oil and tire wear. These costs were obtained from several studies done by Adolph D. May, Jr., Frederick A. Wagner, Jr., K. A. Stonex, and the American Association of State Highway Officials. These costs are reported in Joseph, Hyman, "Automobile Operating Costs," *CATS Research News*, Vol. 3 (1959) No. 4.

[6]"Speed of Motor Vehicles 1945-1960," *Statistical Abstract of the United States, 1961*, Table 761, p. 560, Washington, D.C.: U.S. Department of Commerce, 1961.

[7]This is to be expected, since mass transportation facilities, particularly buses, carry higher proportions of the very old, very young, and those who are not in the labor force than do other modes of transportation. But, also, this is reasonable, because these are slower for most trips. See Table 12, Volume I.

The value of time was set conservatively at $1.33 per hour for an automobile—less than suggested by the studies listed in Appendix Table 23. As indicated in Table 2, this puts the average cost of a person's travel time at $0.85 per hour, since average automobile occupancy is 1.56 persons. With 12.5 per cent of all vehicles in the traffic stream being commercial, at an estimated $4.00 per hour, the value of the average vehicle (trucks and automobiles combined) is $1.66 per hour. When traffic volumes are converted to auto equivalents, i.e., where trucks are divided into passenger car equivalents, the value per unit is $1.50 per hour.

TABLE 2
VALUES OF TIME USED IN COMPARING ALTERNATE TRANSPORTATION PLANS

Item	Value
Per Automobile Hour	$1.33
Per Truck Hour	$4.00
Per Vehicle (trucks and automobiles combined 14 per cent trucks and 86 per cent automobiles)	$1.66
Per Person (whether via automobile or mass transportation)	$0.85

This estimate is somewhat lower than many investigators have used previously. The figures proposed will prove even more conservative in 1980 when people will be more productive, wealthier on the average, and, therefore, inclined to increase the value they place on their own time. Subsequent investigations showed that slight increases in time values do not have significant effect on optimum designs of road networks. Consequently, the above figures have been used throughout this report as a reasonable estimate of the average value of time.

Increased Safety

Accidents are an extremely costly adjunct of travel. This is measurable not only in the monetary loss, but also in the pain and anguish of personal injury and death. Any inventory of agencies engaged in helping to reduce accidents will testify to the social and individual desirability of this goal.

Measures of accident costs are difficult to make. Anyone is reluctant to place a value on human life, because all agree that life is very precious. Furthermore, some amount of risk is associated with any human activity, and the fact that people travel is evidence that they do somehow set a value on the associated risks. The question, of course, is how much risk people will tolerate and how much government should budget to reduce the risks of accident. For this purpose, accidents must be assessed in monetary terms as carefully as possible.

A thorough study of the costs of motor vehicle accidents in Illinois was completed recently by the Urban Research Section[8] of the Illinois Division of Highways. Interviews were made from a sample of all vehicle owners in the state—not just those making official accident reports. These interviews established the direct costs of all motor vehicle accidents, many of which would not be covered by insurance policies and many of which are not required by law to be reported.

Preliminary estimates from that study indicate the annual direct cost of motor vehicle accidents to be about $180 million in the Study Area alone. This is at the rate of almost 1.3 cents per vehicle mile or about .8 cents per passenger mile.

These dollar costs of motor vehicle accidents are very high, but the numbers of people killed and injured is more shocking. Over five hundred persons are killed on the streets of the Study Area each year, and over 59,000 persons are injured. While direct accident costs represent, in part, the dollar charges incurred as a result of such accidents, there remains an immeasurable additional amount of pain, distress and family readjustment which cannot be objectively appraised. The all-inclusive costs of accidents must be counted as greater than those that can be measured.

It can be agreed that accidents are costly and that, within reason, it will be desirable to spend money to reduce them.

Two elements of highway traffic can be affected by planning, and these can bring about reductions in accidents. The first is street congestion, the second is the design of new and safer roadways.

Motor vehicle accidents vary by roadway type and also by the level of congestion on

[8]This is the title of that section, within the Bureau of Research and Planning, which is continuing the work of the Chicago Area Transportation Study.

each roadway type. The increased accident hazard with increased traffic congestion is reasonable. The more traffic, the greater the chance a vehicle in the stream will hit another. Figure 2 illustrates the tendency for accident rates to rise with increases in volume. Similar findings are reported in exhaustive studies of arterial streets and freeways in California.[9] From this information it can readily be seen that reducing congestion will have a significant effect in cutting down on accident risk.

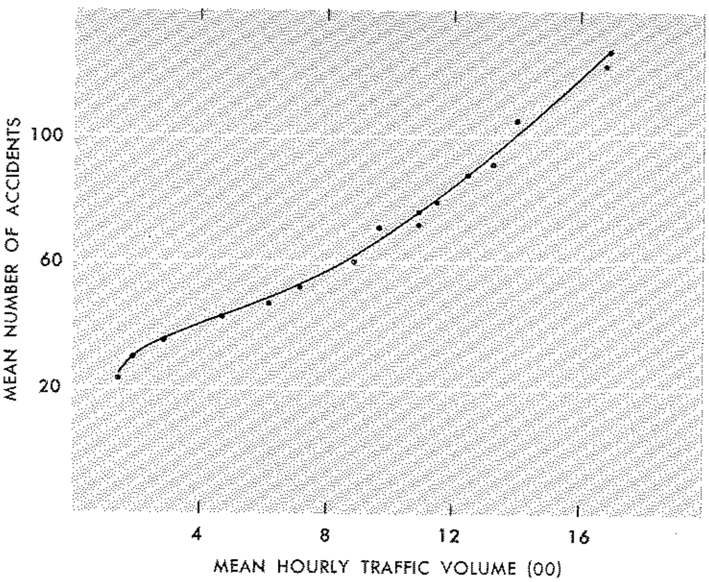

FIGURE 2—ANNUAL REPORTED MOTOR VEHICLE ACCIDENTS RELATED TO HOURLY TRAFFIC VOLUME FOR NINE ARTERIAL STREETS IN CHICAGO, 1958

See Table 24 in Appendix.

Accident risk is different on different types of roadways, too. Table 3 gives the number, the cost and the cost per mile, by type of facility, of accidents in the Study Area. It can be seen quickly that local streets have the greatest hazard (and, therefore, cost) per mile of travel. Arterial streets are next, and expressways are the safest, by far.

If more of the travel can be placed on expressways, gains are possible in two directions. The miles of travel shifted to expressways are safer and, because the congestion is less, the miles of travel remaining on surface streets are also safer.

TABLE 3
ANNUAL DIRECT TRAFFIC ACCIDENT COSTS—
BY STREET TYPE
CHICAGO AREA TRANSPORTATION STUDY AREA—1958

	Local Streets	Arterial Streets	Expressways	Total
Vehicle Miles of Travel (in millions)........	2,100	10,575	1,027	13,702
Number of Accidents				
Fatal................	146	332	12	490
Injury...............	23,771	48,069	939	72,779
Property Damage Only.	190,443	208,071	4,291	402,805
Total..............	214,360	256,472	5,242	476,074
Cost of Accidents				
Fatal................	$ 788,931	$ 1,751,239	$ 100,172	$ 2,640,342
Injury...............	27,691,631	70,745,114	1,492,061	99,928,806
Property Damage Only.	36,486,223	40,837,784	1,569,152	78,893,159
Total..............	$64,966,785	$113,334,137	$3,161,385	$181,462,307
Number of Accidents Per 100,000 Miles of Vehicle Travel				
Fatal................	.007	.003	.001	.004
Injury...............	1.132	.454	.091	.531
Property Damage Only.	9.069	1.968	.418	2.940
Total..............	10.21	2.43	.510	3.475
Cost of Accidents Per 100,000 Miles of Vehicle Travel				
Fatal................	$ 38	$ 17	$ 10	$ 19
Injury...............	1,319	669	145	729
Property Damage Only.	1,737	386	153	576
Total..............	$3,094	$1,072	$308	$1,324

Data given above are for Cook and Du Page Counties which are very nearly the equivalent of the Study Area. Pedestrian accidents and their costs are included. For details on this subject, see Jorgenson, Dayton P., "Accident Costs and Rates on Chicago Area Streets and Highways," *CATS Research News*, Vol. 4, No. 4.

This same reasoning applies with equal force to transit. The Chicago Transit Authority, which provides the bulk of all mass transportation service in the Study Area, must budget about $9 million each year to cover the cost of settling accident claims. In serving nearly three billion annual passenger miles, the CTA must figure at least 0.3 cents per passenger mile as an accident cost. But the rates are substantially less on the grade separated rapid transit lines (0.1 cents per mile) than they are on bus lines (0.4 cents per mile). This is to be expected, of course, since buses travel along the most heavily traveled streets, and more often in the hours of peak congestion.

These facts indicate that when specialized facilities, whose very design is such as to minimize potential conflicts, are built, the result is greatly improved safety. Further, if traffic volumes are reduced on streets which have a high accident potential, then the number of accidents is sure to drop. Subject to the limits of reasonable cost, then, it is quite certain that

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[9]Moskowitz, Karl, "Accidents on Freeways in California," paper presented at the World Traffic Engineering Conference, Washington, D.C., August, 1961. He shows that accident rates tend to rise twenty per cent faster than volume.

value will be placed on a plan that stresses the design best calculated to reduce the number of accidents.

Reduced Operating Costs

Operating costs represent that set of costs which reflect the direct output of work required to move a person over the distance of his journey. These are the costs of gasoline and oil, and wear on tires and other parts of the vehicle. In the case of transit vehicles, they include a unit share of the wages of the driver or other personnel actually on the vehicle. Not included are the costs of accidents, interest, debt repayment or, in the case of transit companies, of general overhead. Obviously, these operating costs are directly affected by the design and quality of the facilities over which vehicles move.

That people individually, and society collectively, value lower operating costs may be taken as axiomatic. All seek to economize, and the hue and cry over fare raises by public carriers, together with the recurrent price wars between oil companies, provide testimony of popular preference with respect to these costs.

Many studies of fuel consumption, tire wear, and other operating costs have been made. Detailed records and careful accounting of vehicle operating costs are common also in the transit industry. As a result, these costs can be estimated with a great deal of reliability.

Figure 3 shows how automobile operating costs vary with speed in urban driving. Costs are high for lower speeds, because these speeds reflect a large number of stops and starts which produce greater gasoline consumption and tire wear. As average speeds rise, operating costs decline, reflecting steadier flows of vehicles in the traffic stream. But as speeds increase beyond forty miles per hour, costs start to rise once again as a result of the greater frictions of higher speeds.

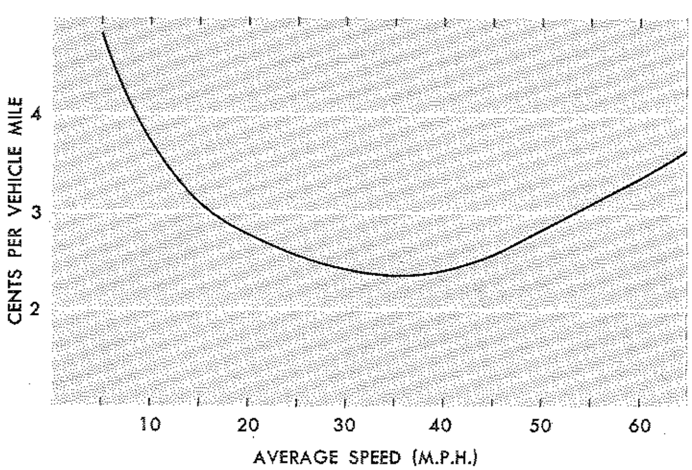


FIGURE 3—RELATIONSHIP OF AUTOMOBILE OPERATING COST TO AVERAGE SPEED FOR URBAN DRIVING

See Table 25 in Appendix.

Such information indicates how the design of transportation systems can reduce operating costs. The elimination of sharp bends in rails or roads saves distance. The reduction of congestion cuts the energy loss of acceleration and deceleration—producing benefits for every vehicle in the traffic stream. In short, the same amount of metropolitan travel, with improved system planning, can be undertaken at lower cost.

Some planners have advocated a more fundamental attack on operating costs—namely, by reducing the amount of travel undertaken on an average day. This appears to be attractive, especially when thirteen per cent of consumer expenditure currently goes for personal transportation, plus an additional amount for the transport costs of goods and services. However, it is unlikely that such an economy can be made, or that it would, in fact, be an economy. People perform travel for rewards. If the reward is not worth the cost of the journey, then the trip will not be made. Unless there are to be cutbacks in these rewards, people are bound to travel. An expanding economy, implying more rewards, is likely to increase travel. Only in national emergencies is travel likely to be repressed.

Over longer time periods, and with effective planning, another approach would be to reorganize land uses so that people would not have to travel so far. While the result may be desirable, the cost of achieving it is not well known. One price to pay might be increased residential densities. An additional cost might be that required to have a higher vacancy rate in housing. More vacant units would be needed to make it easy for people to relocate nearer to work every time the head of the family took a new job. Still another price might be smaller (and therefore less efficiently operated) stores and factories distributed closer to houses, or even reduced choices as to jobs or living quarters. These prices are fairly high in view of known preferences, and of the fact that business is constantly seeking ways to maximize its efficiency. Travel is a lubricant which oils the machinery of urban society; to reorganize the machinery to save oil is unlikely to be an economy in the long run.

Still another suggestion, often proposed for reducing these costs, is for more travelers to use public transportation facilities. To the extent that more travelers divide the cost of moving one vehicle, the per capita share can be reduced. But it appears that to increase the average loads of transit vehicles would require greater headways between vehicles in order to increase the passenger accumulation. In this fashion, additional time is spent waiting at stations in order to conserve on operating costs. Since time is valued, travelers become increasingly reluctant to wait and so the less convenient service tends rapidly to offset any savings in operating costs.

Economy in New Construction

Transportation facilities are among the most expensive public works that can be built. Expressway costs range from two million dollars per mile in rural areas to twelve or fifteen million dollars per mile in urban areas. Right-of-way alone normally accounts for forty per cent of costs in urban areas. Subways cost from ten to twenty million dollars a mile, while transit lines in the medians of expressways, even with free rights-of-way, exceed a million dollars per mile. Stations, ballast, track and power lines require this much capital outlay. The widening of an arterial street from four to six lanes, without land acquisition, normally costs $500,000 per mile in the Chicago area.

The area's residents certainly will wish to economize on capital outlays for new transportation facilities, since the construction and financial resources of the region are limited. But a policy of no new construction of any transportation facilities would obviously be a false economy. Instead of paying for new facilities, people would pay in delay, congestion and inconvenience. Some expenditures for new facilities are necessary. These new facilities will assure safer, less congested travel, which can more than justify the expenditure. In this sense they are like large pieces of machinery—the investment required is great, but the return from increased productivity is even greater.

The means of reducing the costs of new facilities range from the detailed design and use of steel and concrete to the planning of regional networks. It is taken for granted here that design engineers, in fixing final locations and designs of new roads and transit lines, will use great ingenuity to build economically. In this report, attention is concentrated on recommending the right facility type, at the right time, for the correct traffic load. For example, when new expressways are built, additional improvements should not, by and large, be programmed for nearby parallel surface streets. A high cost express highway should not be built where a lesser design will prove to be more efficient. Additional construction economies can be effected through wise advance planning so that one year's work will fit with that scheduled five years later. Taken together, there are many ways in which careful planning can conserve on construction costs and substantial concern must be given to this important criterion. Advance acquisition of rights-of-way will also allow reserving of land so that later expensive acquisitions are avoided.

Minimizing Disruption

The construction of any major transportation facility is bound to cause disruption to homes and businesses, and possibly to utilities, communications and other ongoing urban activities. Land acquisitions for rights-of-way can displace people or cause factories and other businesses to be relocated. During construction, temporary detours must be established and utilities relocated. All this is expensive, irritating and time consuming. Nevertheless, all changes cause disruption, and change is necessary if cities are to renew and to improve themselves.

All such possible dislocations should be avoided since they are expensive. Yet this objective is not so great as to cause all construction to cease. Not making improvements can also be undesirable in being erosive rather than disruptive.

Disruption has costs, and these costs allow evaluation of the amount of attention to devote to this effect of new construction. Many such costs are counted when property is acquired, because the costs of inconvenience and re-location are assessed against the acquiring body. In this sense, disruption already is measured in the capital costs of new transportation facilities.

In a larger sense, however, the problem of correctly assessing the costs of disruption defies solution. How can the dismay and inconvenience of families being displaced be weighed? Yet these factors must be weighed, and with all the acumen and statesmanship of local government leaders. This requires a great deal of courage too, because the less distinct, but very important, long term gains to future members of the community hang in the balance.

It is the duty of both the systems planner and the design engineer to reduce both direct and indirect disruption as much as possible. In more rural areas the problem is not so acute, since there are fewer people and less intensive uses of land. In the built-up parts of the region, engineers and planners constantly are weighing the details of route location according to the amount of disruption likely to be caused by new construction. Stable residential neighborhoods, thriving business areas, and industrial districts are avoided. Where possible, of course, vacant land is the preferred route. A badly blighted area, which is likely to be cleared in any case, is preferred as a location for new facilities over a sound and stable area. The policy in preparing plans, in short, is to locate new facilities, both in general alignment and in detailed site, so as to create the least disturbance.

The making of firm plans will be a very helpful step by itself. This will indicate the general aims and programs of government agencies and will show when new facilities must be located. Plans, coupled with advance right-of-way purchase, can do much to illustrate consistent policy and prevent new buildings from being placed where they will later have to be removed.

It is not, however, solely a problem of doing the least harm which should influence transportation planning. New transportation facilities are part of a large campaign to improve urban areas. They should be used creatively to improve the urban environment—and this is the last objective to be considered in this series.

Promoting Better Land Development

New facilities can be used not alone to make travel easier, but also as a positive means of creating land values and better arrangements of land uses. This is an important objective and one of some scale, since nearly one-third of urbanized land is devoted to some aspect of transportation.

One example of promoting better land development could be the use of expressways as buffers between residential and industrial areas. A three hundred foot wide expressway—either elevated or depressed—is a major strip of land use. The noise of industrial activities or other aspects objectionable to residential land users can be insulated more effectively from residential areas by judicious placement of such expressways. Their wide rights-of-way introduce light and air into formerly congested portions of the city and can, by careful landscaping, enhance the view from adjacent property.

A major obstacle to good land development is traffic itself. Heavy traffic on residential streets detracts from the value of adjoining property. Even commercial development suffers from having too much traffic at its doorstep. So the construction of new facilities which will relieve existing streets of unwanted through traffic will, indirectly, but effectively, promote improved land values. In a Chicago urban renewal project, the additional capacity of new routes may allow other roads to be closed, thus allowing a safer and more attractive unit development—Lake Meadows, for example. (See Figure 11, page 33.)

Details associated with new transportation facilities can do much to improve the appearance of a city. Noise can be cut by adequate rights-of-way for roads and transit lines, and by the planting of trees. Design of structures and landscaping, and the careful location of driveways and parking areas, are necessary to promote good relationships between land uses and public rights-of-way. Some of these matters are touched upon in Chapter III.

Separation of pedestrian from surface street traffic is increasingly demanded. The connecting walkways between the State Street and Dearborn Street subway lines are examples. Possibly, new pedestrian ways or even moving belt systems can replace the now unsightly elevated structures and thus enhance the attractiveness of the central business area.

A society which has a record of increasing productivity and available leisure time, and which is free from hunger and lack of shelter, is likely to prefer the more attractive, even if more expensive, solution. Greater effort in creating a pleasing environment will be rewarding to ever more people as regions grow. Thus, while no pretense is made to put this aspect of new facilities plans under the impartial eye of statistical measure, this should not reduce its importance. Double care should be exercised to insure that this objective is not submerged because of the presence of more measurable criteria.

DETERMINING THE BEST COMPROMISE BETWEEN CONFLICTING OBJECTIVES

A bus rider or an automobile driver caught in a traffic jam loudly demands better transportation, but later at home complains about high taxes, and would complain even more loudly if a highway department were to take his house for a new roadway. These conflicting demands, multiplied thousands of times and made even more pressing by the enormous stakes in the game, face anyone concerned with improving a city's transportation system.

How is one to compromise between conflicting demands? Each of the six preceding major objectives tends to bend planning in a certain direction. For example, reduced levels of capital investment mean higher accident rates and greater losses in travel time. Roads which wind in and out in order to minimize land takings require extra driving miles for thousands of cars over decades of time, as well as extra construction dollars. For each gain taken in one direction, a loss may have to be taken in another. Clearly, it is necessary to compromise in order to reach a decision.

Though it is logical to determine the safest transportation plan, or the fastest, or the cheapest, it is impossible to define one which is the cheapest and the fastest and the safest, all at one time. To achieve any measurable "best" plan, it is necessary to find the one that measures best with respect to a single criterion. This is the law of the single superlative.

The task of compromising between conflicting objectives is thereby involved with another task—to determine a single criterion for plan evaluation. This single objective must meet certain conditions. First, it must be measurable, since it must be measured to convince reasonable men that one plan is superior to all others. Second, the objective should be measurably related to as many of the six preceding objectives as possible. And finally, it must be one to which residents of the area would generally subscribe.

The single objective chosen is *to provide that transportation system for the region which will cost least to build and use over a period of thirty years.*[10] In other words, the target is to plan a system the sum of whose measurable costs for all travelers and taxpayers in the region will be at a minimum. Ideally, every cost should be included, and cost should be used in a general way to cover many indeterminate and non-measurable elements. But this form of universal social accounting is not presently possible—every cost cannot be measured. Therefore, total costs are defined here as construction and travel costs, the latter including time, accident and other user costs. What this means and how it relates the preceding six objectives is described in the following paragraphs.

The Minimum Total Cost Transportation System

The planning task might be approached through the eye of a chief executive with the authority to make decisions on transportation for the entire metropolitan region. He has very large funds at his disposal. He must determine

[10]This statement was worked out by the Design Subcommittee as the preferred, single, governing objective.

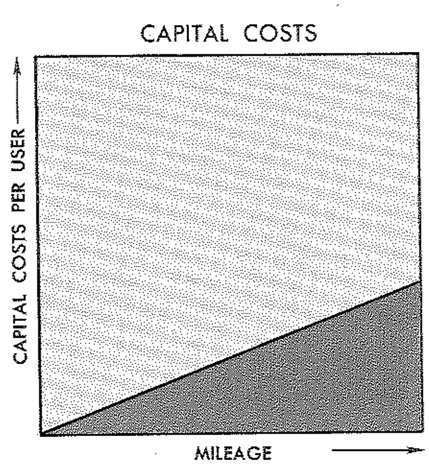
how much to spend for other governmental needs—schools, hospitals, urban renewal and parks. He also wants to be reelected and so taxes cannot exceed a level determined by voter tolerance. However, his immediate and pressing problem is transportation. How much and how fast should he spend for transportation improvements over the coming years?

One course of action might be to spend a great deal. If this were done, many miles of new facilities would be built, and they would lie together very closely throughout the whole area. Since there would be many facilities, each would tend to be lightly used, and service would be very good—few accidents and high speed travel. This would be a luxurious system in which capital was used liberally. Another course would be to spend slightly less. In this case there would be fewer facilities and they would be more widely spaced. A third option would be to spend very little. In this case, new roads would be very far apart. In a growing region this third option would mean that both new facilities and existing surface streets would be more congested and travel would be slow and would involve greater accident risks.

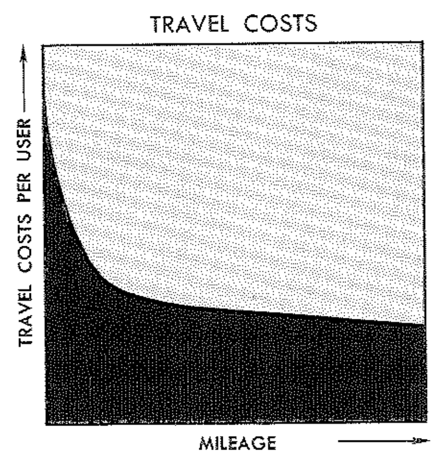
Much finer degrees of these different courses of action, which illustrate the effects of different kinds of policies, can be diagrammed. Capital costs rise when there are more facilities. Thus, capital costs are a direct function of the extensiveness of the transport system.

But the chief executive must consider also the costs which the users of the transportation system will have to bear. If many new roads or other transportation facilities are built, then direct costs of travel will decline. This is because accident, time and other user costs are lower on modern, less crowded facilities. These reduced costs will not only yield rewards directly to the traveler, but indirectly through lower costs of producing goods and services in a more modern and efficient urban physical plant.[11]

While additional capital investment reduces user costs, such reductions occur at a diminishing rate. In planning improvements, the first expenditure generally will have the greatest effect, with successive segments helping to improve system performance, but always at a lesser rate. This is an example of the economist's "law of diminishing returns." To illustrate, user costs are diagrammed below as functions of the amount of new transportation facilities. User costs are shown to decline very rapidly with initial investment and then more slowly as additional miles of new facilities are built.



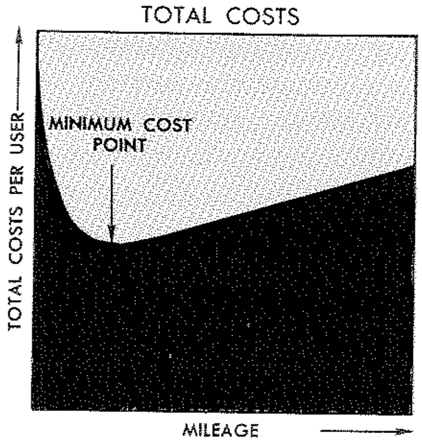
Increasing mileage of high quality transportation facilities requires increasing capital investments. This increases the cost to each user.



Travel costs are lower for each user when greater amounts of high quality transportation facilities are available.

All of these costs so far discussed can be put in the same terms. The daily time, accident and operating costs can be capitalized over a period of twenty or thirty years. And, since these costs come ultimately from the same source—the wealth of the region's people—it is possible to consider both together. This is done in the diagram which appears on page 17.

[11]See Part VI, *Final Report of the Highway Cost Allocation Study*, H.D. 72, Washington, D.C.: USGPO, 1961.



The objective is to build that transportation system, the sum of whose costs is at a minimum.

This diagram indicates that there is a point at which the total costs of building and operating a transportation system are minimized. This, then, is the visual image of the target just stated: to provide that system which will cost least to build *and* use over a period of thirty years. If more money is spent for new facilities than indicated by the point of minimum cost, then the costs for users will not decrease sufficiently to make it pay. Contrariwise, if less than the proper amount is spent for new facilities, the total costs for the region will remain at an uneconomically high level, because user costs are so high.

An objective has been established, then, which provides both a target for planning and a means by which four major objectives can be brought into line. Each of these four objectives is, in fact, a component part of the more general objective.

This single procedure, however, is not a magical formula whose application will solve all transportation problems. All subjective decisions cannot be eliminated, nor can a computer comprehend all of those facts of a real situation which a designer can in planning a system of new facilities. In fact, two of the objectives stated above—minimizing disruption and promoting better land development—can only be considered in the stages of detailed location and final design. Here is where art and innovation, coupled with good design standards, seem presently the best means for obtaining good results.

There are, furthermore, other questions which must be answered. In seeking to achieve the stated goal, what means should be used? What types of transportation facilities should be incorporated in the solution? It obviously is desirable to find types which are inherently safe, swift and economical to build and use. If such facilities can be found, then it is all the more likely that the main target will be reached. These questions are considered in the next chapter.

Another question is the proper balance to place upon transportation investment as opposed to other public investments. Where will investment yield the greatest social return? There are as yet no good means by which benefits can be calculated as between different types of public investment. In this situation, however, the target itself is sound; if the least total cost transportation system is built, more money should be available for other public—and private—needs. The attainment of the goal, however, can only be achieved in time, and this raises problems of short as well as long term investment. In these situations where the factor of ignorance is relatively large, the most appropriate solution seems to be one of charging a rather high rate of interest to transportation investment.

The question of the proper rate of return to expect for investment in transportation facilities is difficult to answer. The lowest rate conceivable could be in the range of from three to six per cent. This is the range for a variety of low-risk investments, such as insured home mortgages, municipal bonds, and the stocks of large, stable corporations. However, when risks are larger or capital more scarce, much higher rates of return are warranted. Many companies will not invest their capital unless the project is expected to yield a return of ten to twenty per cent.[12]

Even though governments are very large and stable corporations, they do not have unlimited capital available for investment. They can only spend money in democratic countries by popular mandate or approval. Responsible officials will recommend only those investments which have a high rate of return so as

[12]See Winfrey, Robley, "Concepts and Applications of Engineering Economy in the Highway Field," Highway Research Board Workshop Conference on Highway Economics, Washington, D.C., September 17 and 18, 1959.

to achieve the most useful reward for public investments.

Based on these considerations, a ten per cent rate of interest was included as part of the cost of each facility. The conditions were set to insure that no facility would be built unless it was expected to effect a reduction in travel costs sufficiently great to repay the investment in twenty-five years at ten per cent interest. Of course, the over-all rate of return for the entire transportation system would be substantially higher, since initial investments will be much more profitable. The marginal or last item invested may be required to return the minimum rewards—i.e., a ten per cent rate of return. This policy is a means of insuring fair investment consideration of many other public needs than transportation facilities.

Despite the unknown elements which are inherent in all planning, use of the single objective, together with measured weighting of component objectives, serves to narrow the number of possible solutions. This is extremely important, because, lacking precise and measurable criteria, no plan can be demonstrated to be more in the public interest than any other. The point in specifying objectives and arranging them in proper order is to narrow the target area within which suitable answers must fall—and also to focus public policy. Transportation planning is not yet at the point where two designers, working separately under the same rules, will develop exactly the same plan, but it is toward this kind of goal that present work is pointed.

A VIEW OF THE FUTURE CITY

At this point it is worth while to stand back to see what kind of urban region is likely to emerge if a transportation plan based on the preceding objectives is carried into being. The preceding objectives stated are mainly in economic terms. Are plans based on such goals likely to produce a desirable Chicago region?

The fact that the preceding question contains many other ill-defined and essentially insoluble questions does not deny its importance. For example, it is virtually impossible to define what is desirable by all members of society—especially the future members. It is impossible to demonstrate conclusively the connections between transportation and urban form. But there still remains the problem of displaying whatever image of the future city does exist. The reason is that this image, however imprecise it may be, is an important part of every resident's working and living equipment and, as such, must influence the plan.

A city is seen in many ways, depending on the outlook of the viewer. To the transportation planner it is essentially a system of movements of people and vehicles which must be accomplished with dispatch, safety and economy. There are two other viewpoints which are especially important. One is the view of the city as a productive society. The other is the city as a visual image—an environment with aesthetic qualities.

The City as a Productive Society

It is assumed that cities have the purpose of providing a richer, more complete life for their residents. This is the image of the city as a productive society. If the city can be made more productive, then its residents ought all to benefit from this.

No census figures are needed to prove that cities and large metropolitan regions are continuing to grow. It can be assumed that growth takes place because it is profitable. This does not mean that there are no drawbacks to urban living. It does mean that, on balance, people must find urban life superior to other possible arrangements.

It can be stated as a proposition that the greater material rewards of urban living occur in some measure because there is greater freedom to take and leave jobs. This permits more specialization and the opportunity to put together more productive combinations of men and machines. The trend to the city is evident in all parts of the world where industrialization is growing faster than agricultural output. Moreover, the bigger communities, by definition, provide a more diverse array of opportunities. What holds in the economic sphere is true also in the social and cultural worlds. The large urban communities increase the potential for wider experience and association and this increases the social attraction of these places.

The greater opportunities in urban areas occur, because large numbers of people live together in one place. Their mutual closeness is a product of a transportation system. But as cities grow, people are bound to live farther apart, on the average, unless densities rise rapidly. This is simply because people require space, and more space means greater average distances between each person and the remainder of the people in the metropolitan area. So transportation must improve as cities grow, if only to maintain their existing degree of proximity.

It would seem that the proper objective for the future city as a productive society is to improve its transportation so that it becomes more unified than before. The goal here is to undercut provincialism within cities—in other words, to allow them to function more effectively as metropolitan units. For example, a resident of Chicago's western suburbs is more likely to shop or attend a university in the Loop now that the Congress Street Expressway is open. Therefore, it is more advantageous for him to remain in this region than before.

The goal of unifying the metropolis indicates that the plan should consist of a network of facilities allowing high speed travel in all directions. Such a network is more efficient than a system of facilities which requires people or vehicles to route themselves to a central point before proceeding to their destinations. It permits trips to be shorter and avoids the inefficiencies of congestion at focal points, such as the Central Business District. If travel times throughout the metropolitan area can be reduced, more opportunities are brought within range of every individual. Thus, high speed travel in every direction is an important characteristic of the future city.

The Appearance of the Future City

The idea of a plan created by a series of successively tighter restraints is repelling to many persons because it conveys an image of rigid geometry, lacking in imagination and vision. Is dull efficiency the image of the future city? This might be the case if a transportation plan, which stressed only economic and operation objectives, were carried out. What kind of city actually is wanted and how is this considered in plan making?

Everyone wants to live in a beautiful and exciting city—one which they would be proud to show visitors from other parts of the country, or from abroad. Tree-lined boulevards, handsome buildings, monuments, parks with fountains, gracious residential areas, clean and efficient commercial and industrial areas: these convey ideas and images which most people find desirable. These are what people want. They can be an expression of a powerful, energetic and artistic society. These certainly are objectives which any transportation plan would like to aid in achieving.

The difficulty is that what people see in the city is only partly a function of transportation. Within an efficient transportation system either a dull or an exciting city could be built. What its image is to the resident of an area, or to a visitor, is more dependent upon other things. Such things are the architecture of buildings, the ways in which the landscape is arranged, and the contrasts between building masses and open spaces. These really are matters of civic design—things which can be seen within the ordinary range of vision in an urban area—rarely more than half a mile, and often much less. Transportation systems should play their part in this composition through careful landscaping, structure design, and location which is sensitive to other land uses.

While the handsome and proud city is an objective of universal desirability and all citizens must aspire towards this, the crucial task of transportation is to serve the function of interchange. The construction of regional transportation plans requires a plan maker to view the urban region as though from a great height. From this viewpoint the aspect of an orderly, functioning system must stand out. This is quite important to the traveler, too. If there is an orderly arrangement of roads and rails, the average person will appreciate this as he lays out his path in his mind's eye. He can say, "My destination is framed by these known routes, so I must go this way."

If the plan looks like a series of cow paths, then it is less likely to satisfy this requirement. Thus, a final criterion of regional importance is that of maintaining the comprehensive system-wide view and scale. It is the major, regional network of facilities that responds to and reflects the great metropolitan community.

CONCLUSION

This chapter has brought a new element into the process of transportation planning—the element of value judgment. All the other steps leading toward the plan have been based on a scientific, detached observation of facts and of historical development. Values are a fresh insertion into the equation, but a very important one. They raise critical questions: What is good? How can things be done better? What is the objective against which proposals can be measured?

What is good for one person may not be so good for another. Value judgments are deceptive, subject to varied interpretation, and essentially not arguable. For this reason, great care has been taken in presenting objectives. The objectives selected were chosen on the basis of universal desirability. Examples are the reduction of accidents, the speeding up of transportation, the saving of money, and the minimizing of disruption and dislocation which goes with any major improvement. Very few persons would ever argue that these are undesirable goals. It is presumed that these goals correctly reflect those of society as a whole and thus properly represent what is good for the community.

A key problem has been to find a way to measure the extent of improvement towards any of the six objectives. For time saving, accident reduction, economy of operation and economy of investment, measurable ways to assess the value of improvements were set. Being cast in value units of dollars and cents, it was shown to be possible to combine separate objectives into a single one. This single aim was to develop that transportation plan which would, in light of future traffic estimates, be the least expensive to build and use over the next thirty years.

As will be shown later, the actual measurements of performance are made during the testing of plans, so that the total annual cost of any plan can be computed for the approximate year 1980. This involves estimating traffic usage of every part of the planned system, computing travelers' costs, and adding in the interest and amortization costs of new improvements. Such an estimate of system performance provides a direct and measured linkage between the objective and the final plan.

Chapter III
ROAD SYSTEM PLANNING

Having established the prime planning goal —i.e., to provide that transportation system costing the least both to build and use—the next step is to consider how to attain it. In this chapter the means to be considered are the types of roadways to be used in the plan and, in a broader sense, the ways in which they are linked together in systems and related to land use. Transit facilities will be dealt with in Chapter V.

Systems or networks, rather than individual roadways, are the dominant concern. It is not possible, under expected traffic pressures, to continue to use streets as all-purpose ways. They must be specialized, each doing a particular part of a larger job. To specialize them, they must be joined in networks, and this requires an increasing degree of interdependence.

In this chapter, system planning is approached by selecting modular units and then studying ways of combining them into efficient networks. This is done within the context of the Chicago metropolitan area—taking into account its densities, street patterns and street widths. First, various possible street types are evaluated with respect to their performance and cost, so as to identify the more effective types. Land use requirements then are considered. Finally, network design principles are listed and optimum combinations of roadway types are developed. These things define roadway requirements which, when adjusted to the particulars of the Chicago region in Chapter IV, produce the long range regional highway plan.

SELECTING STREET TYPES FOR SYSTEMS PLANNING

Transportation facilities have two principal functions: providing access to land and providing channels for the movement of persons or vehicles. The dirt road leading to a farm, for example, is built primarily to enable the farmer to reach an area to cultivate it. At the other extreme is the expressway, whose sole purpose is to serve vehicles in motion. In between these extremes is a variety of street types which serve both land use and the traveler.

Theoretically, there might be an infinite range of street types, varying from the driveway of a single family house to the expressway, yet, practically, there are only three or four basic types of streets. Their degree of specialization toward land use or traffic affects the kind of service they provide and the extent to which they can be used in the plan.

Local Streets

One clear-cut type is the local street. Most of these are residential streets, but there are local, or land service streets for other land uses. Drives in parks, driveways in shopping centers, and industrial access roads fall in this group. The primary function of local streets is land service, but, of course, these streets must carry the volume of traffic which the adjacent land use generates. Such volumes are naturally very low—suburban residential streets in areas averaging four families per acre will typically carry less than five hundred vehicles per day.

Because local streets are laid out to serve land and because the main charge for their construction rests on the land owner, these streets are kept narrow. Their alignments also are subordinated to the needs for providing good building sites; little concern is shown for providing the capability to move large traffic volumes or to allow high speed travel—in fact, the reverse is true.

Related to the local street is the collector street. The collector is basically a local, residential street where traffic service is given slightly greater emphasis. It is designed to carry two or three times the volumes desired on local streets, collecting traffic from residential streets and carrying it to arterials. In this report the collector is considered as a local street.

Arterial Streets

The second major type is the arterial—or rather, the family of arterials, because there are many variations in design and carrying ability. Most arterials in the Chicago area have four lane pavements in rights-of-way less than one hundred feet wide (see Table 4). Typically, these four lane arterials can carry as many as 14,000 vehicles per day without undue congestion.

TABLE 4
NUMBER OF MILES OF PREFERENTIAL[a] STREETS IN CHICAGO BY RIGHT-OF-WAY WIDTH, 1960

Right-of-Way Widths	Number of Miles	Per Cent
66′ or less	472	53.5
67′- 99′	190	21.5
100′-119′	180	20.4
120′ or more	41[b]	4.6
Total	883	100.0

[a]In effect, the main arterial system. See Map 33 in the Appendix.
[b]Includes sixteen miles of park boulevards. Expressways and Outer Drive not included.

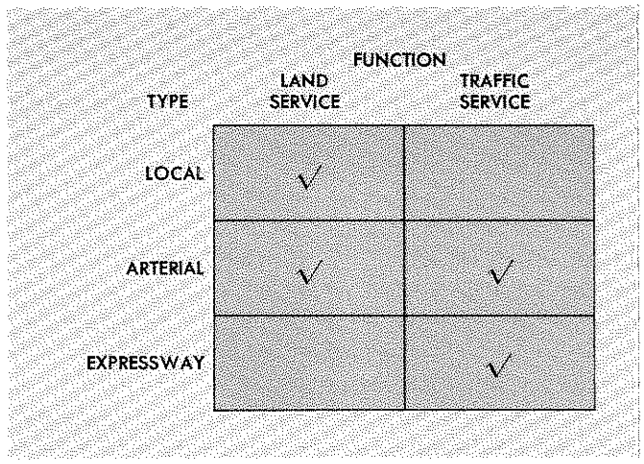
The reason for the high capacity of arterials, compared with local streets, is that arterials are given preferred treatment in the signing and signalization of intersections. This has given rise to the name "preferential street system" for Chicago's arterial network. By virtue of this priority over all local streets, arterials are capable not only of handling more cars than local streets, but they are faster and safer to drive on as well.

Arterial streets also must provide access to important abutting land uses—business, industry and major public buildings. They are thus dual-function streets, serving both traffic and land use. This double duty is a necessity, because these high trip generating activities require the kind of access which an arterial can best provide. Local streets have a limited carrying ability, and expressways cannot connect directly with land uses. Arterials remain, therefore, as the principal site for these activities, even though this means a certain degree of conflict with their traffic carrying function.

Expressways

The third type is the expressway (or freeway)—a specialized channel whose sole purpose is serving vehicles in motion. This represents the most advanced design being built today. The expressway is designed to be completely free of direct land access, with no intersections at grade with other streets and with fully separated directional traffic. Such a design permits expressways to carry volumes of eighteen thousand vehicles *per lane* per day, running at speeds at least double those on arterials, and with much less risk of accident.

To summarize, three basic street types are commonly and easily identified, based on their function with respect to land service and traffic service. The following diagram illustrates their respective functions.



EVALUATION OF TYPES

The number of miles of each type of street proposed in a plan is affected partly by the kinds of work each does. For example, a city cannot get along without local streets to provide access to land. Since the primary function of those streets is to serve land, their mileage is determined by the land platting and subdivision practices. But the extent to which a city invests in other types of roads also depends upon their performance.

Those roadways designed to serve traffic must be evaluated as to their traffic service capabilities. With this information, it is possible to consider how to combine roadways in the best way to achieve planning goals.

The traffic service capability of a roadway depends on the physical design of that roadway. Since each design type would have a somewhat different service capability, a first step involved standardizing a representative geometric design for each of the three basic roadway types. This work was accomplished by engineers from all participating highway agencies. The three standard designs for built-up urban areas are illustrated in Figure 4.

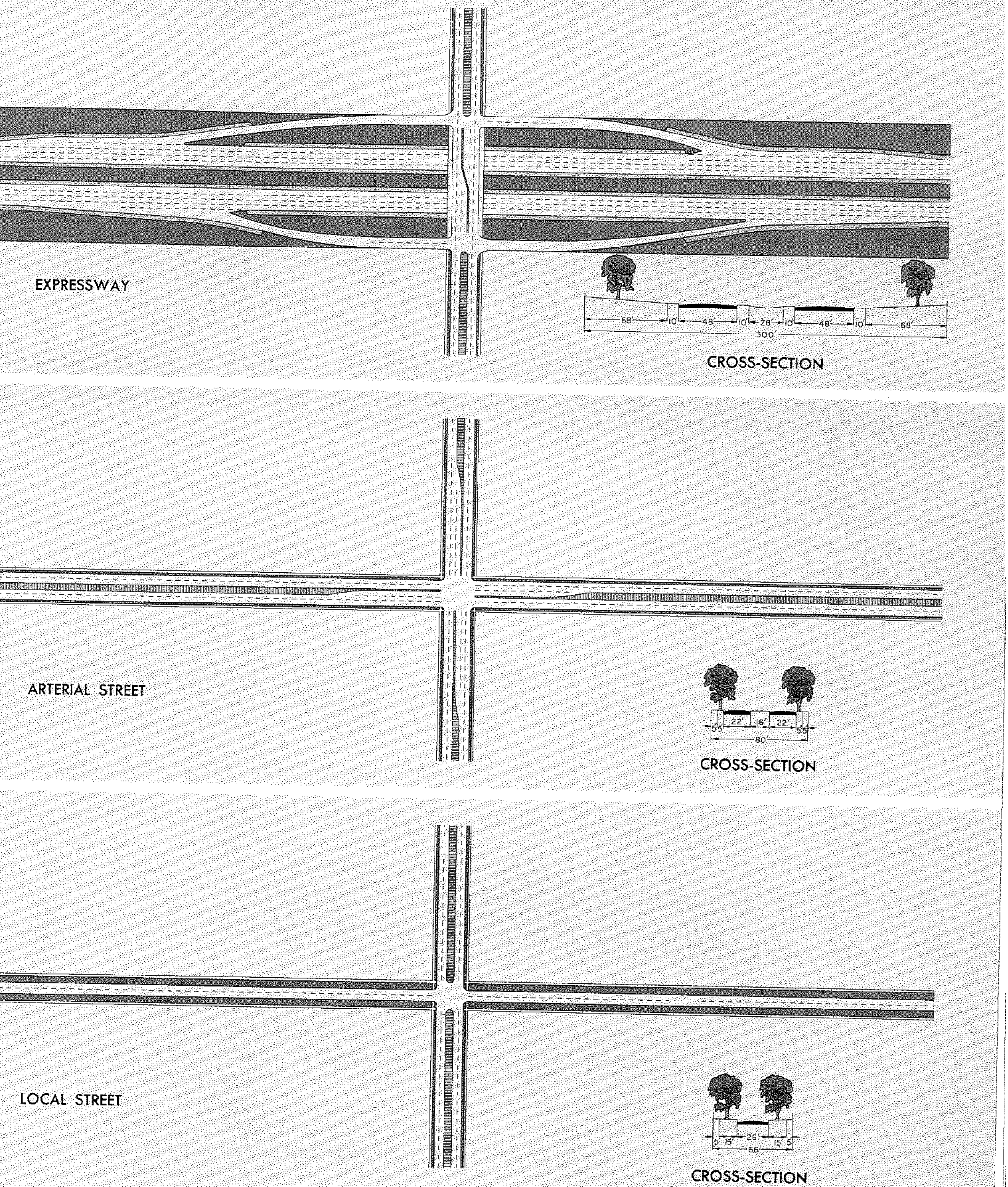


FIGURE 4—IDEAL DESIGNS FOR TYPICAL LOCAL, ARTERIAL, AND EXPRESS HIGHWAYS

These designs were prepared by the engineers of the participating agencies as the best examples of design for specific street types in typical urban rights-of-way. These types were used in establishing traffic performance functions for each roadway type. These became the base types for comparative economic evaluation.

A second step could now be undertaken—i.e., describing the capability of that roadway to move vehicles. Capability, to be more precisely used in plan evaluation, is expressed in terms of travel costs. Safety, speed and operating costs all are aspects of the relative ability of that roadway to serve the user. Therefore, capability can be represented as the sum of time, accident and operating costs to the average user for one mile of travel on the particular facility. In Chapter II it was shown that such costs could be measured.

Yet a single, average cost for an average driver for each roadway type will not be useful in estimating total system performance. The reason is obvious. The costs of travel on any segment of road vary directly with the amount of traffic—i.e., with traffic congestion. For each roadway type there is a travel cost curve which varies with the traffic volume.

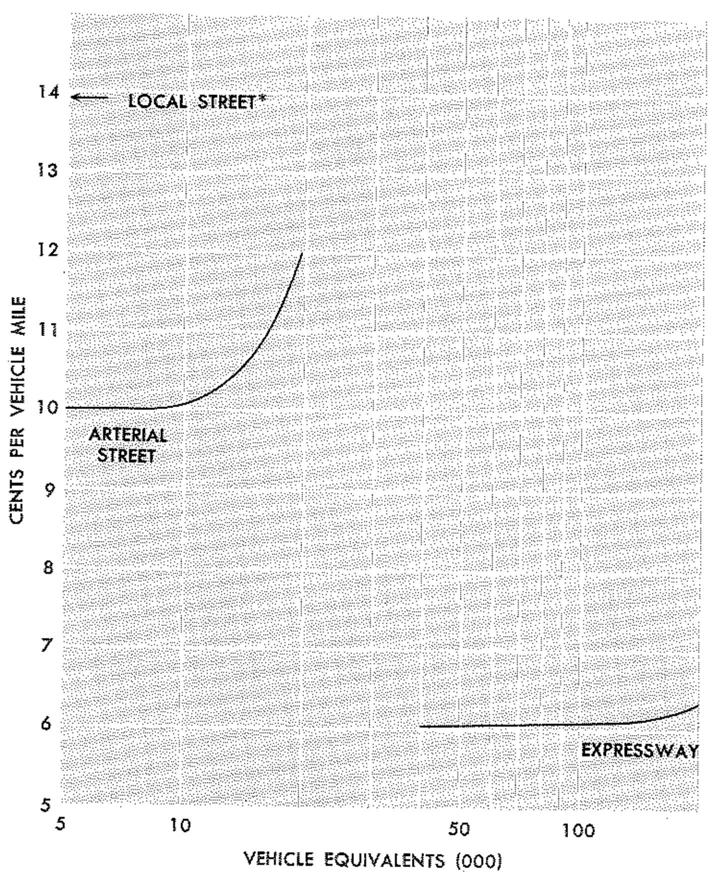


FIGURE 5—TRAVEL COSTS RELATED TO AVERAGE DAILY TRAFFIC FOR THE CHICAGO AREA, 1961

*Local streets should always have volumes less than 5,000 vehicles per day.
Travel costs are the sum of accident, time and operating costs.
See Table 26 in Appendix.

This curve is what the planner needs to evaluate roadway "output," or performance. Such curves were computed for each standard design type, using the background cost studies reported in Chapter II. These curves, or cost functions,[1] are illustrated in Figure 5.

Travel costs are highest for local streets. This is expected, because travel on these streets has been shown to be slower, with more stop and go driving and a greater susceptibility to accidents. As a result, the traveler using these streets pays a high price for each mile driven on them. But, since local streets are rarely crowded, the driver is not presumed to pay any extra penalty for congested driving, and so the travel cost line is quite straight and short.

Arterial streets have markedly lower travel costs. Because of preferential treatment and better policing and lighting, these streets are faster and are safer to drive on. Fewer stops and starts than on local streets help to reduce operating costs.

Arterial travel costs are, however, affected by use. As described in Chapter II, congestion raises accident, time and operating costs. This is understood instinctively by anyone who drives in heavy traffic. The cost curves illustrate how travel cost per vehicle increases as daily volumes exceed 16,000 vehicles. Congestion can force arterial travel costs up to a point where it becomes preferable for a driver to filter through the local street system, rather than to endure the delays of the congested arterial.

Expressways have the lowest travel costs of any type of street. Accident risks are very low per mile driven. Time costs are low as a result of greater speeds; operating costs reflect fewer stops and starts. These low travel costs illustrate why drivers go out of their way to use expressways and, if necessary, pay tolls. It is a sound principle that the traveler, if he is able, will allocate his travel to the lowest cost route.

In contrast with arterial streets, expressway travel costs rise relatively slowly as traffic vol-

[1]See Haikalis, George, *Economic Analysis of Roadway Improvements* (36,500), (Chicago: CATS, 1962).

umes increase. The reason is the more even flow resulting from the absence of signalized intersections, the elimination of parking and pedestrian interference, the improved alignment, and the greater lane width—in short, their greater capacity. Even when it is congested, the expressway generally is superior to competing arterial streets. This evaluation can be checked by observing how drivers remain on an expressway facility even when it is running at low speeds.

From the user's viewpoint, the expressway obviously is best for driving, but the greater metropolitan community must weigh the rewards to the user against the investment costs. The tremendous costs of building these roads can be justified only when they carry a large volume of traffic. The reason is that capital costs then are shared by more vehicles and so the capital cost per vehicle mile is greatly reduced. In Figure 6, capital costs are added to the travel cost curve for expressways. This is the addition made by the responsible government official, because the cost of building this facility is real, and it should be added to the lower operating costs to obtain an objective appraisal of performance. No capital costs are assessed against local streets because their costs should be and usually are borne by the benefited land rather than the traveler. The arterial street may be considered as paid for and in place, so no charge of capital is shown, although some charges must be carried by governmental agencies to maintain and operate these streets. On expressways, as volumes increase, the total cost curve drops, because capital costs are divided among an increasing number of vehicles. It is only when travel costs start to rise rapidly that the total costs stop declining and finally begin to rise.

This begins to illustrate the problem of distributing the community's traffic most efficiently. Clearly, it is wise to have expressways heavily loaded. If this can be accomplished, with arterial street loads kept low at the same time, the community would be served very well. There is a great potential for traffic to adjust itself in this fashion. Nevertheless, the gap in service between the loads on arterials and the very heavy usage desired for expressways raises the question of whether there is some other type of facility that performs better than an arterial street, yet costs less to put in place than the expressway.

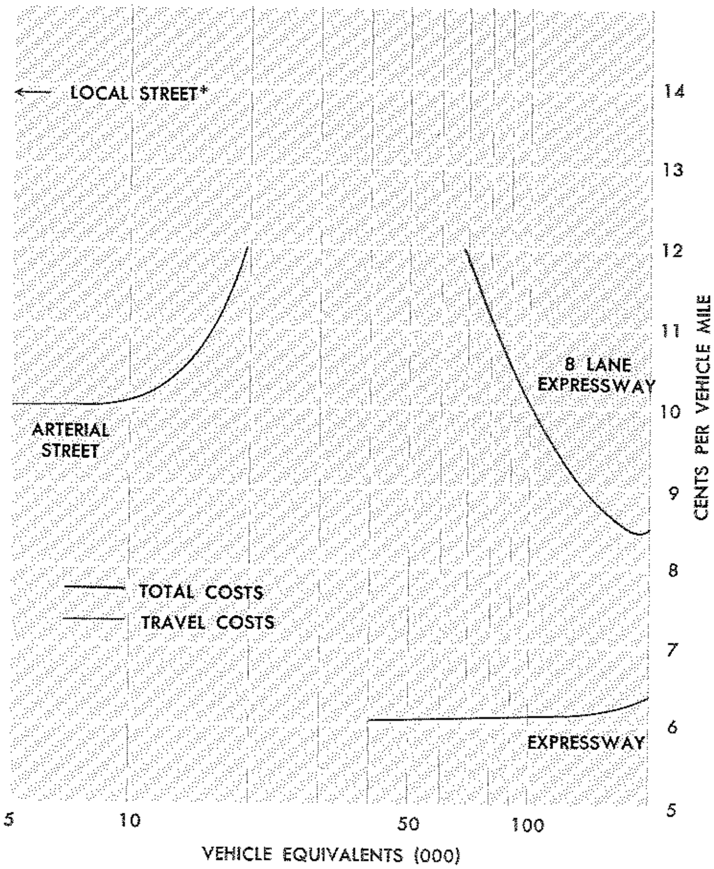


FIGURE 6—TRAVEL AND TOTAL COSTS RELATED TO AVERAGE DAILY TRAFFIC FOR THE CHICAGO AREA, 1960

*Local streets should always have volumes less than 5,000 vehicles per day.

Total costs include construction and travel costs. No construction costs are charged to local or arterial streets.

See Table 26 in Appendix.

The Intermediate Facility

Many professionals have a particular image of such an intermediate type of roadway and they have referred to these by such names as "super arterial" and "junior expressway." To make a systematic investigation of such designs, the problem was first given to the design engineers of the principal agencies responsible for building highways in the region. It was agreed that any design must meet typical Chicago or suburban conditions. Many different possibilities were studied. These were reduced to three basic design types.

The first design developed the maximum improvements possible in arterial streets without the acquisition of additional right-of-way

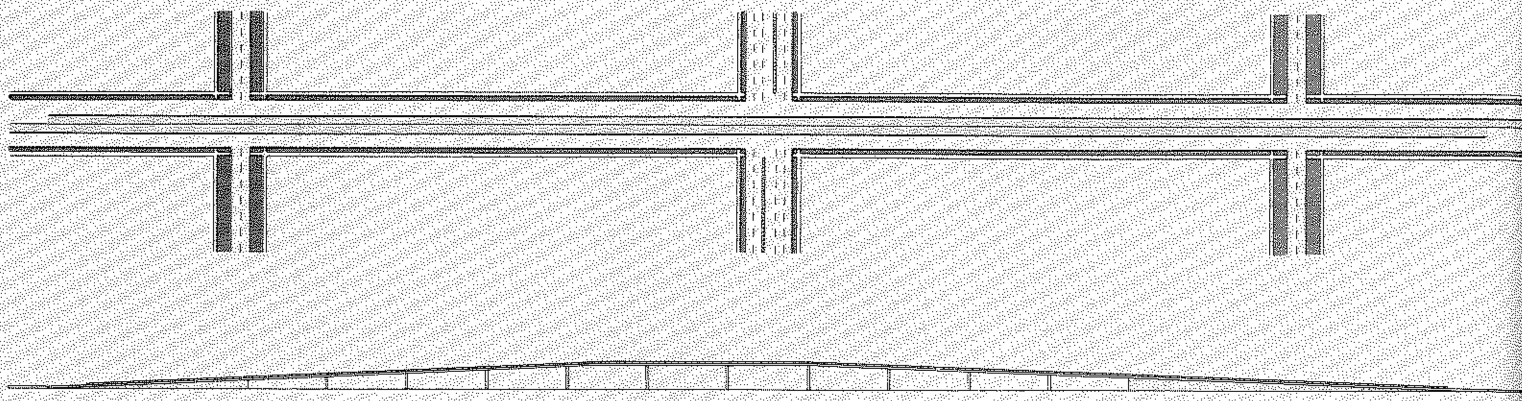


FIGURE 7—DESIGN FOR A THROUGH-LANE OVERPASS

A through-lane overpass is shown for a typical arterial street with an 80 foot right-of-way. This facility improves the volume and speed of traffic in both directions at the treated intersection. Unless an almost continuous series of these overpasses were built—and this would be very difficult to do—the remaining at-grade intersections would control the capacity and performance of arterial streets being so treated.

width. Since most arterial streets are presently developed with commercial frontages, it was agreed that taking this expensive frontage just for widening a street would not represent an acceptable public policy. Pavements were extended to the greatest width possible, considering the limited right-of-way and the need for sidewalks. Also, important improvements such as left turn lanes and median dividers were incorporated (see arterial street design and cross-section in Figure 4).

A second design type consisted of plans for building through-lane overpasses, thus relieving intersection constraints on street efficiency. Experiments with this kind of intersection treatment are presently being undertaken in Chicago. Their virtue is that, without additional right-of-way, such treatment could increase the capacity of the affected intersection and, when placed in series, could raise the capacity and performance of the arterial street to a higher level (see Figure 7).

A third and final type consisted of an expressway design with substantial reductions from full interstate expressway standards.[2] This involved reducing lane widths, turning radii, grade requirements, shoulder widths and the narrowing of median strips. All of these reductions in design standards were directed at reducing the land acquisition requirements. Nevertheless, even such a cut-back design required purchase of additional right-of-way, because most arterials in the Chicago area are so narrow (see Table 4, page 22).

Having settled on designs, the combined agencies next approached the problem of costs. A representative one mile segment of roadway was established in a typical section of Chicago, and all agencies estimated the costs of building each type. From these, a single set of construction cost estimates was prepared.

The staff of the Study estimated the performance cost curves for each design with respect to volume or rate of traffic flow. The separate accident, time and operating cost functions were combined to form special travel cost curves. With both capital and travel cost estimates, these three roadway designs could be plotted on the standard volume-cost chart as total costs. This is done in Figure 8.

The combination of travel costs plus construction costs of such facilities make them somewhat higher in total cost than either existing uncongested arterial streets or new expressways with reasonable loads. They would prove an economical addition to the array of street types only when traffic volumes within a very limited range would have to be carried at a specific location. In a large, solidly built-up urban area such as Chicago (the assumed background for the performance curves of Fig-

[2]This refers to the standards set by the U.S. Bureau of Public Roads for the construction of the Interstate System of Highways—about the highest standards for highway construction existing.

ure 8) there is a great potential readjustment of traffic as drivers adjust to new facilities. Thus, it can be seen that the most profitable strategy of highway improvement will be to build expressways so that they are heavily used, and also so that traffic volumes on existing arterial streets will be reduced below that level which would require widening or other action. If this can be accomplished without recourse to the intermediate designs, it becomes clear that greatest rewards come from adding expressways.

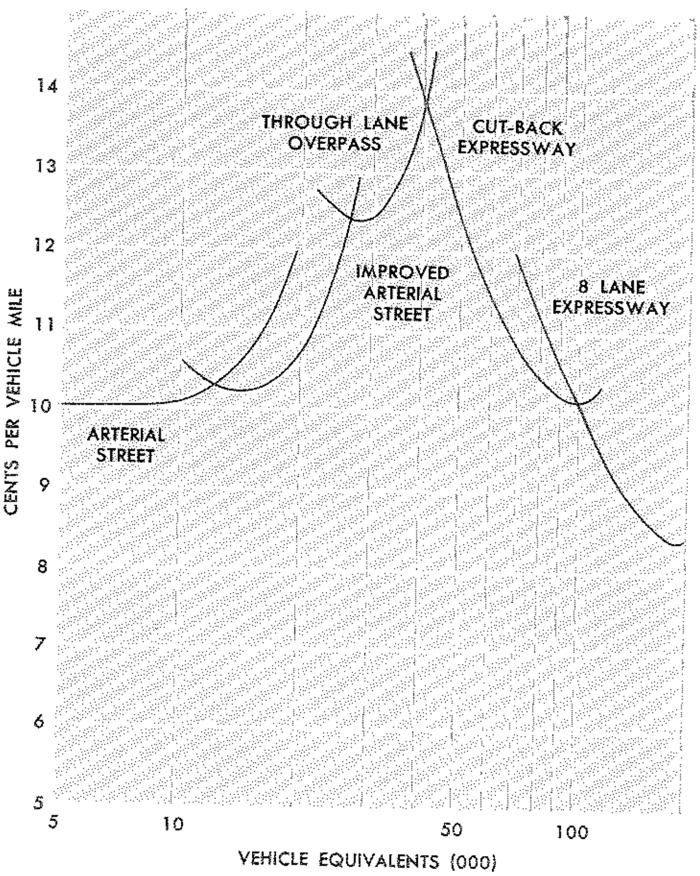


FIGURE 8—TOTAL COST FUNCTIONS FOR FIVE DIFFERENT MAJOR STREET DESIGNS

See Table 26 in Appendix.

This has been important work leading to fixing the standard roadway types best calculated to produce the over-all results desired. However, roads are not laid down without very close relations with the neighboring use of land. So before any work is done on system planning, some attention must be directed to the requirements of land usage. The extent to which healthy land use can be promoted by designs of highway systems will help further to specify the kinds of plans to be drawn. This is taken up next.

LAND USE AND THE STREET SYSTEM

If traffic were distributed evenly among all the streets in the city of Chicago, every street —local as well as arterial—would carry over five thousand vehicles per day. This volume is equivalent to five hundred vehicles per hour in the peak hour. This much traffic would severely disturb the peace and quiet of any residential area. Moreover, traffic accidents would rise, and travel speeds would drop so much that all land would have substantially less accessibility and, therefore, lower values.

Such an even spreading of traffic on all streets may appear absurd, yet growth in traffic in any urban region with a fixed supply of streets will move toward such a situation. As travel increases, congestion on major streets begins to force traffic to divert through the narrow channels of local residential streets.

Evidence indicates that traffic on Chicago streets already is being forced through the local street system. The average volume on all local streets in Chicago exceeds 1,700 vehicles per day, while in the ring lying between two and four miles from the Loop local streets average 2,500 vehicles per day. In many cases, streets situated a quarter mile apart are carrying over five thousand vehicles per day. All this occurs even though local traffic alone would require an average of no more than from five to six hundred vehicles per day.[3]

From the viewpoints of both land use and traffic, such spreading out of traffic should be halted. A sound plan must provide facilities which can contain and discipline vehicular traffic. One method for doing this, already suggested, is to provide streets in quantity and in kind sufficient to carry future loads, i.e., to prevent pressure back-up through neighborhood streets. This means streets in addition to present ones. Merely making more local streets into arterials will not do the job. Quite the reverse would be expected, because such a policy would destroy the effectiveness of existing arterial streets by increasing the frequency of signalized intersections and also would destroy the neighborhood values. New highways must

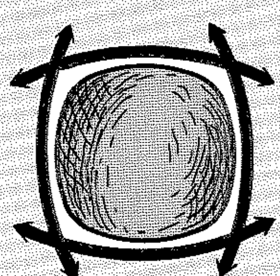
[3]For formula for estimating loads on local and arterial streets, see Schneider, Morton, "Traffic Distribution on a Road Network," a paper presented at the Nineteenth Annual Meeting of the ...

be able to withdraw traffic from the surface system—this can be accomplished most reasonably by providing new capacity on a separate plane—i.e., building new, heavy duty roadways that are below or above the present plane of arterial streets.

A second method would be employed along with the first: to declare certain areas off-limits to through traffic. This idea of having certain areas free from through traffic is not new; in fact, it is one of the most commonly accepted planning standards. Planning and urban redevelopment can make this idea effective in both new and old parts of the city. The task of this section is to give these areas dimensions and meaning, so that transportation plans will aid the total process of providing a better urban land use fabric.

The Local Traffic Island

Many kinds of land uses find that traffic is not a good neighbor. Houses, parks, playgrounds, churches, schools and other institutions usually label heavy traffic as a nuisance. Even business establishments recognize that heavy traffic impairs the ability of their customers to park and walk between stores. More and more urban activities are trying to insulate themselves from traffic and to specialize parts of their sites for parking, for pedestrian movements, and for buildings.

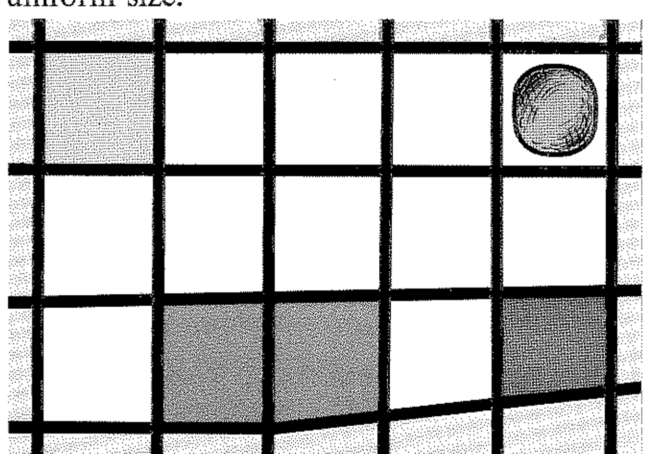


THE TRAFFIC ISLAND is an area free of through traffic, designed mainly from the viewpoint of land use and the pedestrian.

One of the recognized goals of city planning is to establish a module, or land use building block, within which the claims of land use will have priority over those of transportation. Such a module can be called a "local traffic island" —a unit of land, like the pedestrian traffic island in the middle of the street, around which traffic will flow. The channels for through traffic are, of course, arterials although, in some cases, expressways, canals or railroads may form boundaries. The main characteristic of this unit of land use is that only traffic destined to, or originating from, activities within the unit will be found on its internal streets.

The principal problem here is to find the appropriate size of these local traffic islands. This, of course, has a great bearing upon the spacing of through streets. There are a number of factors which influence the size to be used. These include system continuity, the attendance areas of elementary schools, the density of traffic generation, and the section lines laid out by surveyors more than a century ago.

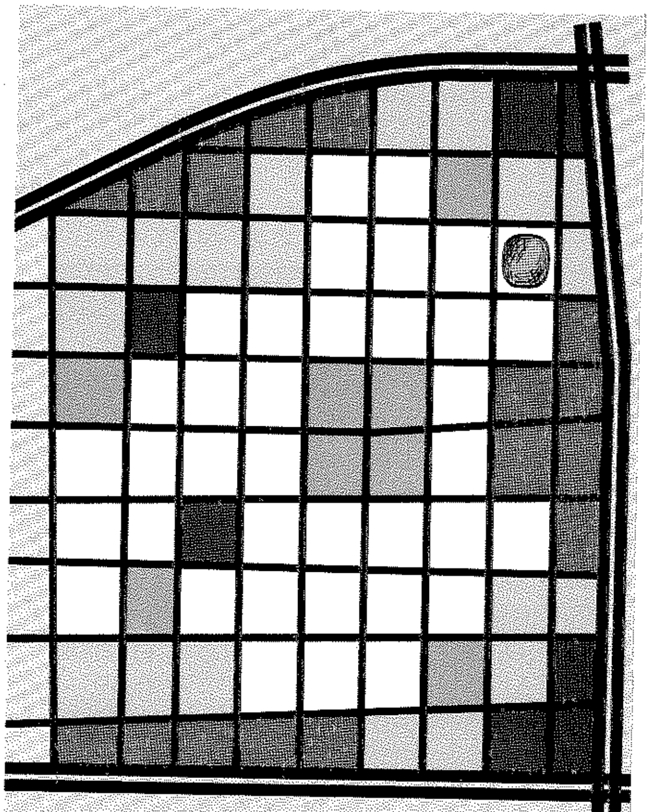
By and large, traffic islands all must be of the same size within any given part of the metropolitan region. The reason is that the arterial street system must form a continuous network. If it does not, the kind of service it can provide is greatly reduced (see design principles, page 37). Of course, there are bound to be exceptions, as when a railroad or canal slices through part of the region, but, for the most part, the islands will be expected to fit within a gridded arterial network and to be of uniform size.



SYSTEM CONTINUITY requires most traffic islands to be about the same size, regardless of their land use.

The majority of traffic islands will be residential in character. This is because housing, with its companion local streets, schools, small parks, and service and shopping areas, takes up over sixty per cent of all urban land. The size of the residential island then becomes a major influence on the size of the island module and the spacing of arterial streets throughout the urban region.

One of the major activities of a residential area is elementary education. Normally, a population of five thousand persons will have enough children to fill an elementary school, or about four hundred to six hundred children in kindergarten through grade six. These children should not have to cross major streets on their way to school—such crossings are a danger and they necessitate training and stationing of crossing guards. Thus, it would seem wise to make the traffic island and the elementary school attendance area the same, thereby minimizing the need for children and vehicles to cross paths.



COMMUNITIES may exist with centers in common for various activities, or with overlapping functional areas, but the expressway network normally encompasses two or more such community areas.

At suburban densities, five thousand persons will need five hundred to six hundred acres of land for their houses, streets, schools, churches, shops and other neighborhood land uses This is nearly a square mile. Such an area indicates an arterial system spaced, on the average, at intervals of about one mile.

In densely built-up Chicago, the average enrollment in elementary schools is fairly high —about nine hundred children, kindergarten through grade eight. This implies neighborhoods with greater population than in the suburbs, averaging about nine thousand persons. A population of this size can be accommodated at the prevailing high residential densities (twenty-five families per acre) within a quarter square mile, including streets and necessary nonresidential uses. This implies arterials spaced one-half mile apart. It can be surmised, of course, that Chicago school authorities have long recognized the existing major street pattern, which is spaced at half mile intervals, and have adapted their school sizes to the larger populations contained therein.

Schools, then, are an important factor affecting the size of the land use module. Neighborhood playgrounds also have a similar influence. Of course, all residential areas can not fit precisely within such a package, but the conception of an island with a self-contained school district is an ideal with strong merits of safety and economy. Moreover, it is a simple unit into which more complex land use arrangements can be settled.

From an operational viewpoint, the size of the "island" must be conditioned both by the traffic density in the area and by the capacities of the arterial streets. In regions of very dense traffic, arterials must either be placed very close together or their capacities greatly increased. Chicago's Central Business District is an example of the very highest trip densities. Large volumes of vehicle trips have made virtually every street an arterial. The necessary introduction of signals at block intervals severely cuts street performance. The result is a large number of relatively low capacity arterial streets and extremely small "islands." Sometimes a single building, like the Merchandise Mart, is a self-contained community.

As islands become larger, arterial streets naturally are forced farther apart. In any given part of the region, the more widely spaced the arterial streets, the greater the load each must carry. Since arterial streets in the built-up sections of the Study Area have their rights-of-way "frozen" by existing buildings, too great spacing would result in severe congestion, because it would not be possible to enlarge the present arterial right-of-way excepting at great expense.

Table 5 illustrates how particular densities and spacings would affect the demands which would be made on arterial streets. The average trip density for Ring 4—the ring containing the outer parts of the city of Chicago, Evanston and Oak Park—is about seventeen thousand vehicle trip origins per square mile per day. Without expressways to carry a significant portion of the load, arterials would have to be spaced less than a half mile apart, and, even so, they would be crowded. This would force local streets to continue to carry non-local traffic.

Table 5 also shows how, in high density regions, arterials must be spaced at half-mile intervals. Even with this very close spacing, arterials are shown to be so heavily loaded that the construction of expressways is necessary to aid in reducing traffic volumes and congestion. In regions of lower trip density, arterials can be spaced as much as a mile apart without creating undue volumes on local streets or arterials. Major routes spaced more than one mile apart will be feasible only in rural or semi-rural parts of the region and, therefore, are not a satisfactory long range solution for the suburban parts of the metropolis.

A most practical and immediate factor affecting traffic island size is the layout of existing streets. This cannot be altered except at extreme cost. The original mile and half-mile roads laid out by surveyors in the early nineteenth century have survived as a system of major streets. These have been emphasized further by streetcar lines, by zoning, and by the building habits of a century. In Chicago, most half-mile streets are arterials—parts of the preferential street system. In the outlying suburban and rural areas, the section line, or mile streets, are prevalent as arterials; but the half-mile streets have not been drawn into the signalized and signed network.

All of these facts combine to fix the size of local traffic islands, for all practical purposes, at one-quarter square mile in Chicago and the nearby, high-density suburbs, and at one square mile in the remainder of the Study Area. Arterial streets accordingly would be spaced at one-half mile intervals in Chicago and at one mile intervals in the low density suburban regions. This does not mean that such streets must form a perfect checkerboard pattern. There always will be variations. It does, however, help to establish the design scale of a continuous arterial network for future traffic planning.

Within either of these sizes of traffic islands, schools can function with fewer children having to cross busy streets. But more important, perhaps, is the opportunity for useful design and re-design of the local street system. Safety, amenity and economy can be served by careful planning of new subdivisions or re-planning of streets in renewal areas.

With regard to safety, it is clear that the local street is characterized by the highest risk

TABLE 5
APPROXIMATE VOLUMES ON ARTERIALS AND LOCAL STREETS AS FUNCTIONS OF ARTERIAL SPACING AND THE NUMBERS OF TRIPS GENERATED PER SQUARE MILE

Trip Densities in Weighted Vehicle Trip Destinations Per Square Mile Per Day	ARTERIAL SPACING[a]					
	½ Mile		1 Mile		1½ Miles	
	Arterial Volumes	Local Street Volumes[b]	Arterial Volumes	Local Street Volumes[b]	Arterial Volumes	Local Street Volumes[b]
10,000	14,000	230	26,000	430	36,000	600
15,000	21,000	345	39,000	645	54,000	900
20,000	28,000	460	52,000	860	72,000	1,200
25,000	35,000	575	65,000	1,075	90,000	1,500

[a]Assuming no expressways in the vicinity.

[b]Assuming that arterials could carry the indicated loads and so would not become congested and force traffic back onto local streets.

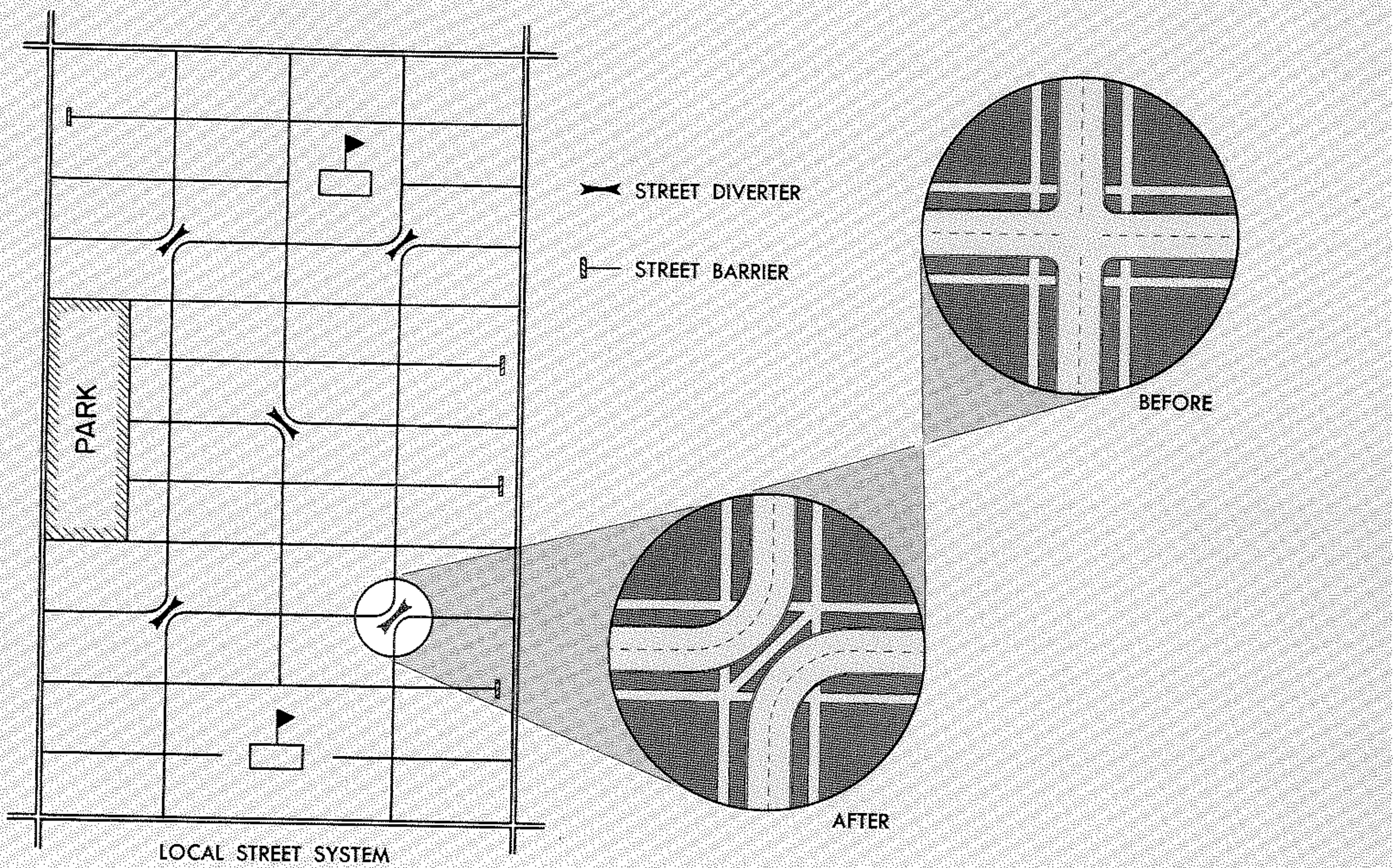


FIGURE 9—LOCAL STREET SYSTEM RE-DESIGNED TO IMPROVE SAFETY AND DETER THROUGH TRAFFIC

and highest accident cost (see Table 3, Chapter II). The chance of an accident per mile of travel on a local street is almost five times as great as on an arterial street. Of particular concern is the fact that thirty-two children under the age of fourteen were killed on local streets in 1957. Studies have shown that the elimination of 4-way intersections and the breaking up of gridiron local street patterns can reduce accidents significantly.[4]

The re-design of local streets to improve safety also can be an effective method of deterring through traffic. By judicious treatment of existing or new systems, designs can be worked out to make it very difficult to use local streets for through or by-pass travel. Figure 9 illustrates how intersections can be treated for this effect. Figure 10, page 32, shows how the local street design of a new subdivision can be used for this purpose.

[4]Wallen, Martin A., "Landscaped Structures for Traffic Control," *Traffic Engineering*, January, 1961 and Marks, Harold, "Subdividing for Traffic Safety," *Traffic Quarterly*, July, 1957.

Finally, there is some economy in a more flexible use of local streets. Figure 11, page 33, shows the "before and after" local streets in the Lake Meadows re-development area. The re-platting of only enough streets to serve property brought about a thirty-five per cent reduction of land area devoted to streets, which increased the land area available for buildings or other uses.

The Question of Community

If the traffic island is a modular unit fitting within the webbing of arterial streets, is there a larger module or grouping of land uses which would fit within the strands of an expressway network? This question is important because if there were such a unit it would affect the spacing of expressways and so be a major influence in transportation planning.

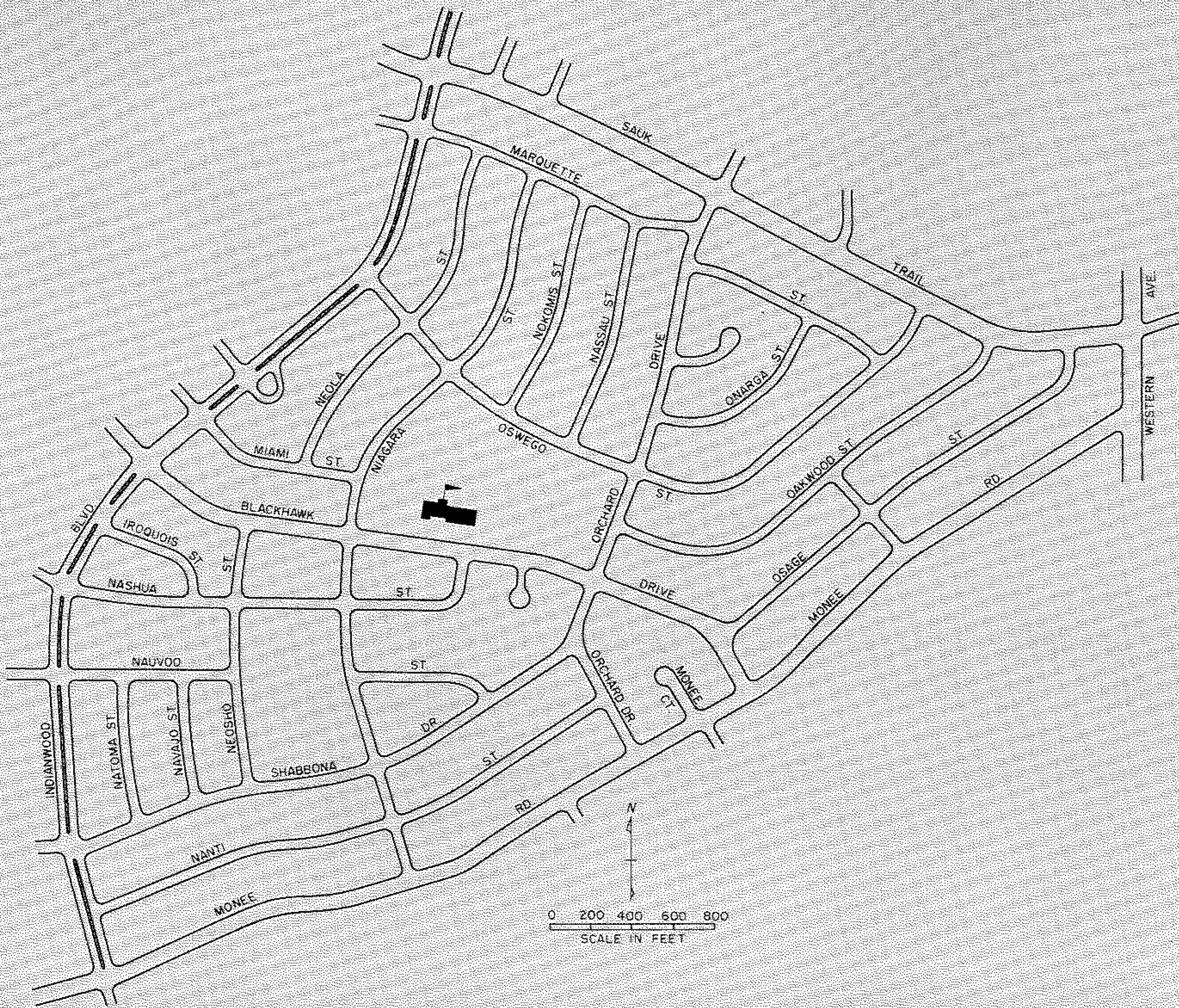


FIGURE 10—LOCAL STREET PLAN FOR A LOW DENSITY RESIDENTIAL NEIGHBORHOOD IN A NEW SUBDIVISION DESIGNED TO ELIMINATE THROUGH OR BY-PASS TRAVEL

A neighborhood in Park Forest illustrates a street system designed only for local traffic. Heavier volumes use surrounding arterial facilities. The school is centrally located for maximum accessibility. The number of dangerous crossing intersections that would have been built if a grid system had been used has been substantially reduced.

City planning literature often refers to the community—a unit composed of a series of neighborhoods or traffic islands. The community is thought of as an area with a population of from 30,000 to 100,000 persons, more or less self-contained as to its school, shopping, government and social facilities, and distinct and separate from the "trade areas" of facilities serving other communities. An example of a community in the Chicago area might be Oak Park, a municipality coterminous with its own school district, and with a strong sense of local identity.

Careful examination was made of the Chicago area for evidence of a natural tendency for communities to form.[5] Detailed measurements of school districts, travel patterns, statistical areas and social groupings were used in an attempt to discern natural subdivisions of the city and suburbs. While there are a number of cases where such communities apparently exist, most of them are in the suburbs where contrast with surrounding farm land gives them an especially clear identity. As the urban area grows, it appears that these communities tend to merge and lose their former sharp identity.

Even more important, there is strong evidence that the functions of school, shopping, government and social groupings rarely are coterminous in the Chicago area, but have overlapping "trade areas." This should not be surprising, because their functions are different. There is no obvious reason why the best

[5]See Black, Alan, *An Examination of the Community Concept with Reference to the Study Area* (32,860), (Chicago: CATS, 1961).

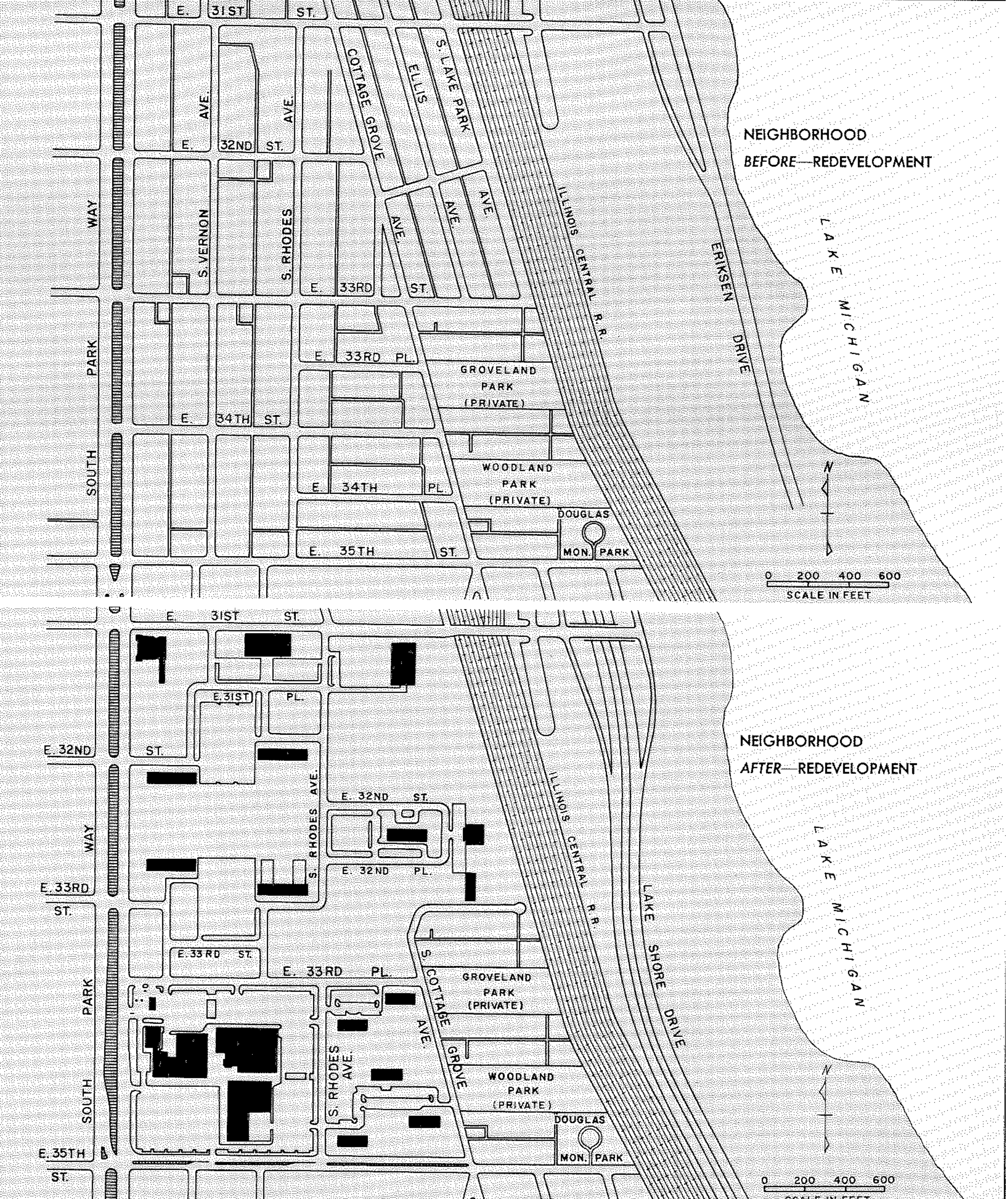


FIGURE 11—DESIGN FOR A HIGH DENSITY RESIDENTIAL NEIGHBORHOOD—BEFORE AND AFTER REDEVELOPMENT

The Lake Meadows project is an example of how redevelopment can make an area safer and more attractive. The new street system uses less area and discourages through traffic from crossing the project. Before, 25 acres were devoted to local and arterial streets—but after, only 16 acres are required. In addition, surrounding arterial streets have improved traffic control median barriers.

trade area for one should be the best trade area for another. This does not prove that communities do not exist, nor, in fact, whether there is value in having communities or in fostering their growth. It simply indicates that in the Chicago area, where land is fully developed, there is no evidence that such idealized types have evolved in clear-cut, discernible form. In addition, it became clear that expressway spacing would have to embrace much larger populations than the 30,000-100,000 nominally sought for communities. So there is no presently discernible "community" cluster or size that would dictate desirable expressway spacings.

While the community remains a question mark, it is apparent that a real goal in locating expressways is to avoid damaging the functions which were thought to characterize the community. Expressways should not divide the "trade areas" of schools, governments or shopping centers. While it obviously is impossible to avoid all these areas (since their boundaries are not all the same), this goal is considered important in route planning. This remains an objective which will influence the more detailed plans for the construction of new facilities.

One way of identifying these functional trade areas—and hence avoiding them in planning expressways—is to map the short trips which are made in automobiles. This has been done by the Cartographatron, and the results are given in Figures 12 through 15.

As can be seen, short trips tend to cluster in fairly well defined areas. The suburban clusters are sharpest because of their contrast with surrounding rural territory. Within Chicago, clusters are formed by the breaks caused by industrial developments, railroad yards, canals and major parks and cemeteries. Where these clusters exist, there are large numbers of local and arterial streets serving these movements. These are areas where new expressways would cause the greatest disruption in local traffic and where the costs of providing overpasses and underpasses would be very heavy. Thus, while these functional areas will bear on final location, other considerations must be used to scale the spacing of the expressway network.

Conclusion

When the standards for planning transportation systems are considered, it is necessary to hold in balance many different requirements. Among the more important of these is land use, which exercises a strong influence on transportation plans. The reason is that a transportation system is like a hollow, porous bonework—that is, it serves both as the blood stream and the skeleton of a metropolis. Plans must be adjusted so that land use cells are well organized and adequately nourished with transportation services while being protected from damage by the flows of traffic.

A basic cell, or land use building block, has been identified as the local traffic island. This is an area free from through traffic with its own capillary system of local and collector streets designed to serve only local traffic and the pedestrian. Residential islands are called neighborhoods. In the give and take between land requirements and transportation requirements, system continuity imposes the restriction that these islands should all be of about the same size in any given part of a metropolitan region. Land use requirements—mainly those of elementary schools—coupled with trip generation requirements, indicate that the islands should be about one-quarter square mile in Chicago and nearby high density suburbs, and one square mile in low density suburban regions.

There emerges, then, a conception of an urban region organized as a group of cells or building blocks defined by the arterial network. This is a flexible system, allowing different constellations of activities to develop their own efficient trade areas—some overlapping, some identical with those of others. And, in general, this seems necessary, since outside the traffic island most circulation must be vehicular. Of course, it is assumed that good sense in planning and zoning practice will be followed—that heavy industry will not be located next to housing, that parks and playgrounds are in correct quantity, and that the details of

FIGURE 12

AUTOMOBILE TRIPS LESS THAN THREE MILES LONG

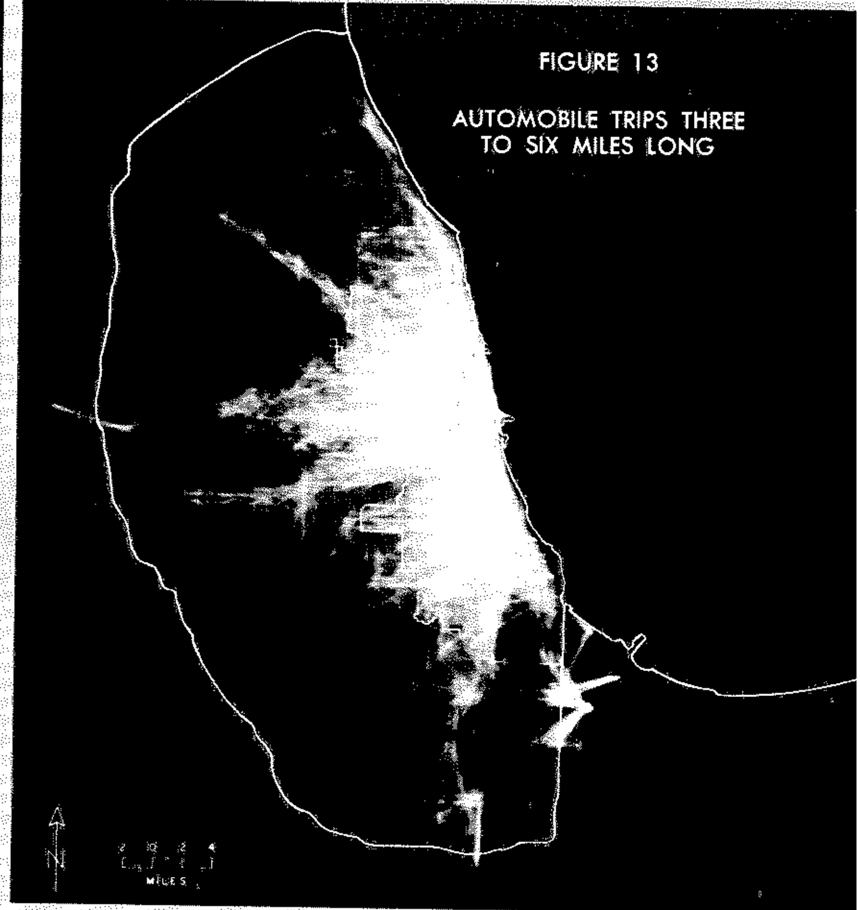


FIGURE 13

AUTOMOBILE TRIPS THREE TO SIX MILES LONG

The short, localized trips of less than three miles account for 43 per cent of all automobile trips, but only 18 per cent of the total vehicle (automobile) miles of travel. These trips are made primarily on the local and arterial street systems. The three to six mile trips make up 26 per cent of all automobile trips and 22 per cent of the total vehicle (automobile) miles of travel.

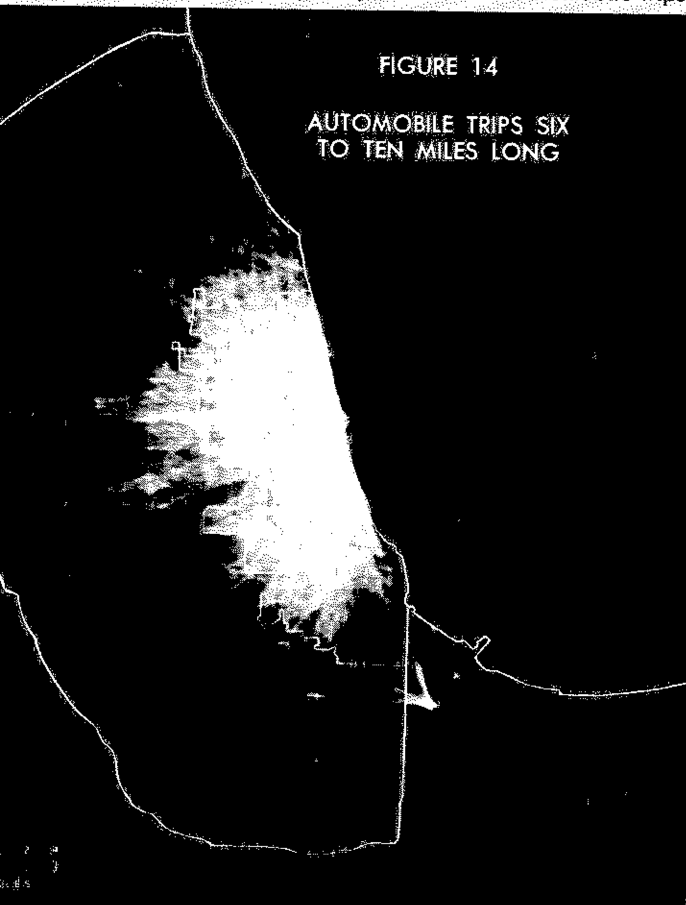


FIGURE 14

AUTOMOBILE TRIPS SIX TO TEN MILES LONG

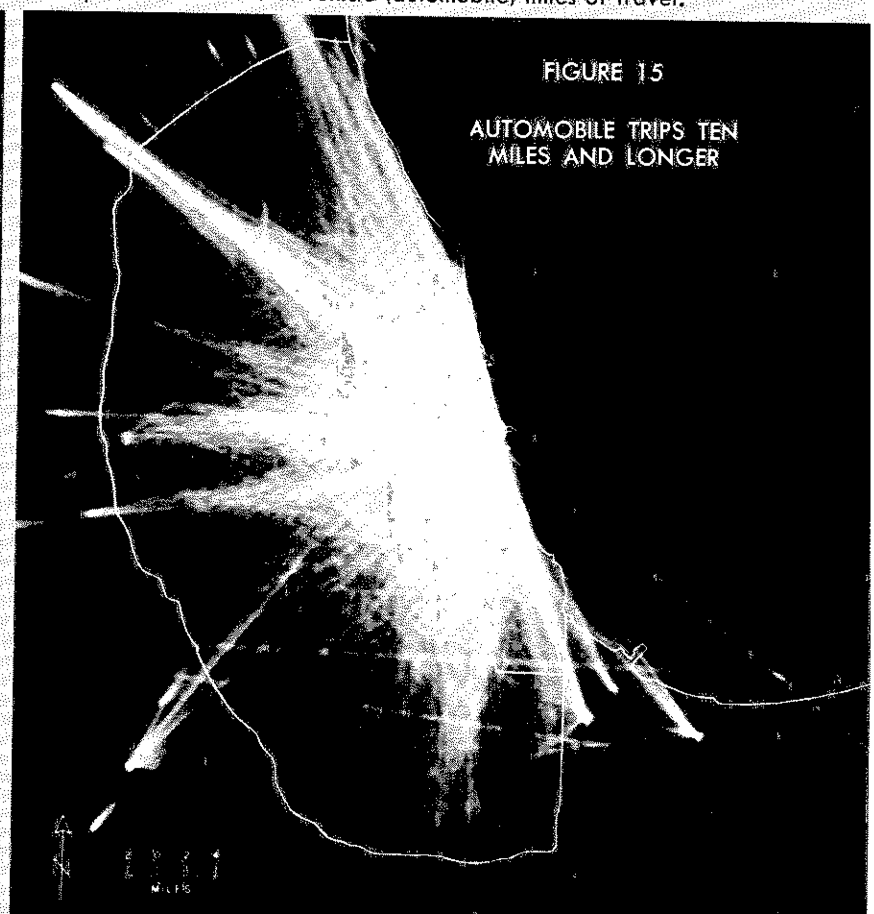


FIGURE 15

AUTOMOBILE TRIPS TEN MILES AND LONGER

Nearly equal in the number of trips, the two displays differ in their respective shares of the total vehicle (automobile) miles of travel, the six to ten mile trips make up 26 per cent, while the ten mile and longer trips account for 34 per cent. Of all trips over ten miles in length, 74 per cent have both their origin and destination inside the Study Area.

highway design and site planning are handled well.

If this conception of urban organization is to work, however, there must be a third network—the expressway system. This system's function is to drain long distance traffic from arterials, leaving that system free to serve land uses and carry medium length trips. The expressway network is on another plane—above or below the arterials and not connected with land uses. It must, however, recognize the heaviest generators of trips and must avoid damaging functional trade areas. Yet it has its own requirements, which are considered in the following sections.

PRINCIPLES OF SYSTEM PLANNING

No urban roadway can exist in isolation from other roadways, since each must interconnect with others at some point. In this sense, roads always have been planned with some thought for system connection. Yet, until recently, planning emphasis has been primarily on the individual road—the arterial connecting the residential area with the downtown business area, or the expressway by-passing a city—a single road with a single name. Today's thinking, by contrast, is directed to the comprehensive network of roadways, recognizing that no single segment is independent of others.

In this Study, network planning is the dominant concern. This is essential for several reasons. Better information has shown that one new roadway immediately alters traffic patterns on the neighboring streets. For example, the Northwest Expressway has reduced traffic volumes not only on parallel surface streets, but also on the northern part of the Outer Drive. On the other hand, streets leading to expressway ramps have experienced increased traffic requirements. Current information has shown also that there is such a widespread distribution of origins and destinations that single facilities cannot possibly serve these enlarging requirements—only a fully interconnected network will succeed. Planning and designing whole networks and estimating the traffic usage presents very complex problems. Fortunately, however, the more efficient record keeping systems of modern business machines and the large and fast computers enable the planner to deal with these more complex problems.

It is the objective of system planning to see that roads do not interfere with, but rather complement, one another. This is necessary to extract maximum benefit from each new piece of construction. To secure this objective, attention is focused on two principal aspects of network—the junction points of roads, and the spacings and patterns of the strands of the network. In this section only one network, such as an expressway network, is dealt with at a time, leaving consideration of the combinations of networks until later.

Basic Networks and Their Characteristics

There are a number of different network patterns which can be used in transportation system planning. There are grid patterns, ring and radial (spider web) patterns, combined grid and radial patterns, and irregular patterns. These are illustrated in Figure 16.

By inspecting these patterns, some observations can be made of the features that make for a good network. The irregular pattern illustrates several aspects to be avoided. First, stub ends of expressways, in more dense parts of the area, indicate a great likelihood that the expressway will be underused and that the adjacent surface streets will be highly congested as a result of the traffic concentrated by the expressway capacity. Secondly, some routes are laid out with changes in direction, or jogs, which will require many drivers to travel greater distances and thereby increase costs and reduce performance. Thirdly, several expressways feed into one as the more intensive traffic areas are approached. This leads to built-in traffic congestion. The other network types are more systematic and therefore less subject to the same criticism. But they do present other good and bad design features.

The ring and radial pattern provides an even distribution of facilities against demands. That is, it provides more roadways and capacity near the center, yet progressively less as distance outward is increased. Since densities decline as traffic moves outward from the central area, the roadways are seen to thin out where

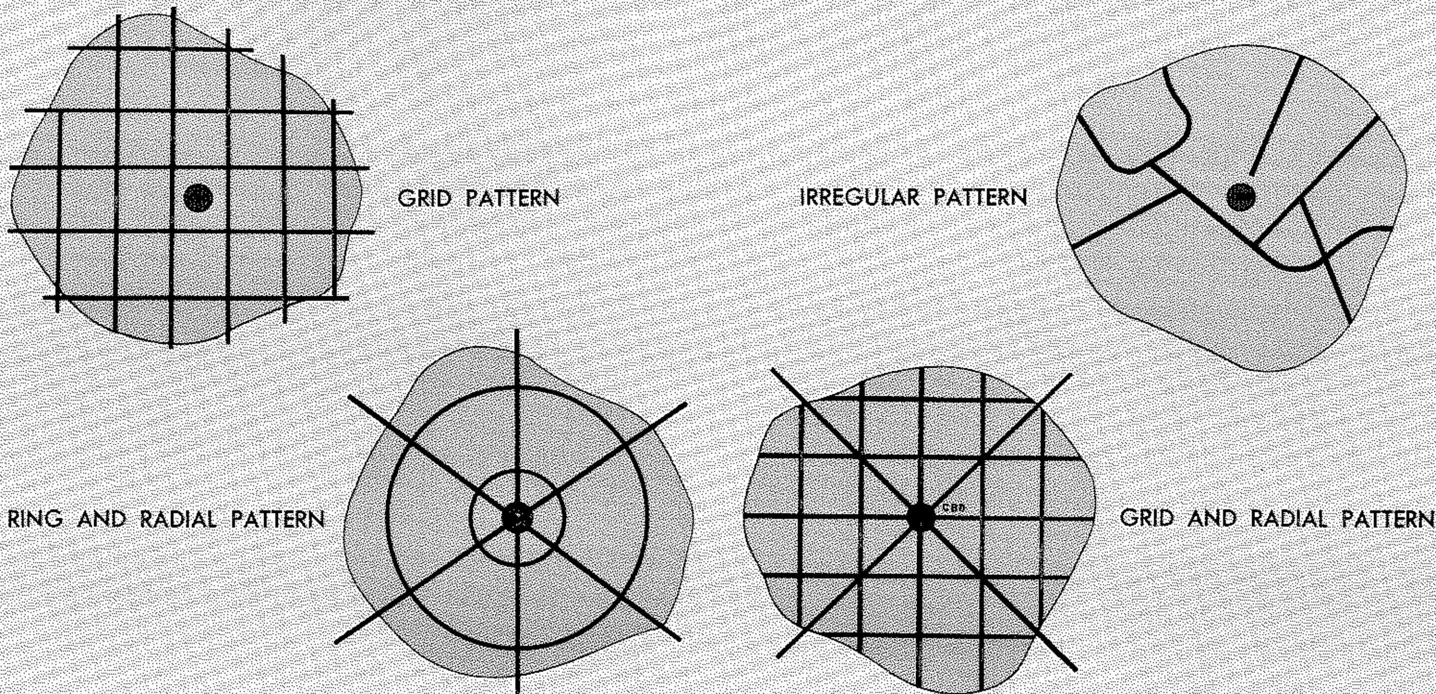


FIGURE 16—BASIC EXPRESSWAY NETWORKS

traffic requirements will be lower. On the other hand, the radial system does provide roadways aimed at the center of town where it will be desirable and even necessary to encourage transit usage. Feeding cars to the center can build up heavy parking and street capacity problems and so work to inhibit a densely developed CBD. Densely developed centers can exist only if a sufficient number of customers and workers can be delivered each day in a satisfactory manner.

The grid system overcomes the problem of too much central focus. But it does not appear to serve (excepting by the possibility of differential numbers of lanes) the variety of trip densities of the region. It is simple and regular, making the intersection design easy and the user orientation very satisfactory.

A combination of grid and radials would meet the requirement of increasing service where there are higher traffic demands. But it presents intersection problems of virtually impossible scale. It would be prohibitively expensive to try to design and build six-legged intersections.

A plan for the Chicago area would appear to be best constructed if it could have some blend of the attributes of the grid with those of the ring and radial system. To a large extent, the region is heavily committed to the radial system by the Northwest Expressway, the Southwest Expressway and the Chicago Skyway. On the other hand, the underlying arterial system is a strong influence for a gridded network of expressways. The need to meet distributed traffic demands without encouraging further concentrations of flow also argues for a grid-like design. Making a compromise between the two would require ingenious design, but represents the direction that seems most likely to meet traffic needs and, from a network viewpoint, sensible design.

Expressway Connection and System Design Rules

Individual roads have recognized design criteria, but systems of roads also need design criteria governing both the junctions between roads and their locations with respect to one another. In answer to this need, engineers of the sponsoring agencies adopted a series of design precepts. These have been used in laying out a comprehensive system of expressway and arterial networks. Those precepts which most affected system design are given below.[6]

1. At the junction of two expressways there should, wherever possible, be provision for all turning movements.

[6]This is the list approved by the Planning Design Subcommittee of the Study.

2. "T" intersections between expressways should be avoided, particularly when the top of the "T" faces toward a region of higher average traffic density.
3. Two facilities should not reduce to one in areas of increasing traffic density: instead, they should branch as traffic loads become higher.
4. The number of lanes entering an expressway intersection should balance those leaving.
5. Ramps in urbanized areas (including suburban areas) should not be less than one mile apart nor more than three miles apart.
6. There should be no stub ends of expressways.
7. No intersection of expressways should have more than four legs.
8. Roadways in both express and arterial networks should be so located as to approach uniform spacing between parallel segments. At the same time, spacing should vary inversely with local traffic density.

These very sensible rules create an image of a smooth, interconnected system, distributing service to all parts of an urban region. The things these rules prevent are sudden concentrations of traffic loads, excessively complicated interchanges, or duplication of service.

Only one final element of design criteria is missing to complete the description of ideal networks. Evidence of efficient street types, together with the general rules for assembling them into networks, has been reported. Yet, to identify ideal networks, the problems of exact frequency and spacing must be dealt with. These are problems of degree. How closely or loosely should the warp and woof of these networks be woven? All kinds of general statements may be made, but to proceed to designs requires that the planner be armed in advance with knowledge of the particular spacing most likely to produce a "best" plan. He must have specific, measured spacing information.

The hard way towards such answers would be to design alternate systems which appear to meet these precepts, to test each one by allocating future traffic, and then measure the cost and performance to see if improvements resulted. But this would be a time consuming approach. The objective of the next section is to specify further the design limits for successfully producing a least cost transport system.

DETERMINING THE BEST COMBINATION OF FACILITIES

Suppose that a farmer has to drain a meadow so that it can be plowed. Consulting his catalog, he finds two sizes of agricultural drainage tile—four inch and eight inch. These will do to remove water from his fields, but they are not large enough to carry the water away to a nearby river. To do this he must construct open drainage ditches—and these, although more effective, are more costly. How many feet of each size of pipe and how many feet of ditches must he install to achieve the least costly solution?

This kind of problem faces the urban planner seeking the best design for an urban highway system. The kinds of roads to be used have been identified. How roads must connect with one another and how they must relate to land use is known. The large unknown factor is the proper quantity of each type to recommend—i.e., the most efficient spacing pattern to follow.

Both local and arterial spacings are fixed largely by land use considerations. For local streets no traffic capacity problems are expected. The objective of local street design and layout will be to minimize the mileage of this road type, yet still supply access to every land parcel. Moreover, as reported later, designs which eliminate four-way intersections and possible through connecting paths between adjacent arterials will succeed in discouraging nonlocal trips and will reduce accidents on the local streets.

Arterial streets should be spaced far enough apart to contain reasonably sized neighborhoods corresponding to elementary school attendance areas. Yet, the spacing should not be so great as to force undue traffic volumes onto essentially local streets. Existing practice has developed preferential or arterial street spacing of about one-half mile intervals in the built-up, dense center of the region, but increasing to a one mile spacing interval in outer suburban areas. And it is of interest that this spacing is about the right size for elementary school neighborhoods.

If local and arterial streets are spaced in this fashion, the remaining—and very significant—problem is to find the best spacing of expressways. Unlike arterial and local streets, there is substantial latitude in building expressways. Land use considerations are not such a determining factor and, unlike arterial streets which are already in existence, expressways are built new and on new locations. The spacing problem is real, because this network is now under construction and has not crystallized in shape. The quality of a future regional highway plan turns on this very point of expressway spacing, so this question is taken up next.

Defining Optimum Spacing of Expressways

Travel on expressways has been shown to be substantially faster, safer and cheaper than travel on arterials—especially on congested arterials. The relative costs of travel on each type have been evaluated. It is less costly for the community as a whole if traffic can be shifted from the arterial to the express network. This is not only because travel on expressways is innately more economical, but because, with less congestion, travel costs will be lowered for those travelers who remain on the arterial system.

Drivers will respond readily to the invitation to use expressways, and savings will result. The Congress Street Expressway illustrates this point. Before it was opened, all vehicular travel on the West Side of Chicago was on the surface streets—i.e., on local or arterial streets. Now the new expressway carries 1,000,000 vehicle miles of travel daily or 2.5 per cent of total vehicular mileage in the region! A sampling of traffic volumes taken on five parallel arterial streets illustrates the reduction in volumes on surface streets (see Table 6). This rearrangement of traffic produces superior service to motorists—especially in improved speeds. Speeds on parallel arterial streets will be better by virtue of less traffic congestion, and speeds on expressways are known to be superior.

TABLE 6

SHIFT IN TRAFFIC VOLUME ON PARALLEL STREETS AFTER OPENING OF THE CONGRESS STREET EXPRESSWAY FROM LARAMIE TO FIRST AVENUE

Count Location East of Harlem Avenue On	Distance From Expressway (In Miles)	Weekday Traffic Fall of 1960		Percentage Traffic Volume Decreased
		Before Opening	After Opening	
Jackson Boulevard	¼	14,800	5,500	—63
Madison Street	½	26,700	15,000	—45
Roosevelt Road	½	27,000	14,000	—48
Washington Boulevard	⅝	16,000	9,000	—44
Division Street	2	10,200	8,000	—22

Source: Village of Oak Park and special counts by CATS.

There is an improvement in accident experience as well as in speed. This is illustrated in Table 7. Evidence was obtained by comparing the accident reports for the West Side police districts with those for the remainder of the city. Between the years 1955 and 1959, the main new improvement in the city was the Congress Street Expressway. While the measures are very gross and cover many other

TABLE 7

CHANGES IN TRAFFIC ACCIDENTS ON WEST SIDE AFTER OPENING OF CONGRESS STREET EXPRESSWAY

Severity Class	Total Reported Accidents				Percentage of City Accidents West Side Area	
	West Side		Remainder of City			
	1955	1959	1955	1959	1955	1959
Fatal	140	100	237	190	37.1	34.5
Injury	9,646	8,280	18,083	18,780	34.8	30.6
Property Damage	26,954	26,982	52,036	57,145	34.1	32.1
Total	36,740	35,362	70,356	76,115	34.3	31.7

Source: West Side is the sum of twelve police districts on or near Congress Street out of a total of thirty-eight in the city. Based on recorded accident reports obtained by Police Department and Chicago Park District Police.

Table 28 in Appendix gives changes in annual accidents on adjacent boulevards.

factors of influence, every indication is that the difference is significant. This is particularly true in light of the evidence that increases in traffic volume in this period were greater on the West Side than elsewhere.

From this evidence, it is clear that drivers will seek to use expressways. Such increased use will result in economies of time and reduction of accidents. Yet, there is an obvious limit to amount of traffic that can be moved from arterial streets to expressways. Trips are anchored to land terminals and must use local and arterial streets for at least a part of every journey.

If the problem of the best spacing is to be answered, it is necessary to estimate the amount of traffic that will move naturally into expressways at different spacings. This answer depends, principally, upon three things: the density of trip origins and destinations in the area and the surrounding region, the distribution of trip lengths and, of course, the specific characteristics of the system of roadways.

The number of trips for 1980 was estimated for the entire Study Area in Chapter IV of Volume II. Variable trip densities were forecast ranging from 28,700 vehicle equivalent trips per square mile per day in Ring 2, to 9,000 in Ring 6. Where there are more trips, it is probable that more miles of travel will be able to use expressways—all other things being equal. In the balancing of costs, then, it is expected that high trip densities will weight the answer toward a closer spacing of expressways.

The length of trips is another matter. The current pattern is illustrated in Figure 17. Half of these trips are under three miles in length, a quarter between three and seven miles long, and a quarter over seven miles in length. There is reason to believe that this frequency distribution will remain steady over the next twenty years.[7]

The distribution of trip lengths is of critical importance in the estimation of expressway usage. So the argument that the length of trips in 1980 will be distributed in the same frequency pattern as in Figure 17 requires some proof.

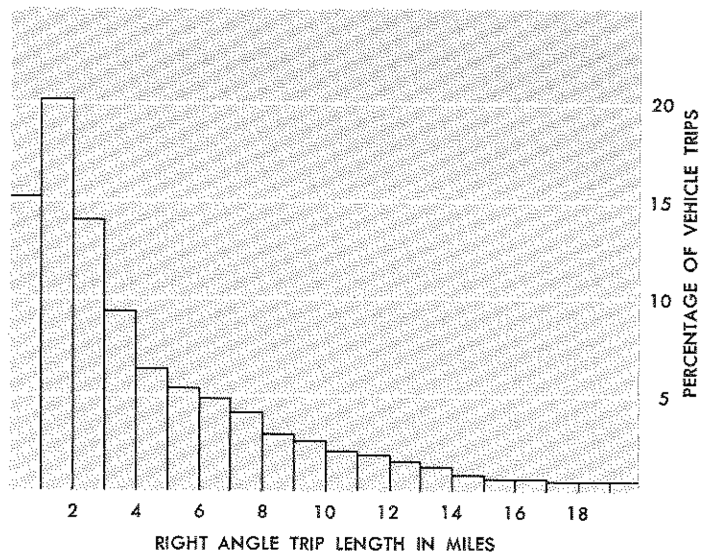


FIGURE 17—DISTRIBUTION OF WEIGHTED VEHICLE TRIPS BY RIGHT ANGLE TRIP LENGTH FOR THE CHICAGO AREA, 1956

See Table 27 in Appendix.

The reason for the trip distribution observed is that travelers find most of their common needs close at hand. This occurs because stores, service establishments and other agencies seek to find efficient locations close to their customers. This will continue to happen, and so provides an underlying stability to trip length distribution.

But it may be reasoned that larger incomes and more cars will have the effect of lengthening the average trip. To test this, trip length distributions were recorded for each ring of the Study Area. The automobile trips reported by all residents of each ring were arranged in frequency distributions and all were plotted on a single graph as shown in Figure 18. This shows similar distributions for each ring from 1 to 6, with no systematic pattern of variation.[8] Ring 7 is different. There the trips are more sharply bunched in the very short or very long groups, with less emphasis on trips of intermediate length. This is expected, because in this part of the region there are small, nucleated communities with large vacant, agricultural or park lands surrounding them. Because of this, travelers from Ring 7 *must* either conduct their business in their own towns or travel greater distances. However, by 1980 there will

[7]See Chapter VI of Volume II.

[8]For definition of Study rings, see Map 34 in the Appendix.

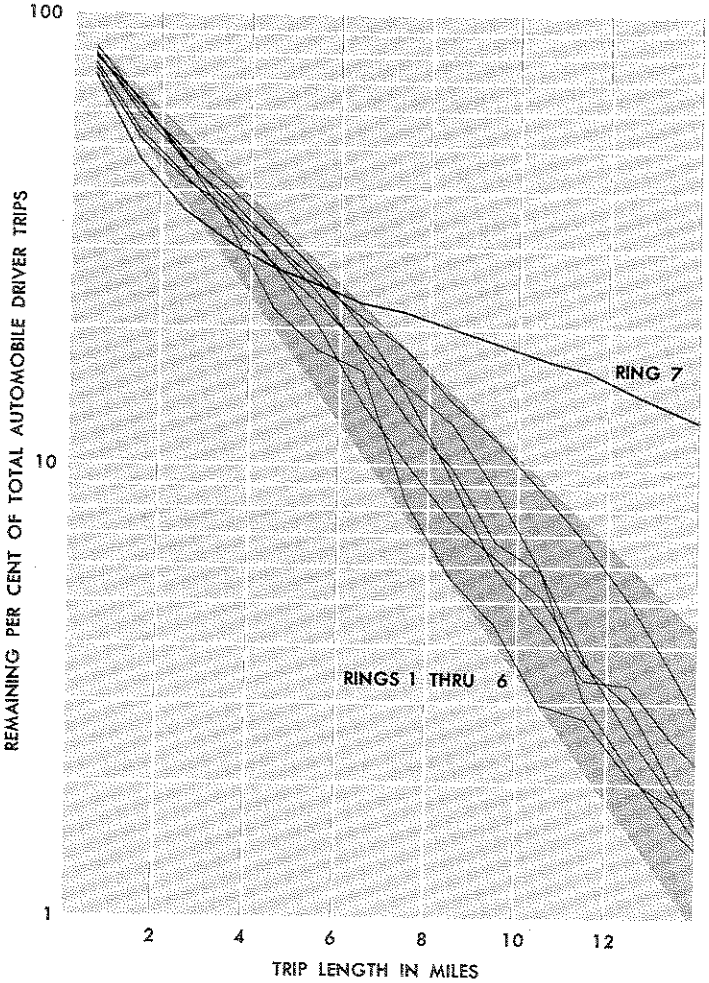


FIGURE 18—CUMULATIVE PER CENT FREQUENCY DISTRIBUTION OF AUTOMOBILE DRIVER TRIPS BY TRIP LENGTH —SEPARATE PLOTS BY RING OF RESIDENCE

See Map 34 in Appendix for ring locations.

be a much more complete development in Ring 7, so the travelers of 1980 who live there can be expected to behave much like the Ring 6 travelers of today. Because of this cross-sectional stability of pattern, it is quite reasonable to expect future trip length distribution to be much the same as it is at present.

The small percentages of long trips does not indicate their impact on the road system. This is shown more clearly in Figure 19. Whereas, only twenty-five per cent of all trips are longer than seven miles, fifty-eight per cent of the vehicle miles are contributed by these trips. And a quarter of all the vehicle miles are driven by the five per cent of trips which are eighteen miles or more in length!

From Figure 19 it can be seen that it is possible to put a substantial proportion of an urban region's travel onto express facilities. Assuming efficient network design, the amount depends upon the number and placement of these facilities. If they are built closer together, with ramps at frequent intervals, short and medium length trips get a chance to use them. As a result, more miles are likely to be driven on expressways and travel costs of the region will be reduced. However, if expressways are built farther apart, only the longer trips can use them; fewer miles will be allocated to expressways and regional travel costs will not be reduced by so much.

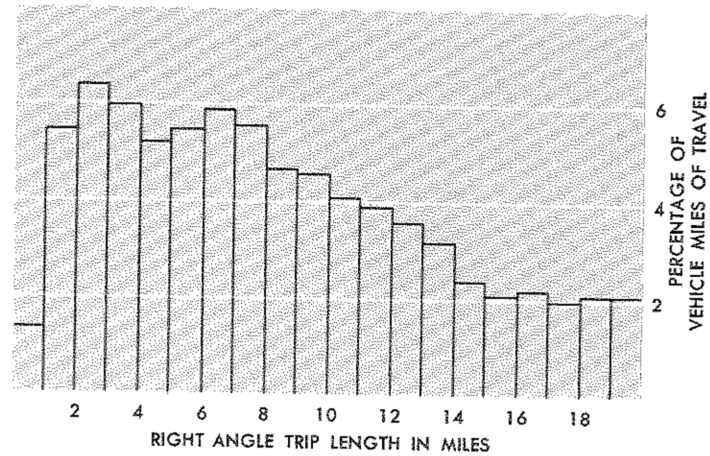


FIGURE 19—DISTRIBUTION OF VEHICLE EQUIVALENT MILES OF TRAVEL MADE BY TRIPS OF DIFFERENT RIGHT ANGLE TRIP LENGTH FOR THE CHICAGO AREA, 1956

See Table 27 in Appendix.

Reductions in travel costs are achieved, of course, only at a price. The price is the cost of building expressways. How much can the public afford in the way of investment in order to reduce the travel bills of all members of the community? This question is simply another way of asking for an objective—and the objective already has been defined in Chapter II: to build that system with the least total transportation costs.

The policy, therefore, is to plan additional investment in new transportation facilities as long as total transportation costs drop—i.e., as long as the reduction of total travel costs is great enough to offset the investment costs of building new facilities. To insure that the capital investment is allocated wisely—since there are many competing demands for public funds—an interest rate of ten per cent is charged for capital funds, and a twenty-five year life is assumed. This means that the last mile of expressway fitted into the recommended plan will return ten per cent on investment. To put it another way, the last, delicate reduction in spacing must reduce total travel costs each year for the next twenty-five years by an average of eleven per cent[9] of the cost of building that last increment.

This puts the problem quite directly and it can be dealt with objectively. Given a particular network of arterial streets, and a particular distribution of trips by length, what is the optimal spacing for a regular grid of expressways? This can be stated—and solved—mathematically. The result is a formula which yields the measure of optimal spacing. This is obtained through the following steps.

First, expressway construction costs are described as a direct function of expressway spacing. This is done readily, because the spacing determines the miles of expressway within any given area and, of course, construction costs are directly related to route length.

The second step is to describe operating costs (in the same annual dollar terms as construction costs), likewise as a function of expressway spacing. This again can be done, because the trip length distribution is expected to be stable, and the behavior of traffic in seeking the quickest (or cheapest) route is expected to be constant. This means that the vehicle miles of travel on the expressways will vary inversely with spacing and that the total travel costs will vary directly as a function of spacing.

Construction costs rise in a measurable way as spacing falls. In contrast, the travel costs fall as spacing is closer, and also in a measurable way. It is possible to write all of these relationships in equation form, so that total costs are a function of spacing.

Doing this, and solving for the case where total costs are at a minimum (i.e., where the first derivative of costs with respect to expressway spacing is set equal to zero), the following formula is obtained:

$$Z = 2.24 \sqrt{\frac{C}{DKP_s (W_a - W_e)}}$$

[9]The required annual rate of payment to amortize an investment in twenty-five years at ten per cent interest.

Here Z is the optimum expressway spacing in miles; C the average annual capital cost per mile of expressway; D is the trip density of the region in vehicle equivalent trip destinations per square mile; K is a constant for converting travel cost differentials to annual dollar values; W_a and W_e are the average cost of a mile of travel on arterial and expressway facilities respectively and P_s represents the proportion of all trips which will use an expressway for part of their journey.[10]

A simpler illustration is contained in Figure 20, where a graphic solution of the problem is portrayed. In this example, costs were worked out for a region of uniform traffic density and with a constant and regular spacing of arterial streets. These two assumptions—i.e., that densities and arterial street spacing are uniform throughout the region—are not true in real situations, yet they do allow useful answers to the spacing problem at a scale that the planner can apply to problems of regional design.

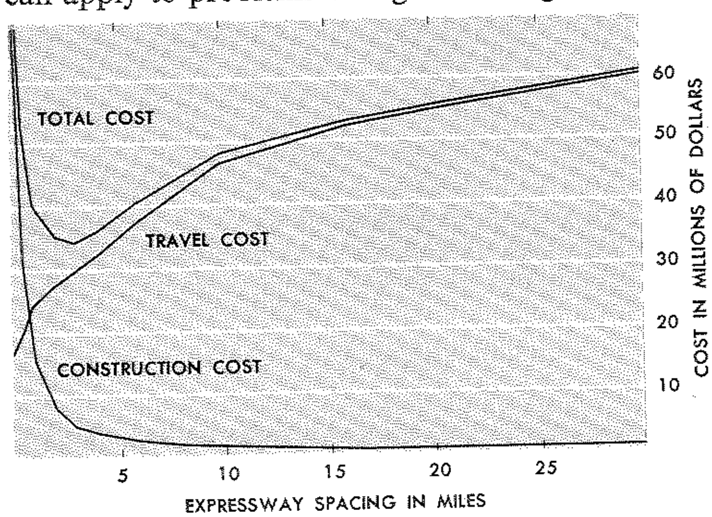


FIGURE 20—CONSTRUCTION COSTS, TRAVEL COSTS AND TOTAL COSTS AS A FUNCTION OF EXPRESSWAY SPACING FOR AN AVERAGE SQUARE MILE OF AREA

Calculated for an area of 20,000 daily trip destinations per square mile, with expressway construction costs of 8,000,000 dollars per mile and arterial streets one-half mile apart.

In this figure the known shape of costs as functions of spacing are shown. As spacing increases, capital costs fall and operating costs rise. The sum of both costs is at a minimum

[10]See Creighton, R. L., *et al*, "Estimating Efficient Spacings for Arterials and Expressways," a paper prepared for presentation before Highway Research Board, 39th Annual Meeting, Washington, D.C., January, 1960. Also, see Appendix for derivation of mathematical equation.

at a particular spacing value. This "best" spacing value will change with density, so that it will be different in different parts of the region. New graphs would have to be prepared for different densities.

These methods, while they don't provide a final answer to the problem of a best network design, can point to the kind of design most likely to approach the desired result. They serve to narrow the search for a best plan and to allow a more direct approach to the desired solution.

Using these methods, a best spacing was calculated for conditions typified by each ring of the Study Area. For Rings 2 through 5, vehicle trip densities were based on the estimated 1980 trip making in each ring. In Rings 6 and 7, instead of 1980 figures, "ultimate" trip densities were used. These represent the number of trips which could be expected if almost all the land in each ring were in use. It would clearly have been unwise to estimate spacings for a condition when these parts of the area are only partly developed. The results of these estimates, together with current construction costs, are reported in Table 8.

TABLE 8
ESTIMATED LEAST COST SPACINGS OF EXPRESSWAYS FOR 1980

Ring[a]	1980 Vehicle Trip Destinations Per Square Mile	Current Expressway Construction Cost Per Mile (In Millions)	Estimated Least Cost Expressway Spacing
2	28,700	$14	3 miles
3	25,300	$12	3 miles
4	19,600	$ 8	3 miles
5	13,400	$ 6	4 miles
6	10,000[b]	$ 4	6 miles
7	7,700[b]	$ 2	6 miles

[a]Rings 0 and 1 are unique areas and, therefore, were not computed.

[b]These are trip densities obtaining when these rings are ninety-five per cent developed—a sounder basis for long range planning than the less complete development of 1980.

The estimated least cost spacings given in Table 8 are the beginning point for designing a regional expressway network. The spacing remains constant in Rings 2-4, because the greater density is offset by a greater construction cost. In the outer rings, however, the decline in density begins to force ever wider spacing. These spacings do not fix a rigid geometry of expressways. It always is necessary, of course, to adjust the recommended solution to the realities of an existing city and landscape. The figures provide scale and sharpness to the planning task ahead—fitting an expressway network to the metropolitan region in a most efficient way.

SUMMARY

There are many hundreds of ways in which transportation improvements can be made—ways to speed up traffic, to reduce accidents, and to increase the carrying ability of streets. It is the job of planning to cull the less rewarding approaches and to select the best ways compatible with available moneys. The expenditure of public funds ought to be programmed to obtain the greatest possible rewards. This implies the need for a careful evaluation of all means for making improvements so as to select those which will be expected to produce the greatest gains.

In this chapter, attention was focused first on street types which might be used in a regional highway system. Local streets, arterials, "intermediate facilities" and expressways were evaluated as to their performance costs in relation to their construction costs. It was found that travel costs decrease as streets become more specialized in their traffic-serving functions, and this is to be expected. Construction costs go in the opposite direction. By combining both operating and construction costs, and considering possible traffic loads, it is possible to find the most efficient designs. Fully controlled access expressways, when fully loaded, were found to have the lowest combined costs. This pointed to the preferred policy of depending heavily upon these more productive types.

Yet, the evaluation of street performance is not the whole story; roads can be combined in many ways, and some combinations are bound to be more productive than others. For a metropolitan region, the object is to determine that complete system of facilities which will be most economical. So, more efficient patterns were identified and rules were devised to insure the best quality of network performance. Traffic being derived from land use, traffic ways must also be arranged so as to promote the socially desired uses of land. Consideration of pedestrian areas and neighborhoods led to a preferred spacing and location standards for both local and arterial streets. These streets constitute the surface system which allows direct connections to the land activities.

Given the surface street pattern, expressways could be spaced to minimize the sum of all vehicular transportation costs. These include accident, time, operating and construction costs. Formulas were developed to calculate the expressway spacings most likely to attain this objective. The result called for expressways spaced about three miles apart in the city of Chicago, but increasing to about six miles apart in surburban areas.

This process of specification of best approaches does much to eliminate wild guessing and inefficient testing of plans. It allows the planner to define more narrowly the territory within which an optimal plan can be found. Using this background, plans can now be drawn and more finely appraised. This is the task of Chapter IV.

Chapter IV

THE REGIONAL HIGHWAY PLAN

To accommodate expected growth in the Chicago region—even to insure it—a vast system of new transportation facilities must be built. The plans of the pre-war era largely have been completed. The time has come once again to raise the region's sights to a new endeavor—to create a new plan matched to anticipated growth.

All the tools needed for the preparation of such a highway plan are now in hand. New understandings of the ways in which people and vehicles move about within an urban area have been developed. Future travel demands have been estimated and divided into roadway and mass transportation components. Objectives have been specified and street types to be used in the plan have been selected. Rules have been set down for assembling the several street types into networks.

The task now is to combine all of these ingredients into a regional highway plan. The fitting of rules and standards to a specific urban landscape requires art and compromise. The early plans and the currently committed facilities provide a base on which to build. The existing geography and patterns of land development provide the real environment to which idealized requirements must be adjusted. The problem of this chapter is the difficult one of turning from principles to proposals.

Extra care is required to demonstrate measurably that the plan selected is the best that can be prepared. Hundreds of millions of dollars and uncounted man hours of labor will be invested in transportation projects over the next twenty years. The plan must be designed as the guide for those investments. So, a number of performance tests have been devised to evaluate proposals. These are described in the central portion of the chapter. Both economic and traffic appraisals of alternative plans are made through the assignment process. Alternative plans are subjected to these tests and the results are used to design with greater certainty. The final proposal is evolved in this "test and try" fashion.

After the major network—the expressway system—is fixed, arterial street improvement needs are considered. These must be planned and programmed to provide a network complementary to the expressways. The relationship between roads and rails also is considered briefly, but the main discussion of a rail plan is reserved for Chapter V.

THE ROAD STRATEGY

The design of a road system is determined by the task it has to perform. Before any proposals are developed, it will be useful to review the travel demands that must be served. This provides scale. Also, it will be instructive to consider the basic strategy that is selected for a design solution.

The measure of future traffic demands was supplied in Volume II. The following paragraphs summarize these broad dimensions as the essential background for plan design.

In twenty years, over two million people are expected to be added to the population of the Study Area. The total estimated 1980 population—7.8 million persons—should have the strength and productivity to support a transport system larger and better than any that have served in the past.

The amount of urban land required by the 1980 population will be nearly twice that required for 5.2 million persons in 1956. Such doubling of land requirements has been occurring in every generation since 1840 and, by 1980, will produce a more dispersed population and more dispersed travel requirements than ever before.

The average resident of the Chicago area in 1980 is expected to make more trips than in 1956—2.3 instead of 2.0 trips per capita. This will result from increased family income (about forty-seven per cent greater in the average household) and will be reflected in an increased number of vehicles. Since there will be more people as well, the travel requirements will grow in two ways—more trips per capita and more people. There will be ninety-two per cent growth in vehicles and a ninety-eight per cent increase in vehicle trips.

By 1980, the number of vehicle miles of travel driven in the Study Area is expected nearly to double. The estimated daily demand for 1980 is 67,000,000 vehicle miles of travel on the non-local streets. This is a continuation of the growth which has been observed over several decades. It derives from people and their needs in a modern urban society, so it is not reasonable that these demands can be reduced or changed by the design of the highway system.

Doubling the demand for road services in slightly more than two decades, for twice the urbanized area, will create tremendous demands for new and improved highways. Without substantial new road building, the increasing travel would be pressed over a street system already heavily congested. This could result only in a radical worsening in the quality of service.

This pressure of increasing demand will require substantial investment in highway improvements merely to keep quality from deteriorating. Yet, for a more productive society, improvement in the speed and safety of travel is wanted. The problem at hand is to define that strategy of public investment best calculated to meet these needs.

Several different approaches are possible. Additional capacity can be achieved by improving the existing system. This can come about through traffic engineering improvements which increase the efficiency of existing streets. This battle of improving performance within existing rights-of-way is going on continually. To suggest that any substantial gain can be achieved by removal of parking or changes in signal timing does not seem reasonable. The projected increases in traffic, imposed on an already overloaded system, are bound to be well beyond the scale of improvement which can be obtained solely from traffic engineering treatment. Thus, while continued attention must be paid to this aspect of highway transportation, long term gains in capacity cannot be expected from this source alone.

Further increases in traffic capacities must be achieved either through enlargement of the present network or by building completely new roadways. The existing system can be enlarged by either of two means: existing arterials can be widened, or existing local streets can be converted to arterial use.

Widening the present arterials would require the purchase of valuable abutting property. Being the busiest streets, these arterials have accumulated, along their rights-of-way, much of the commercial development of the region. To widen them would necessitate the acquisition of intensively used and expensive property. To widen them by opportunity—i.e., to widen whenever there is a redevelopment project or available funds would simply mean a very slow and patch-work enlargement which would be of doubtful value in providing additional capacity. Widening a street for a few blocks is of little help in increasing that street's traffic carrying capability, for capacity is determined by the narrowest part, not the widest. Widened sections would, therefore, merely keep land from effective use until the remainder of the street was widened. Widening to remove bottlenecks is a useful engineering undertaking, but widening to increase system capacity is bound to be a very expensive method of enlarging system capability.

An alternative, often used by traffic engineers in the face of very great traffic problems, involves increasing the arterial capacity by converting local streets to arterials. This may consist of signalizing and otherwise differentiating a formerly local street from its neighbors. In Chicago, and in many of the suburbs, new through streets are developed at less than half mile intervals because of traffic pressures. Another method frequently used involves absorbing a former local street as a matching member of a pair of one-way streets. Thus, an overcrowded arterial can be enlarged by making it one-way and absorbing the adjacent, parallel local street for traffic moving in the opposite direction.

These are devices which have been invented by resourceful traffic engineers to meet spot problems. But it must be recognized that this constitutes, essentially, a means of trying to make a system work by relieving spot pressures. It cannot be substituted for long term system design. Moreover, the practice of converting local streets to arterials begins to destroy many of the land use values sought by the community. Residences must more frequently be found on busy streets, for there are fewer local streets. Neighborhoods are cut into smaller units or into long stretches between two, one-way traffic arterials.

The conversion of local streets to arterial status also begins to defeat its own end. The number of intersections requiring traffic control increases more rapidly than new arterial mileage. More such intersections merely complicate the problems of signal timing and effectively restrict the performance of the existing arterial streets. Thus, what may be a solution at a spot, can, when extended to an entire system, represent an intolerable public policy.

As was pointed out in Chapter III, given a problem of the dimensions shown, the preferred policy is to provide relief and to absorb new traffic by building a completely new network of highways devoted to traffic service exclusively. Fully separated from the surface street system, such a network can perform the function of relieving pressure on the already congested surface streets and also can provide the reserve capacity needed to meet the future demands. Such strategy will have the greatest reward over the next twenty-five years. It is typical of the aggressiveness with which Chicago attacks its problems. This method does not try to enlarge an already over-strained system. Rather, it provides a modern new network of superior quality.

PREPARING THE PRELIMINARY EXPRESSWAY PLAN

The approach of this chapter is to proceed from the largest to the smallest: from the main network of expressways to the network of arterials. It is easier to adjust the smaller facilities to conform to the major ones than the reverse. Looking at expressways, it becomes apparent that much already has been accomplished. Many expressways have been built and more are in progress.

The present expressway system in the Chicago area is the result of past planning. It is instructive, therefore, to examine some of the early expressway plans and to reconstruct the thinking of earlier years. Prior plans all were developed because there were pressures for improvement just as there are today. A review of those plans places this work in perspective and shows current planning as a continuation of the struggle to anticipate and solve the transportation problems of an ever growing urban region.

The Early Plans

The earliest recorded plans for Chicago show a gridiron street arrangement. There were a few radials—the legacy of Indian trails and wagon roads coming to Chicago from other towns—but the grid was the main network. Its prime purpose was to assist in the convenient and orderly development and marketing of land. It was a natural system for the flat prairies and the straight line of the land surveyor.

Space requirements for travel were not great in the nineteenth century. Distances were short. Trips were less frequently made by vehicles. There was no great need to differentiate one street from another, excepting to decide which to pave. Those paved first were the mile and half-mile roads—and they often attracted extra traffic because of the businesses located on them. Later, horsecar, cable car and streetcar lines used these thoroughfares and so they became more important than other streets. Still, street widths and designs were quite uniform because traffic was not yet a problem.

Even Burnham, in his now famous Plan of Chicago published in 1909, saw no need to identify different street designs to accentuate traffic needs. He laid out circumferentials, park drives and a great many diagonals, but his main thoughts were for civic design, and for shortening travel distances. The present pressures for street space simply did not exist then. The congestion that was apparent was on mass transit vehicles, and for them Burnham planned separate underground subways or elevated structures in that area where traffic congestion was most obvious—the Central Business District.

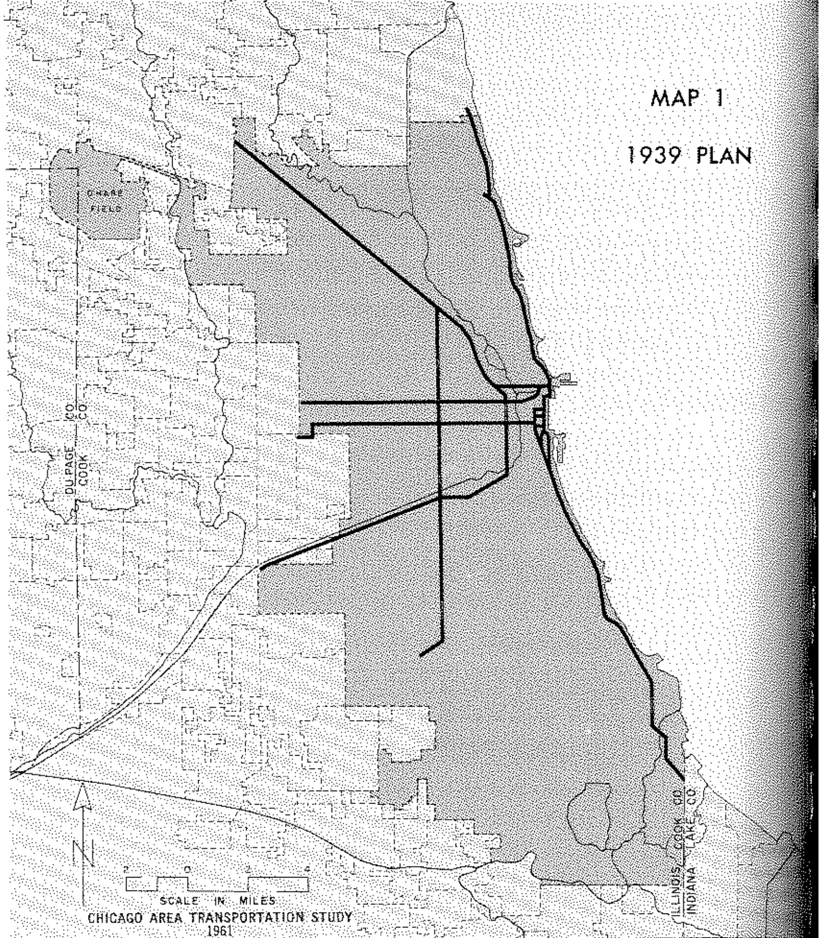
During the 1920's, vehicle registrations rose very rapidly. Adjustments began to be made to this new force, signs and signals were installed, and the beginnings of parking regulation appeared. This was a period of street surfacing, of some pavement widening, and of the introduction of traffic control, but there was little or no reason to search out new types of streets. It wasn't really until the late 1930's that traffic pressures became sufficiently great to suggest that entirely new roads should be created especially for the automobile.

The 1939 Comprehensive Plan for Superhighways, illustrated on Map 1, was the first formal proposal for a system of special, new roadways. This report recognized that a new kind of facility, one that could cope with the flooding tide of automobiles and trucks, was needed. The sportsman's car of 1909 was now mass-produced for millions. Street space was rapidly being used up. Special purpose roadways which would permit the smooth flow of vehicles appeared essential for the accommodation of the enlarged demands.

All the "superhighways" in the 1939 plan were aimed at the Loop. This orientation to the Central Business District was the prevailing philosophy of the time. It was a reasonable philosophy, too, because at that time the Loop and the Central Area attracted a greater proportion of the region's daily travel than they do today.

Evidence has shown that the traffic attracting power of the Central Area has remained stable[1] while the metropolitan region has grown. The natural consequence is that a smaller portion of the total journeys is directed to the Central Area. Traffic problems are moving outward at a faster rate today than ever before.

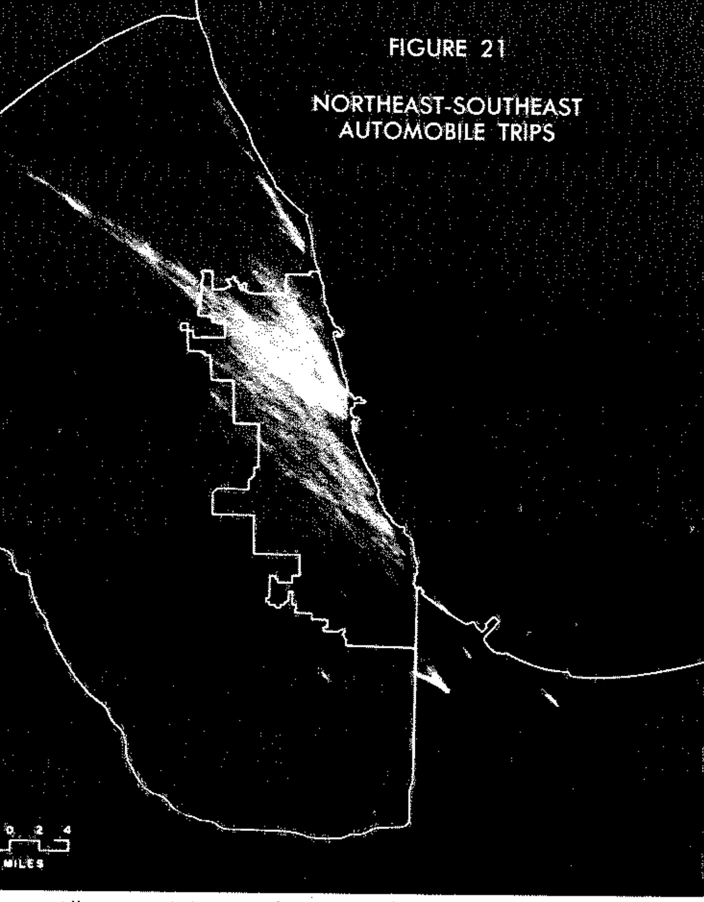
Yet, even while this trend towards more non-central travel is accelerating, the great attraction power of the Central Area continues to shape the patterns of travel demands. As of 1956, the patterns of vehicular trip traces show a marked tendency to focus towards the Loop. The four Cartographatron prints, Figures 21, 22, 25 and 26, show all automobile desire line traces segregated according to the direction of the travel line. In contrast, Figures 23, 24, 27 and 28 have been restricted to display only those lines with one end of the journey in the first two rings, i.e., going to or from Chicago's Central Area. The trips to the center constitute less than one-tenth of the total, still the radial orientation of other journeys persists. By 1980, only one-twentieth of the trips will be to the central rings, and the central focus will not be so pronounced. Yet none of this was apparent in 1939, and the design of that plan reflected the traffic focusing power of the CBD.

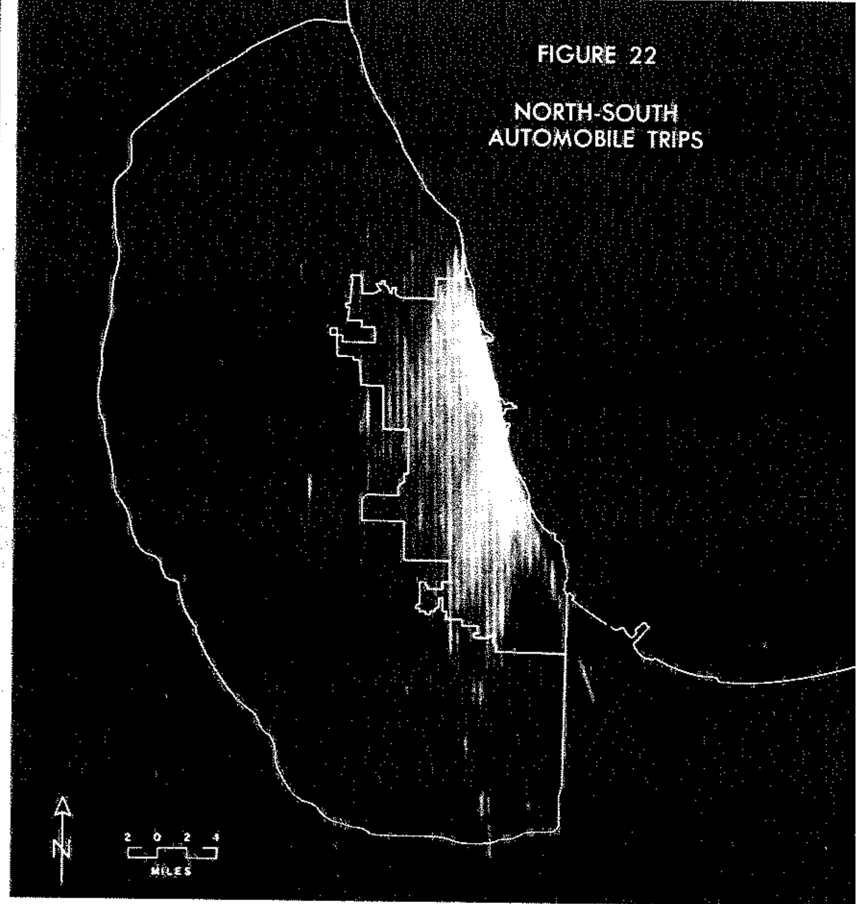


Compiled from the 1939 Comprehensive Superhighway Plan for the City of Chicago.

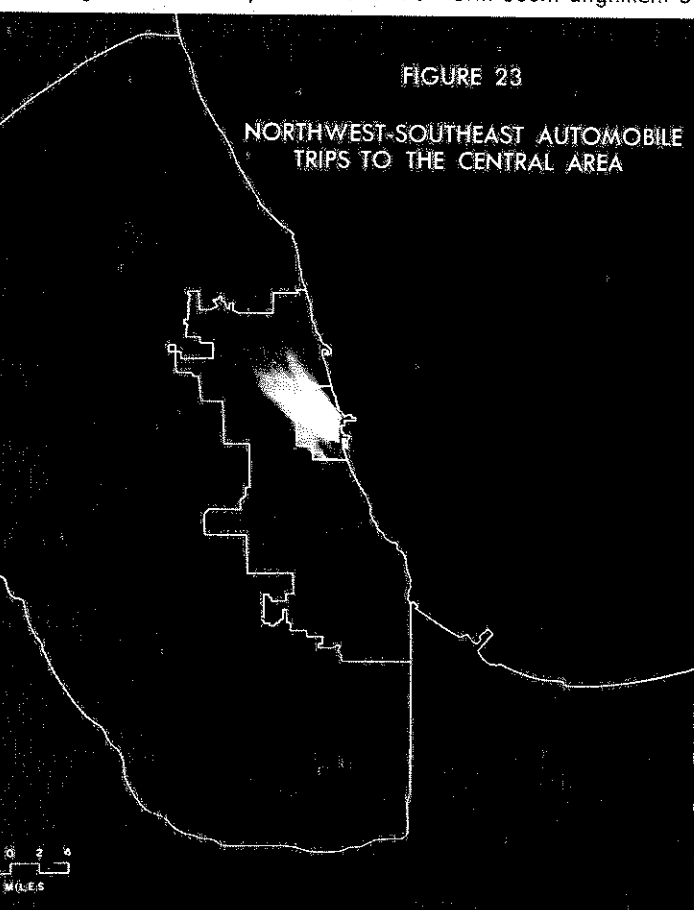
A much more complete scheme of expressways was presented in the Chicago Plan Commission's General Plan of 1946. This plan (see Map 2) proposed a system of over two hundred miles of new facilities in Chicago and the adjacent suburbs. In addition to the radial routes of the 1939 plan, several crosstown routes were proposed. This reflected the increasing spread of congestion in all parts of the city of Chicago,

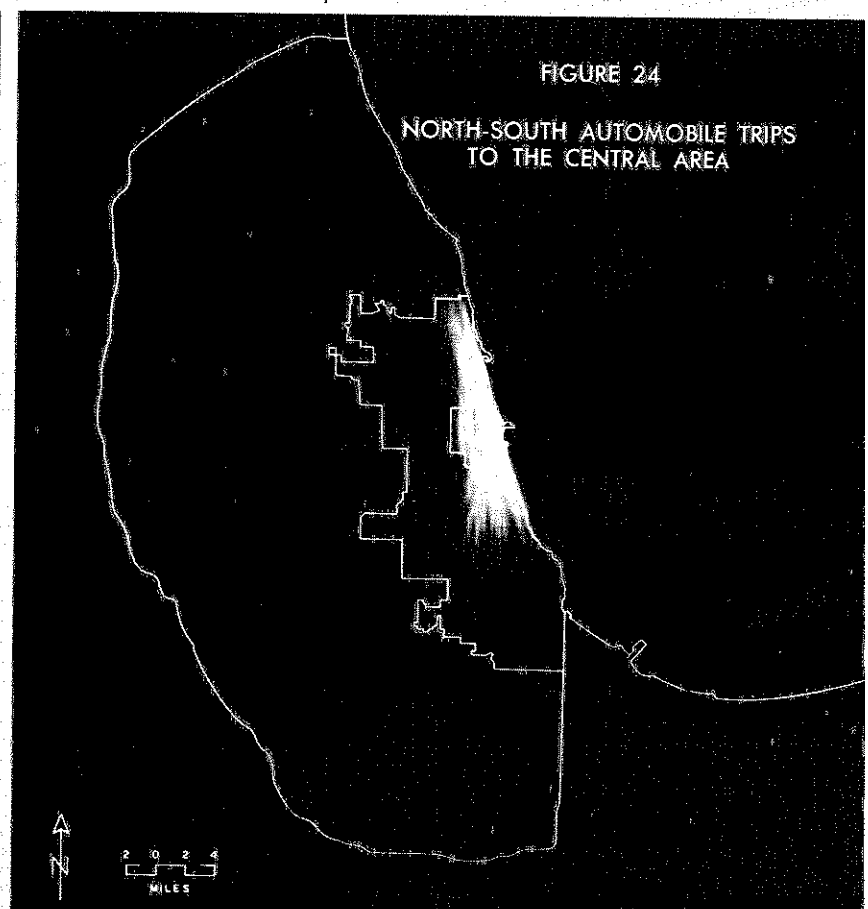
[1]Maximum daily accumulation of people has changed from 350,000 in 1930 to about 300,000 in 1960. See Vol. II, p. 59.



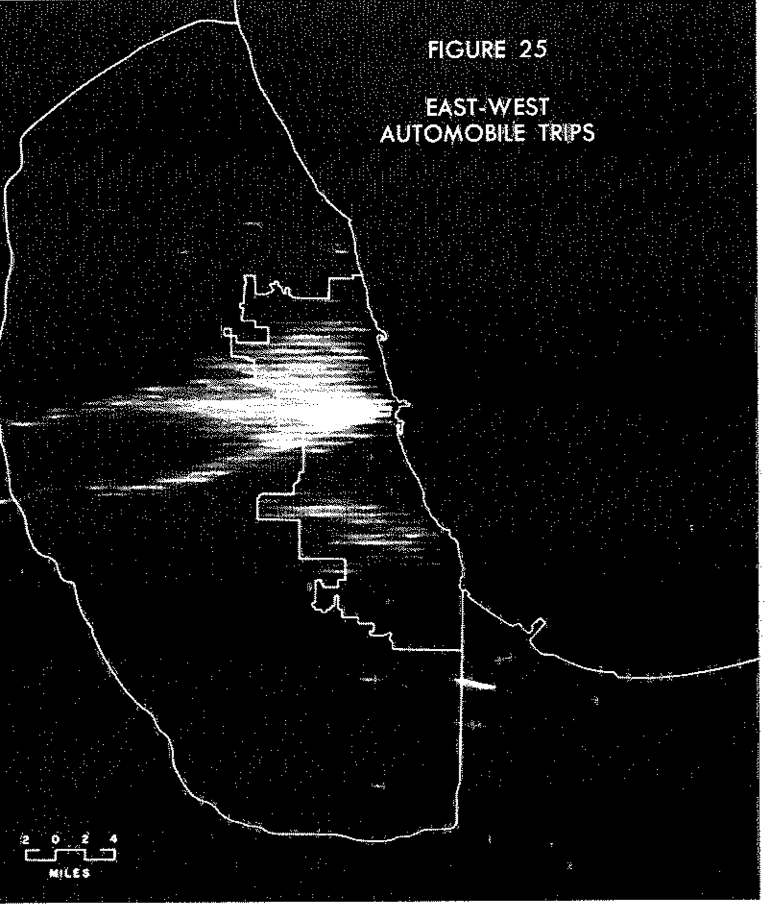


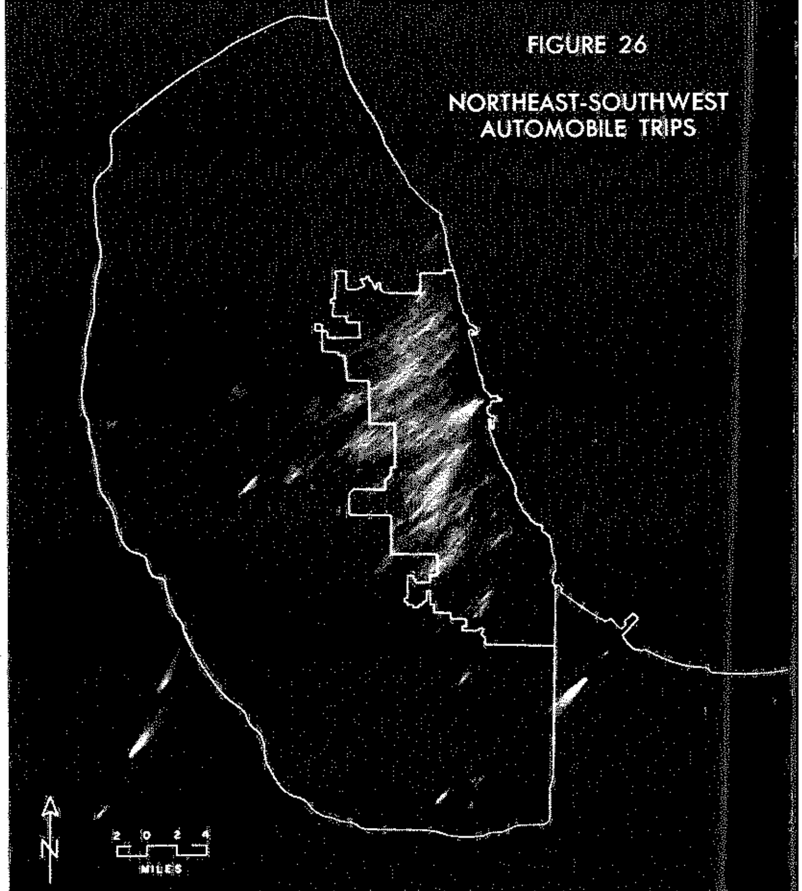
All automobile trips (internal and external) with desire line traces aligned within 22½ degrees either side of the direction indicated are shown on these displays. (The remaining directions are illustrated in Figures 25 and 26.) The Northwest-Southeast alignment has 25 per cent and the North-South alignment 31 per cent of all automobile trips.



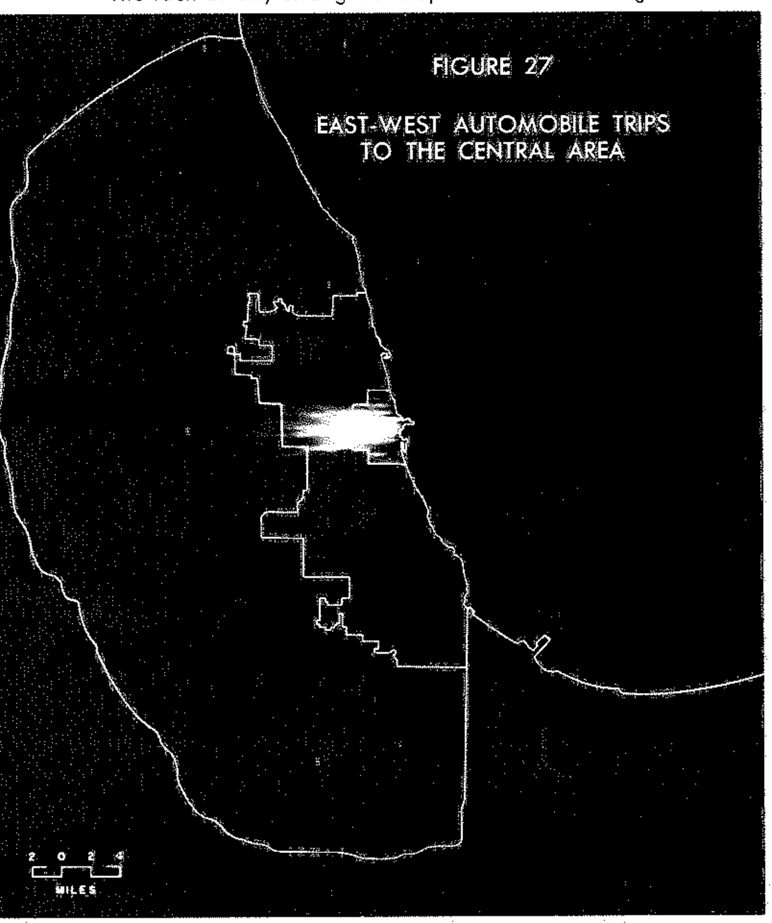


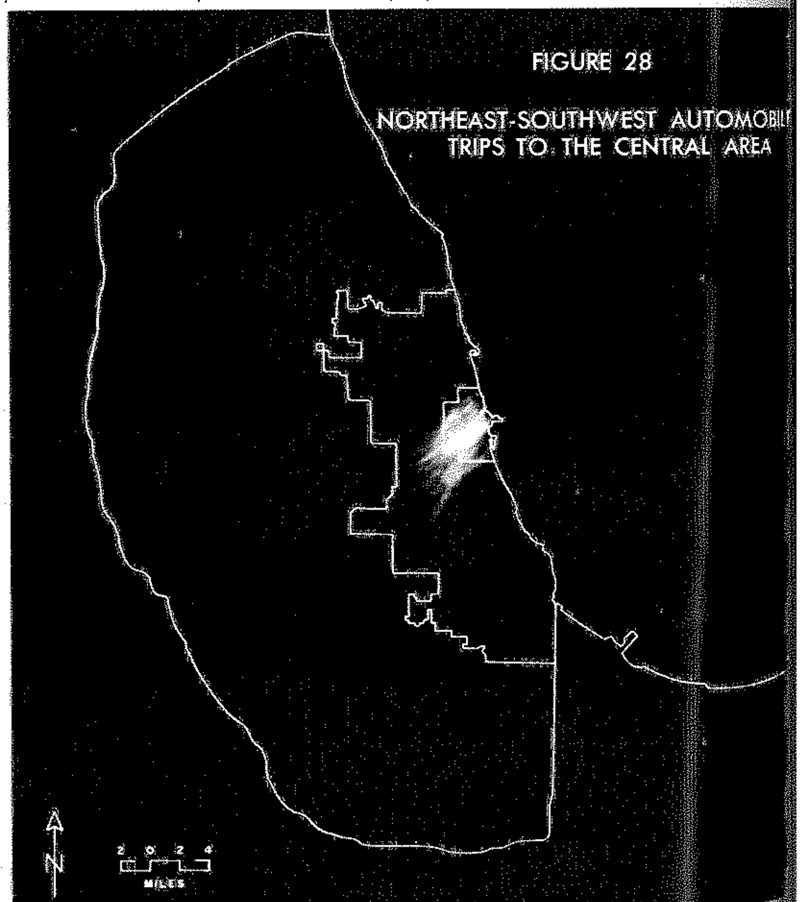
Printed at intensities of 2.5 times their true relationship to the directional displays of all automobile trips, the displays of automobile trips to the Central Area show the limited use of the automobile for trips to this area. The Northwest-Southeast alignment has 7.4 per cent of the total automobile trips for this direction. The North-South has 9.4 per cent, the largest share of any direction to the Central Area.



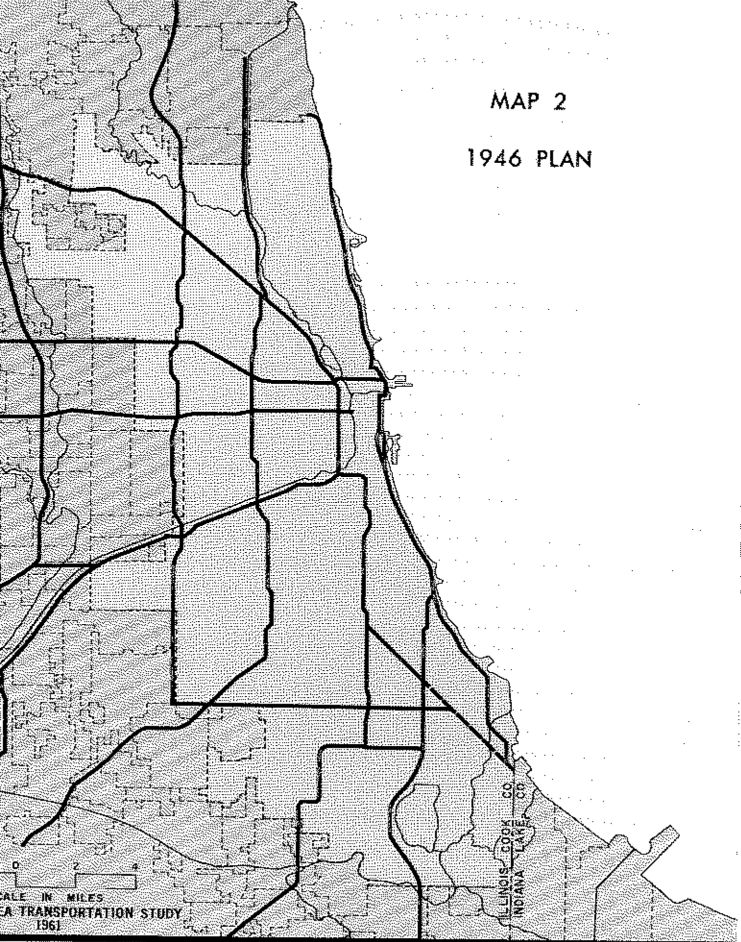


The East-West alignment has 25 per cent of all automobile trips—the same share as the Northwest-Southeast alignment. The Northeast-Southwest alignment has the fewest trips of any direction with only 19 per cent of the total automobile trips. The lack of any strong development of land along the Sanitary Canal limits the pattern on this display.





As with Figures 23 and 24, these displays are printed at 2.5 times their true intensity. The East-West alignment, with 6.8 per cent of all automobile trips in this direction, is similar in pattern to the Northwest-Southeast trips. The Northeast-Southwest alignment with only 5.2 per cent of the trips in this direction has a more restrained pattern.



ompiled from the Chicago Plan Commission's Preliminary omprehensive City Plan of 1946—Proposed Expressway evelopment Program for the City of Chicago, 1943— nd the 1940 Highway Plan for Cook County.

and proved a remarkably accurate appraisal of future needs.

This early planning is sharp and bold. Few expressways existed at that time. The Outer Drive, with its hydraulically operated barriers separating opposing streams of traffic, was familiar to Chicago residents. It was one of the earliest prototypes of the expressway. But the notion of a complete system of expressways must have been a shocking proposal to the public officials with the much smaller financial resources of that time at their disposal. The Merritt Parkway in New York and the Pennsylvania Turnpike still were very new. Yet the planners of the 1940's had the imagination to see that this type of road, which was then essentially a rural type, offered great promise for the alleviation of urban traffic problems.

The Committed System

Many of the routes outlined in the 1939 and 1946 plans have been built or are under construction. The Congress Street Expressway, the Northwest Expressway, the Edens and Kingery Expressways, and the Chicago Skyway have been completed. The Outer Drive has had successive improvements over the years. The Dan Ryan (South) Expressway is under construction. The Southwest Expressway is in an advanced stage of planning and should be completed by 1965. Clearly, the early plans have guided much construction to this date.

Not all work since 1946 has been according to the plan. The toll roads and the enlarged system of interstate highways have brought changes. The toll highway was built to be profitable. Accordingly, it seeks out that one location where the excess of revenues over costs is greatest. There is no thought of system planning here. As a consequence, its location was largely independent of system requirements. The subsequent alignment and designation of interstate routes also produced changes. Interstate highway locations were influenced heavily by considerations of a national system, and by interstate and defense travel needs. So, they, too, have deviated from some of the earlier plans. Yet both the toll highways and the interstate routes must be fitted into any future regional system.

Map 3, page 52, shows the existing plan for the interstate highway system within 180 miles of Chicago. Most of these interstate roads are aimed directly at the heart of the urban area. They are strong influences on any future plan, since each must be built as a high quality urban expressway. Their influence tends to be radial, pointing inward towards the heart of the city.

All of the expressways that have so far been built, or that are under construction or heavily committed, are shown on Map 4, page 53. Altogether, they provide 280 miles of expressways within the Study Area. When they are complete, an estimated \$1.3 billion will have been spent to build them. They reflect the most intensive road building effort in the history of the Chicago region.

The significance of this committed system is that it strongly influences all future plans. It provides, in fact, the take-off point for network planning. Any future system must include all of these routes, so the design problem is to enlarge the committed system by additions until the best plan is achieved.

MAP 3—THE INTERSTATE HIGHWAY SYSTEM IN THE SOUTHERN LAKE MICHIGAN AREA

MAP 4

COMMITTED EXPRESSWAY SYSTEM

This system includes all existing, under construction or heavily committed expressways. The interstate connection 494, between the Chicago Skyway and Edens Expressway, is committed, but, since final location has not been determined, it is not shown on this map.

Spacing the New Facilities

The preferred extent of a new expressway system was estimated on the basis of the recommended spacing between expressways. These recommendations were based on the optimum spacing formulas given in Chapter III. They provide the approximate spacing required to yield, in 1980, the least total transportation cost to all travelers. In Table 9, the ideal and existing spacings are compared, and the mileage of needed new facilities is estimated. The problem of where and how to make these additions remains. It can be seen that an estimated 223 additional miles are indicated, if the preliminary guide of best spacing is followed.

TABLE 9
SPACING OF EXPRESSWAYS PRESENTLY COMMITTED COMPARED WITH IDEAL SPACING

Ring	Spacing Between Expressways To the Nearest Mile: Ideal	Presently Built Or Committed	Additional Route Mileage Needed for Plan
0+1	1.5-2.0	1.6	..
2	3	4	8
3	3	7	15
4	3	9	30
5	4	9	40
6	6	8*	30*
7	6	12	100
Total			223

*This more complete development results from the Tri-State Tollway which lies principally in Ring 6.

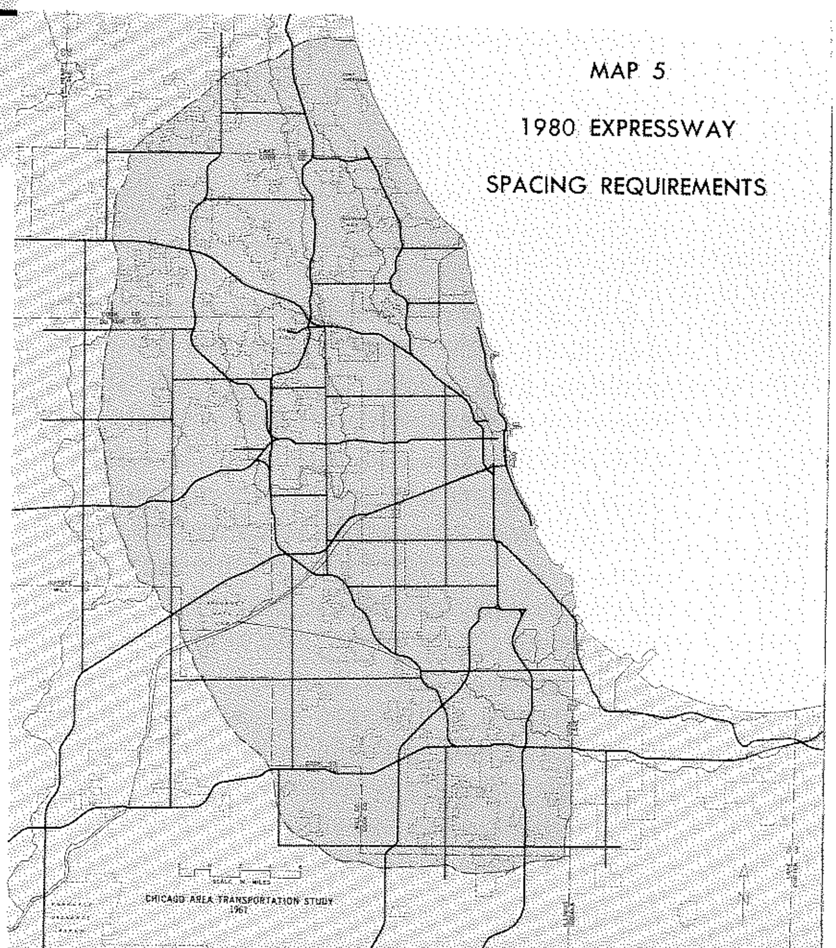
The general alignment of these additional routes must be complementary to those already committed or built. As has been pointed out, the existing facilities stress radial service. Because of the shifting nature of travel demands, the supplemental roadways must emphasize service for the non-centrally oriented journeys. Accordingly, the additional routes will best be assembled in grid fashion, staying in alignment with the east-west and north-south orientation of the present surface system.

On Map 5 is an illustrative exhibit showing, in a general way, where new routes, which meet the specifications of better spacing and rectangular service, would have to be added. These

MAP 5

1980 EXPRESSWAY

SPACING REQUIREMENTS



Needed new facilities, as recommended by the optimum spacing formula, are shown with the committed expressway system.

additional segments have been added without concern, at first, for reality. In this way they can illustrate the kind of design and assembly problem faced by the network planner.

Abstract as these additions are, they do begin to point up certain needs. North-south facilities between the Loop and the Tri-State Tollway obviously are required. Actually, the diagram suggests three such routes. Two more north-south facilities will be required west of the Tri-State Tollway (FAI Route 294). In addition, many east-west needs are suggested, but these are less sharply identified.

Developing a Preliminary Plan

The next step is to rearrange the theoretical diagram into a smoothly interconnected system of expressways serving the entire Study Area. This is a design problem of regional scale. To arrive at a solution, a whole series of requirements must be considered, balanced and compromised. Some of these requirements are: the existing system, the recommended spacings of expressways, and the network design principles described in the preceding chapter. Two other factors have a special influence on the system design: land use and the external highway network.

The influence of land use on the network plan is not that of specific land use parcels or lots, for, at this level, the scale would be too fine. The importance of these specific land uses will be taken into account when the more general regional plans proposed in this report are translated to specific, final highway locations. The regional planning scale needed for system design requires the planner to be concerned with the larger or bulk land uses. These consist of the concentrations of urban uses in communities or villages in contrast to the thinly settled countryside; or certain major land uses, such as cemeteries, railroad yards, major public open spaces or airports.

Concentrations of urban development could readily be identified. The patterns of short trips displayed by the Cartographatron (see Figure 12, Chapter III) illustrate this nucleation of suburban villages by showing the internal travel patterns characteristic of these places. The less developed areas offer the possibility of right-of-way locations which are cheaper and cause less disturbance. Also, if new highways are located close to these communities, they can help the local traffic problems by attracting the through trips and thus giving internal traffic relief. Similar information also was available on conventional maps which helped to define the actual built-up limits and corporate boundaries. Both sources were used in developing plans.

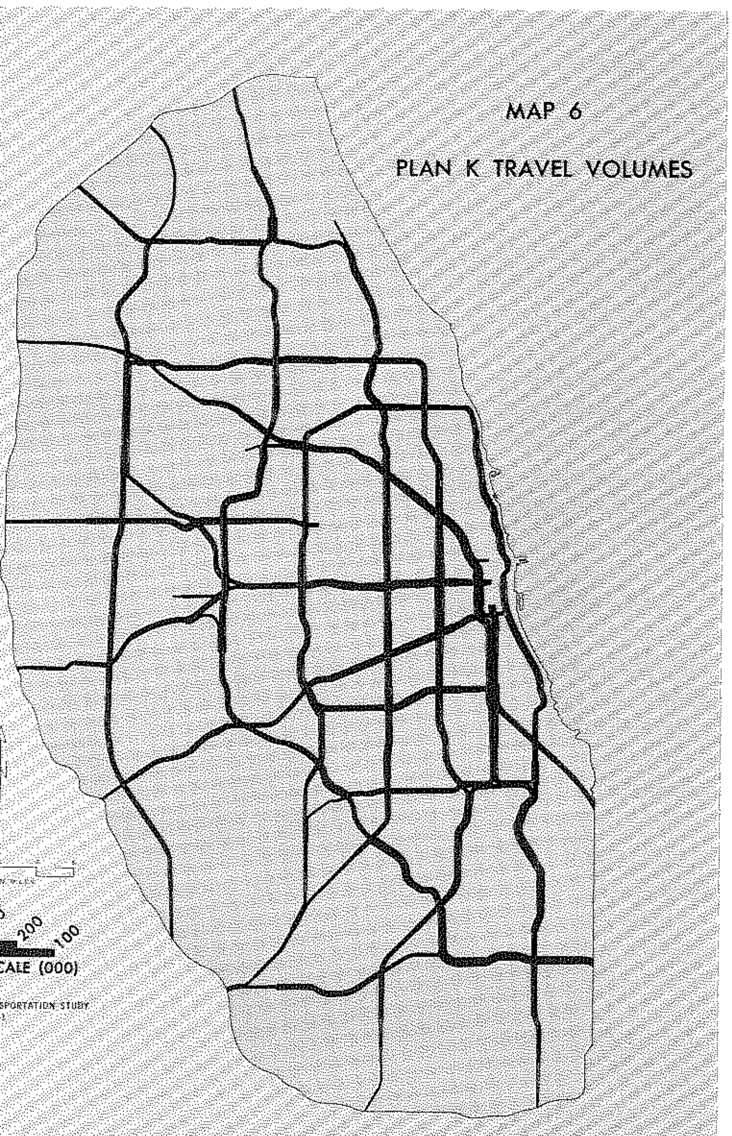
Cemeteries, railroad yards and large public open spaces also were identified prior to putting any lines on maps. The first two types of uses are fairly extensive in area and are especially difficult either to traverse or to buy. No one wants to consider either as a potential right-of-way if alternate locations can be found. Large public open spaces constitute a special case. The best policy is to avoid taking public open space if at all possible. Such sites are necessary for public recreation; they create additional values in their vicinities; and they are difficult to replace. In some cases, however, it is better to take a part of such an open space rather than to dislocate a large number of families.

Besides land use, the external highway network had to be taken into consideration. External roads obviously must connect with the internal express network. But the number of express routes within the Study Area is greater than the number of interstate and toll roads heading out to other parts of the country. A number of expressways within the Study Area must, therefore, connect with rural highways of lesser design standards. This problem was studied thoroughly, having in mind the need for developing, as time goes on, more adequate networks in surrounding counties. It will be noted that all of the plans extend well beyond the arbitrary cordon line that defines the Study Area and do, in fact, anticipate growth well beyond 1980.

All of these considerations were brought together as the preliminary sketches were prepared. This was a lengthy and arduous process. Hundreds of different combinations of routes were studied, weighing and balancing their different effects and the ways in which each change would affect the remainder of the network.

Typical of these preliminary ideas, and perhaps the best of them, is Plan K. This is shown on Map 6. This plan has approximately the same number of miles of route as is recommended by the optimal spacing calculations. It also is a balanced system design, and was prepared with much attention to the land use requirements.

Since Plan K was prepared to satisfy, as completely as possible, all the major criteria of planning an expressway network, it might be considered adequate. But here questions begin



avel volumes for 1980 are shown on the preliminary bal-
nced expressway system recommended by the optimum
acing calculations. All expressway plans assume that
cilities for which tolls are presently collected will be free
1980.

to arise. How will it really work? Could a better plan be devised? What demonstration is there that this one plan is better than another?

TESTING AND REFINING THE PLAN

The responsible official wants to be sure, in reviewing work of this magnitude, that the recommendations of technicians are wise. The public official must make the very best decision, for he is dealing with millions of dollars. He must be certain that these public funds will bring the greatest possible return when they are invested. Responding to this requirement, further and more exhaustive tests were applied to Plan K to bring it into focus.

Fortunately, a reliable means was at hand for testing alternative plans. The means of testing is the assignment process. A complete description of assignment is given in Volume II, but a word about this process, with special reference to its use as a testing device, is in order here.

The assignment process represents a great stride forward in traffic planning. Here for the first time, and because of the great speed and capacity of computers, substantial realism in evaluating the performance of future networks is possible. Figure 29, page 56, illustrates the assignment process developed by members of the Study staff.

Assignment is a technical term given to the process of allocating future traffic to a road network. As a first step, a coded representation of the existing arterial and expressway network is fed into a computer. The computer then is given the number of vehicle trips which begin in each of the Study Area zones and it is instructed to compute the trips from each zone to every other zone, and to route these trips over the road network. The calculation of trips between zones is accomplished according to a probability formula.[2] The allocation or assignment to the roadway network is made according to the rule that each small group of trips (averaging about thirty trips between each pair of zones) will proceed by the shortest time path in the network. As this loading process continues and a segment of roadway collects a certain traffic load, the computer is instructed

[2]See Vol. II, p. 111.

to increase the time required to traverse that section, thus representing congestion as a factor in influencing the driver's choice of routes. The final product of the assignment is a reasonably realistic simulation of traffic behavior.

The output of the assignment process is more than a mere flow map of traffic on future routes. Information is provided which permits two major analyses of the proposed network: an economic analysis and a traffic analysis. For the traffic analysis, information on speeds, delays, accidents, and, of course, traffic volumes is obtained. When it is mapped, or treated statistically, this traffic information provides the planner with an indication of trouble spots in any part of the network. For an economic appraisal, such information as accident costs, time costs, and the vehicle operating costs is available. These, combined with the estimated construction costs of building the proposed system, permit an evaluation of the plan as a whole, in comparison to other plans.

The assignment technique described here is a major innovation in transportation planning. This is the first assignment process capable of assigning traffic to an entire network of arterials and expressways. It is the first capable of including a feedback to reduce speeds on route segments as traffic volumes increase. And it is the first time that analysis has carried the results to the degree of refinement needed to make economic and traffic comparisons between alternate plans.

With such a testing device available, it is possible to test and appraise a series of different plans. A sensible approach appeared to be the testing of plans which have both more and fewer miles of expressways than are recommended by the optimal spacing formula as shown on Plan K. This procedure would verify the accuracy of the general scale of Plan K.

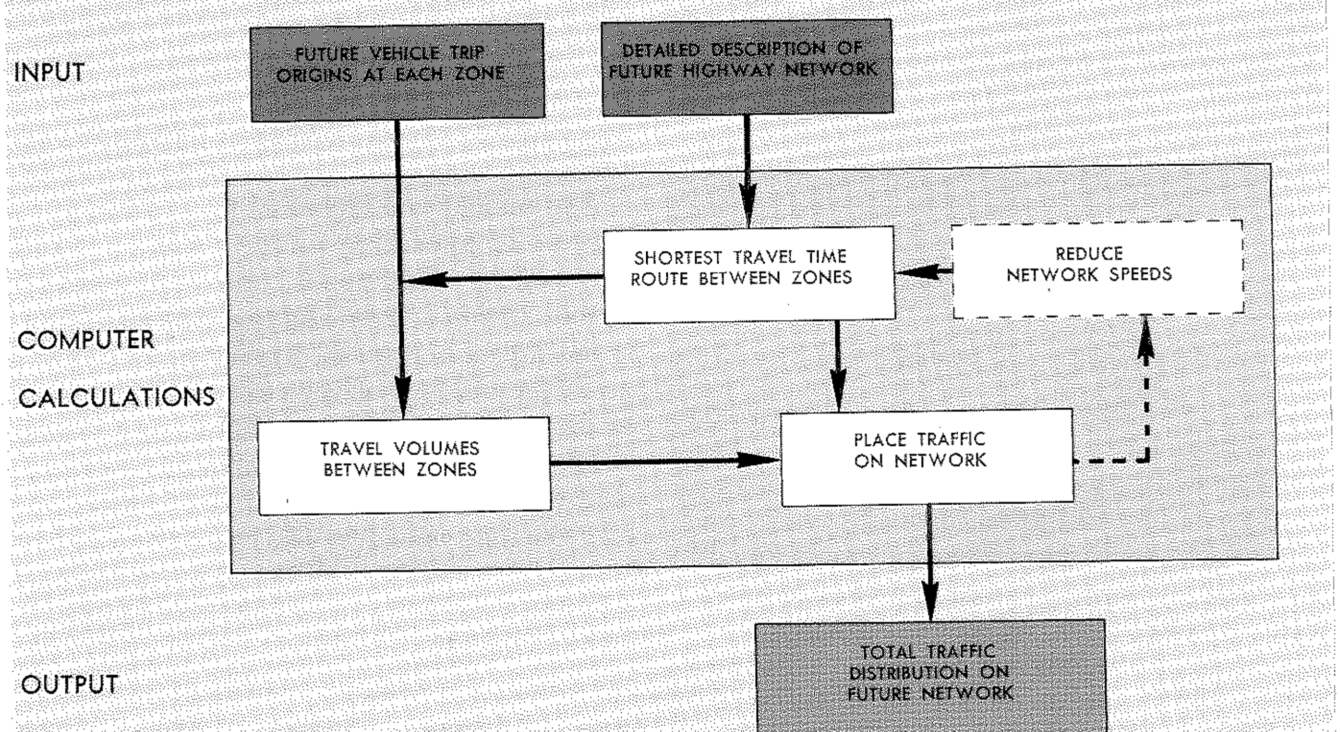
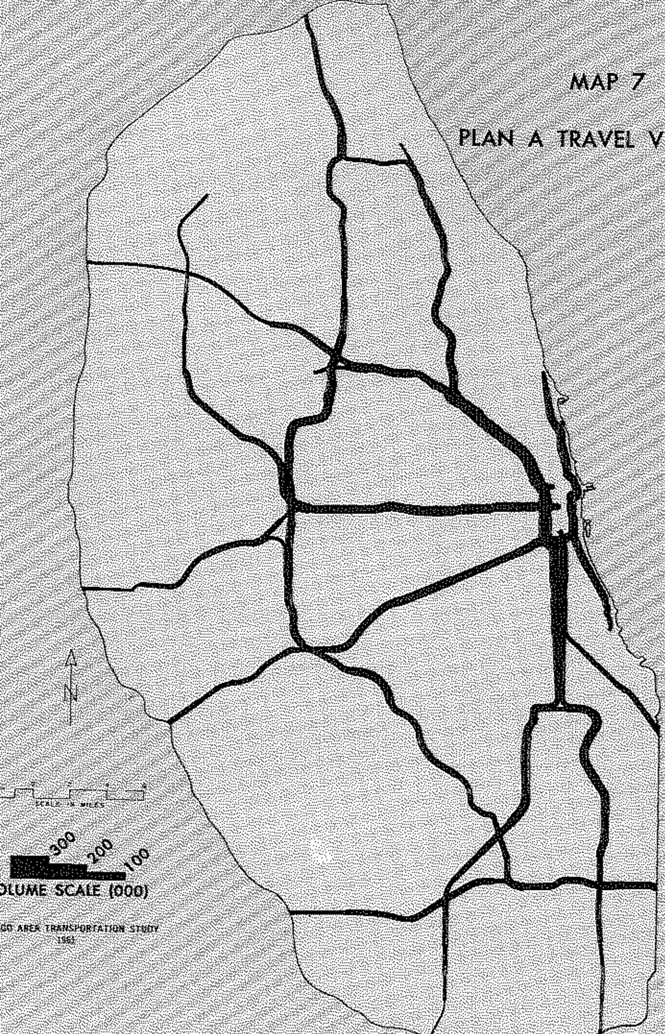
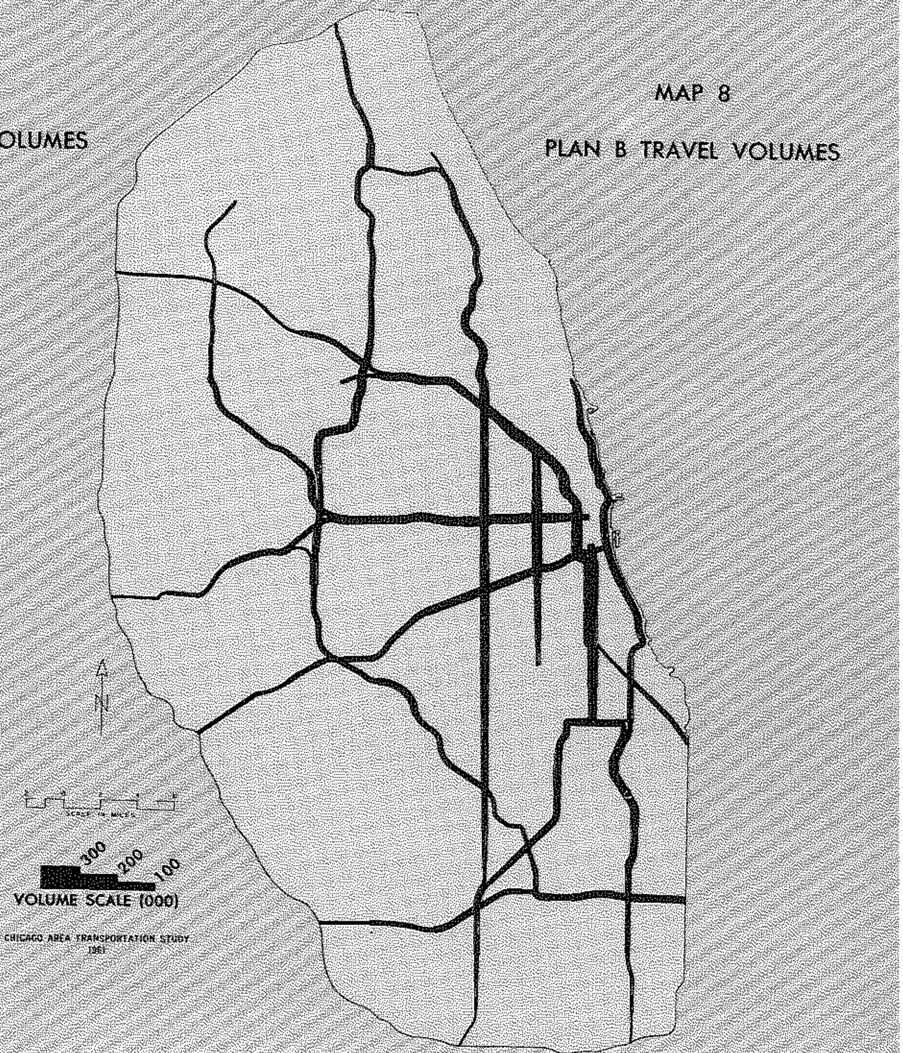


FIGURE 29—SIMPLIFIED DIAGRAM OF THE ASSIGNMENT PROCESS

The assignment process shown here represents a great forward stride in traffic planning. Here for the first time, and because of the great operating speed and storage capacity of computers, substantial realism in evaluating the performance of future networks is possible. This diagram illustrates the assignment process developed by the Study staff.





1980 travel volumes allocated to Plan A, the minimum committed expressway system, and to Plan B, the minimum system, with two important north-south routes added.

And this would also show whether the optimal spacing estimates applied to an entire network design. Then, if Plan K appeared to be in the right order of magnitude, further tests to evaluate the possibility of other improvements could be run. These tests are described in the following two sections.

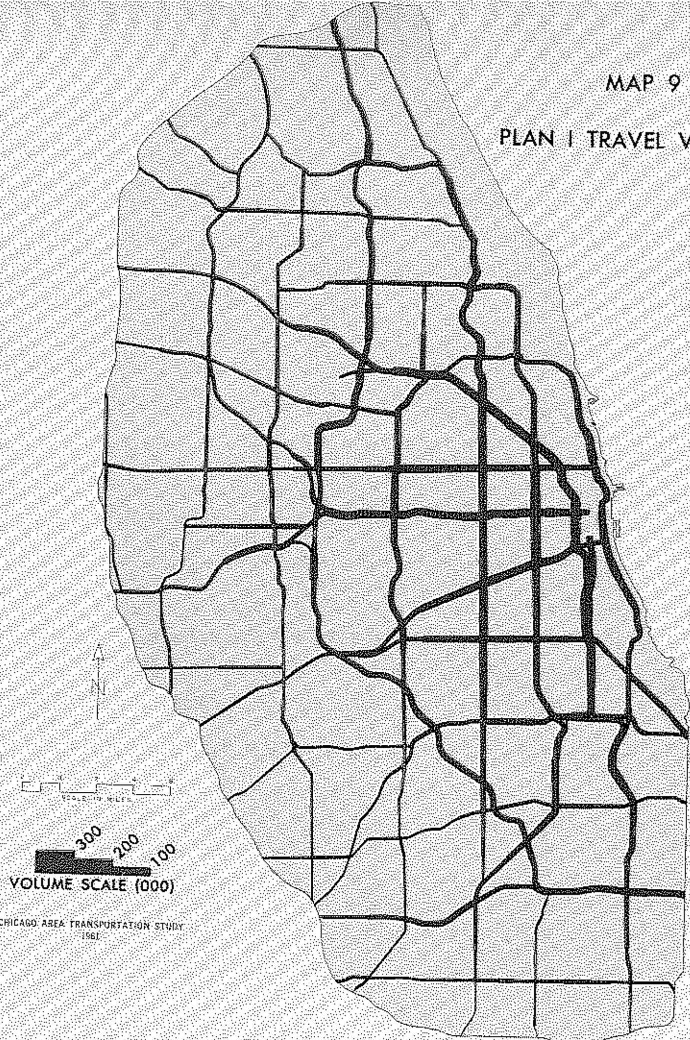
Testing the Scale of the Preliminary Plan

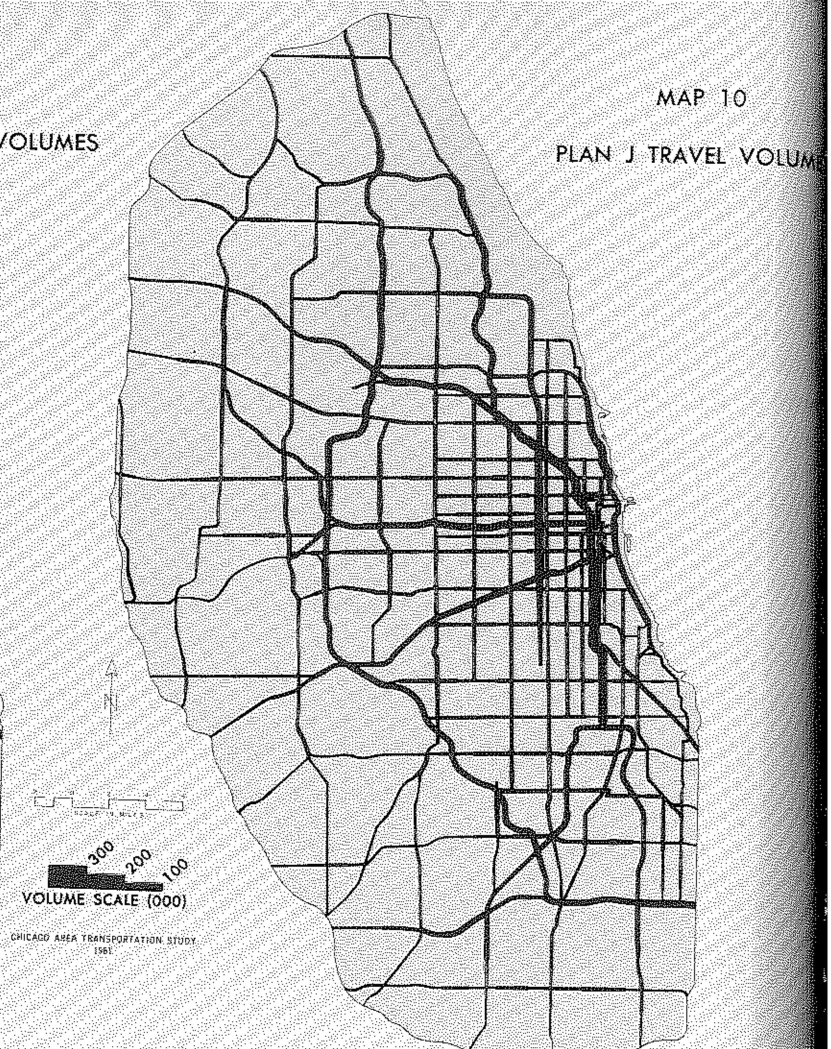
To test the scale of the preliminary plan, four other previously developed plans were given traffic assignments. These four had substantially different amounts of new facilities. They were designated as Plans A, B, I, and J.[3] The mileage of the several plans varied from Plan A with 288 miles of expressways to Plan J with 968 miles of expressways and intermediate facilities.

The minimum expressway plan (Plan A) is the committed expressway system and is shown on Map 7. This describes the network of routes which either are built, are under construction, or are heavily committed to be built. According to current scheduling, all the facilities shown in this committed system should be in service by 1965. Included in this plan, but not shown, is the expectation of widening some eight hundred miles of suburban arterial streets from two to four lanes of pavement by 1980.

A second plan which contains an additional thirty-nine miles of expressways over and above that contained in Plan A is labeled Plan B and is shown on Map 8. This plan features the addition of two important north-south routes located east of the Tri-State Tollway. It contains a total of 327 miles of expressways in the Study Area and has been proposed as a more realistic minimum plan by engineers of the sponsoring agencies because some attention was given to the obvious need for cross-

[3]The use of letters is simply a notation adopted by the staff to identify alternate designs. There is no special significance to the letters used, but it has proven useful to retain these identifying marks in discussion and reporting.





Expressway Plans, with 1980 travel volumes, containing more route mileage than Plan K. Plan I is an intermediate expressway system with more route mileage than Plan K, but less than the maximum mileage of Plan J.

town facilities. This contemplates the same arterial enlargements as in Plan A.

Two plans having more expressway mileage than Plan K also were tested. The first of these, Plan I which appears on Map 9, contained 681 miles of facilities or 215 more than Plan K. The maximum plan tested was Plan J shown on Map 10. Plan J was different in kind as well as in magnitude from the other plans. It contained a very large number of intermediate facilities. These were spaced at one and two mile intervals within the more densely developed part of the urban region and at roughly three mile intervals in the suburban areas. In all, Plan J contained 656 miles of intermediate facilities and 312 of expressways, all within the Study Area. This was an experimental plan designed to show the effect of building intermediate type facilities. If all 968 miles were built to true expressway standards, the capital cost of completing Plan J would be well over $5 billion.

Using identical computer procedures, the same group of 1980 trips was allocated to each network. In each case the trips were generated and assigned to the planned network applying capacity restraints so as to simulate actual usage. The output of each assignment was converted further to total cost estimates by application of identical rules. Thus, comparisons between these plans are quite valid.[4] Results are evaluated in terms of traffic performance and later in terms of over-all economics. They are shown on the successive maps. Only the expressway assignments are illustrated on these maps because the arterial loads cover much too detailed a network. The comparative numerical results of the several plans tested are shown in Table 10.

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[4]Whatever the imperfections of the trip distributing formulas and techniques and however approximate the capacity restrained network simulates real conditions, the *comparative* measures of network performance have much greater value, since the only variable manipulated is the network itself.

TABLE 10
COSTS AND PERFORMANCE MEASURES OF FIVE ALTERNATE HIGHWAY PLANS UNDER 1980 TRAFFIC LOADS

Characteristics	Plan				
	A	B	K	I	J
Miles of Proposed Routes	288	327	466	681	968*
Cost of Completion in Millions (after 1960 and including arterial street improvements)	$907	$1,274	$1,797	$2,457	$3,180
Average Weekday Vehicle Miles of Assigned Travel to Arterial and Express Facilities for 1980 (In Millions)					
To Arterials	45,036	41,963	34,380	31,531	24,245
Express	22,878	25,191	33,320	35,061	41,574
Total	67,914	67,054	67,700	66,592	65,819
Daily Vehicle Equivalent Hours of Travel (In Thousands)	2,420	2,283	2,049	1,937	1,990
Estimated Annual Traffic Fatalities	781	698	638	606	638
Estimated Daily Traffic Accidents	504	450	378	346	416
Costs Converted to Cents per Vehicle Mile					
Travel (accident, time and operating costs)	9.10	8.71	8.11	7.90	8.04
Interest and Principal (on construction costs)	.43	.62	.86	1.20	1.57
Total	9.53	9.33	8.97	9.10	9.61

*Six hundred fifty-six miles were proposed as intermediate type facilities.

If only Plan A were built, arterial driving speeds in most parts of the Study Area in 1980 would be slower than 1956 speeds. This is to be expected. A greatly increased volume of trips forced over a network only slightly larger than that existing today would bring about increases in congestion and decreases in driving speeds. This would be true even with arterials widened in the two outer rings of the Study Area. The added capacity in these regions from this source alone is not great enough to compensate for the expected increase in traffic.

Accidents are another measure of traffic performance. With no highway improvements beyond those included in Plan A, the number of accidents, in 1980, could be expected to rise about fifty per cent over the present annual number. Accidents in the Study Area currently average 330 each day. In 1980, with Plan A built, slightly over five hundred per day could be predicted. Current death rates are about five hundred per year from traffic accidents. The number of traffic deaths in 1980, assuming that current rates hold and if Plan A constitutes the extant highway network, would be 750 per year.

The facilities proposed in Plans K, I, or J would bring about a significant reduction in the expected number of accidents. Actually, Plans K and I would do a better job than Plan J despite the latter's greater mileage of intermediate facilities. The reason is that intermediate facilities, which have grade intersections and allow pedestrian access, have a proven higher accident rate than the fully controlled access designs of expressways.

Can the superior traffic performance of the plans with more expressways be justified in the face of their increased construction costs? This seems a heartless question, especially when lives and injuries are involved, but it is crucial, nevertheless. Lives, health and public welfare also are intimately involved in other programs such as hospital improvements, schools and recreation. All of these make their claim for the public construction dollar and must be evaluated fairly on some common ground. Economic analysis helps point the way to the greatest reward that might be achieved from the spending of the limited public funds.

Economic evaluation of performance of the several plans is illustrated in Figure 30, page 60. The daily costs of each plan are calculated for the year 1980. The costs of travel represent the sum of the accident and operating costs, plus the value of time. These are the costs which are influenced by the highway network.

Added to these direct travel costs are the annual values of the proposed improvements, i.e., the principal and interest payments required to pay for the new capital to be invested between 1960 and 1980. These values assume a twenty-five year life and ten per cent rate of interest. In this fashion the investment costs are weighed and can properly be fitted into the evaluation scheme. The sum of the two measures—travel cost plus capital cost—provides the evaluator to be used in assessing the merits of the various plans. Under Plan A travel costs are very high, so that, even though capital costs are very low, the total transportation costs are quite high. Plan B, with nearly forty miles more of expressways, reduces the total costs because travel costs drop faster than capital costs rise. So it is well worth making this additional improvement. The capital costs of Plan J, on the other hand, are so high (three billion if intermediate facilities are built, and over five billion if all facilities were expressways) that they overbalance the gains in travel costs. This represents overdesign and it would not be economical to make improvements to this extent.

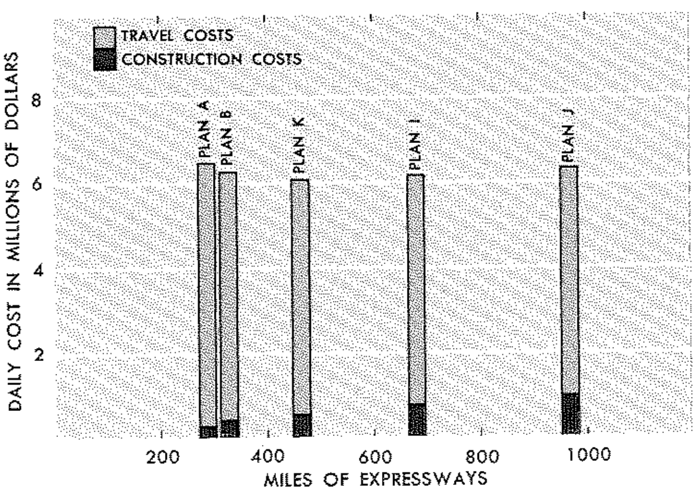


FIGURE 30—ECONOMIC EVALUATION OF THE ALTERNATE PLANS

See Table 29 in Appendix.

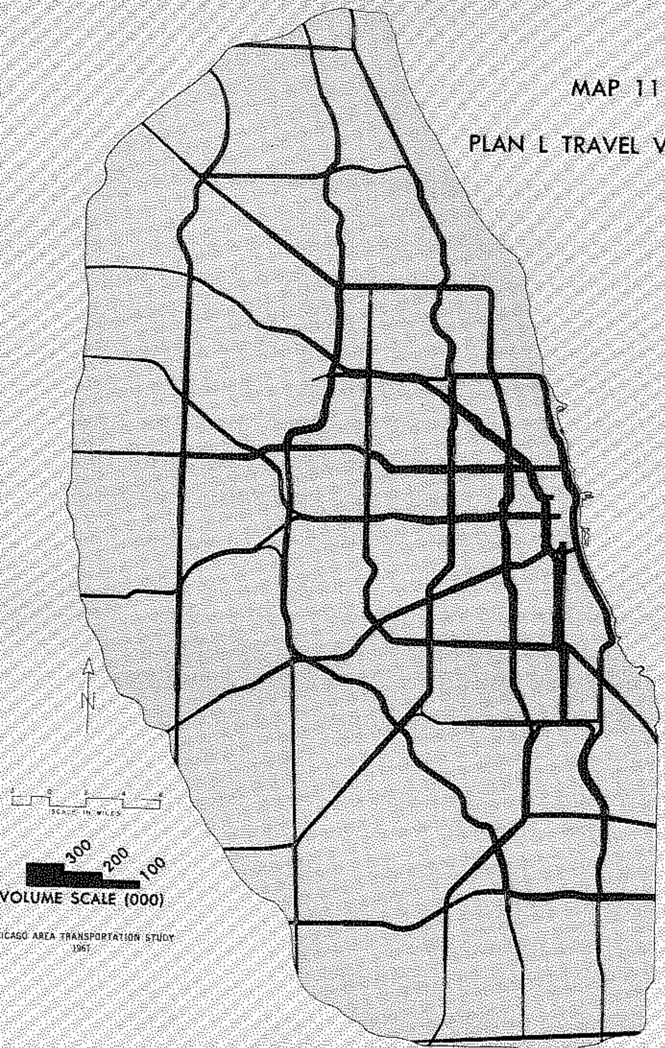
Plan K was the best of those tested. Yet it must be admitted that this does not, as yet, necessarily provide the closest approach to the ideal solution that is possible. Wouldn't some other plan with slightly more or less mileage than contained in Plan K serve better? And, even more to the point, wouldn't some readjustment and realignment of the route mileage of Plan K measurably improve the total performance?

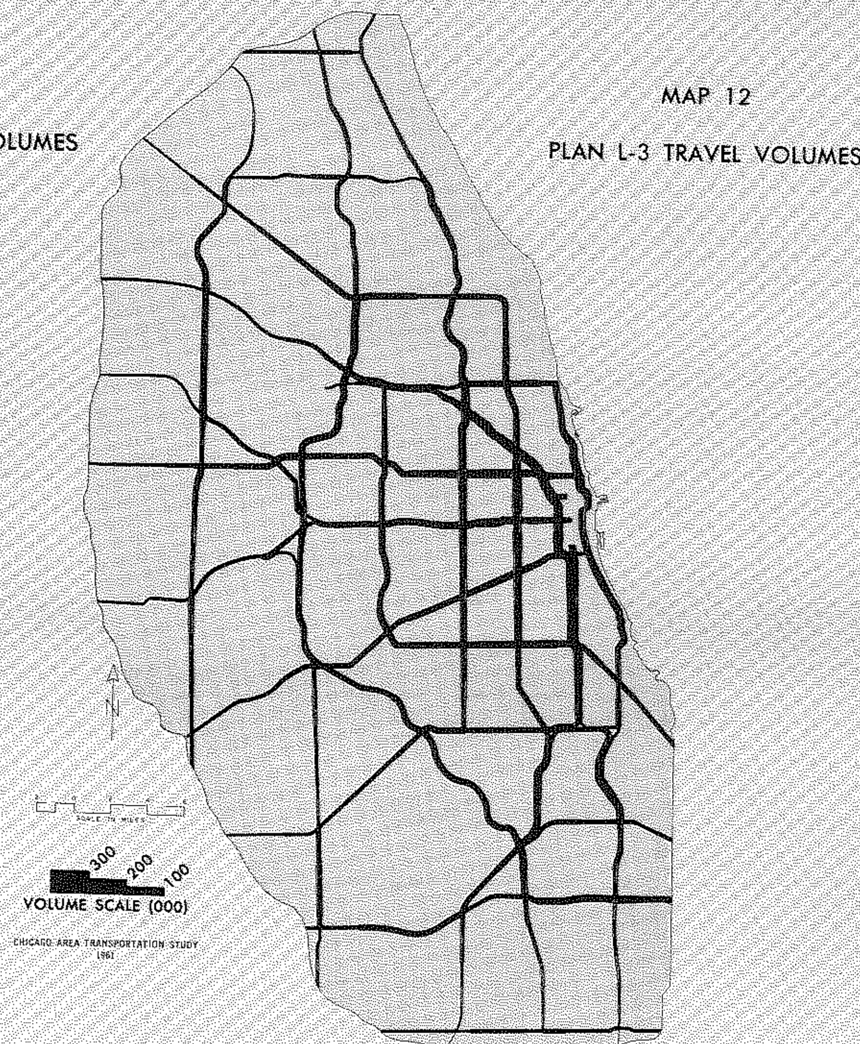
The tests provide helpful evidence in the search for answers to these questions. The evidence suggests the possibility that a slightly larger system would be more rewarding, i.e., the area between Plan K and Plan I on the bar graph needs better definition. Also, study of the several plans and the traffic loads projected allow well defined guesses as to how the loads on the projected network could be made more nearly even as well as higher in volume by readjusting or realigning some of the route locations. Such a readjustment of load would, of course, increase the rated economic performance of a plan.

Refinement of Plan

Plan L was developed as a refinement of Plan K, based on the experience of the assignments to Plan K and the four other plans. This plan contains 527 miles of expressways or fifty-four miles more than Plan K. However, Plan L was more than just Plan K with additional miles of facilities inserted; some parts of Plan K were redesigned or realigned taking advantage of clues obtained by study of the assignments to the other plans. Basically, the idea was to smooth and simplify the network, adding new facilities where over-loads existed, consolidating facilities where expressway volumes were uneconomically light, and generally providing a distribution of service better related to demand.

For example, Plan K, as can be seen on Map 6, had a number of expressways in the southwestern part of the Study Area which, partly because this region is one of low trip generation, carried very light loads. These expressways were too close together for the local traffic density. This tended to reduce loads. In Plan L (see Map 11) this situation was improved by reducing the miles of new facilities and providing a new design of this network in that area. In the northwestern part of the Study Area, Plan K had too few facilities and the design was not properly oriented to serve summer traffic going to the Illinois and Wisconsin lake regions. This situation is improved in Plan L





1980 travel volumes allocated to Plan L, the basic expressway system out of which Plan L-3 was developed, and Plan L-3, the expressway plan recommended by this Study.

by adding more expressways, providing more even spacing, and by aligning facilities so that they bring traffic into the denser development more directly before distributing it to north-south facilities. Other changes can be identified. All were made to achieve a more efficient design in terms of placement and usage.

Plan L was tested by assignment in the same manner as the other plans. Results of the assignment showed that total transportation costs were lower than those for Plan K. Thus, Plan L, by these economic measures, was proved to be better than Plan K.

The next step was to evaluate all aspects of Plan L and, in effect, do the "fine tuning" required to finalize the network plan.

Three variations of Plan L were subjected to assignment tests. There was a question on the alignment of Interstate 90 between its connection with Lake Street and North Avenue near Elmhurst and its junction with the Northwest Tollway. Two different alignments were tested, holding the remainder of the network exactly the same. The traffic assignment showed that one location was definitely superior. In one instance, impossible turning volumes at an interchange and overloading of a short section of the system were produced. These troublesome traffic problems were detected only after traffic loads were imposed on the network by traffic assignment.

This change and some others were incorporated in the final version of Plan L. The total expressway mileage was reduced to 520 miles by the deletion of a seven mile low volume section. One expressway in the northwest was relocated slightly in order to eliminate a five-way interchange. Another in the south was changed to provide a better connection to the southwest. By making these adjustments, Plan L was refined to Plan L-3, shown on Map 12.

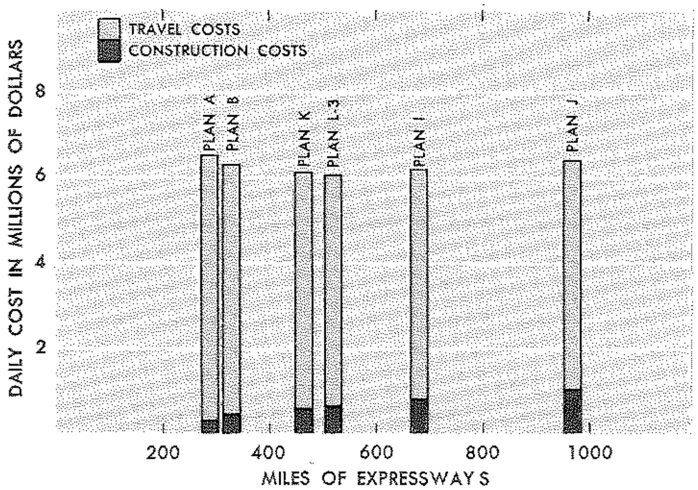


FIGURE 31—ECONOMIC EVALUATION OF THE ALTERNATE PLANS WITH PLAN L-3

See Table 29 in Appendix.

Now the question arises—of all the plans tested, is Plan L-3 the best? Figure 31 shows the economic evaluation of the alternate plans with Plan L-3. Table 11 shows the cost and performance measures of the alternate highway plans under 1980 traffic loads. Plan L-3 has the lowest total transportation costs of all the plans tested. A glance at the table prompts another question. The difference in costs on a per vehicle mile basis is not great. Is there another way to appraise the economic worth of Plan L-3? In the following section the economic evaluation is carried out by using the method of marginal cost analysis.

Marginal Cost Analysis

The first few miles of expressways built in any urban area can easily produce a large return on investment. They will be used heavily —often overused—and thus capital costs will be shared among many users. Rewards from time savings, and from reduced accident and operating costs also are likely to be large because the first expressways generally are built in areas where need is greatest and surface congestion most severe.

As more miles of expressway are built, however, the rate of return on investment begins to decline. Volumes of traffic on expressways are lowered as more facilities share the load. At the same time, arterial congestion becomes progressively less frequent, so large gains are ever more difficult to obtain. The rate of return on each additional mile of expressway built will, therefore, tend to decline steadily. At some point it ceases to become worthwhile to build additional facilities. The calculation of this point is simply a question of marginal cost analysis, a standard economic technique.

Plan B, for example, requires $367 million more investment than Plan A, yet Plan B, each year, will save truck and automobile drivers $115 million in accident, operating and time costs compared to Plan A. This is equivalent to a twenty-nine per cent return on

TABLE 11
MEASURED PERFORMANCE OF THE RECOMMENDED PLAN IN CONTRAST TO ALL OTHERS TESTED

Characteristics	Plan					
	A	B	K	L-3	I	J
Miles of Proposed Routes	288	327	466	520	681	968*
Cost of Completion in Millions (after 1960 and including arterial street improvements)	$907	$1,274	$1,797	$2,007	$2,457	$3,180
Average Weekday Vehicle Miles of Assigned Travel to Arterial and Express Facilities for 1980 (In Thousands)						
Arterials	45,036	41,963	34,380	33,149	31,531	24,245
Express Facilities	22,878	25,191	33,320	34,414	35,061	41,574
Total	67,914	67,054	67,700	67,563	66,592	65,819
Daily Vehicle Equivalent Hours of Travel (In Thousands)	2,420	2,283	2,049	1,990	1,937	1,990
Estimated Annual Traffic Fatalities	781	698	638	626	606	638
Estimated Daily Traffic Accidents	504	450	378	359	346	416
Costs Converted to Cents per Vehicle Mile						
Travel (accident, time and operating costs)	9.10	8.71	8.11	7.96	7.90	8.04
Interest and Principal (on construction costs)	.43	.62	.86	.96	1.20	1.57
Total	9.53	9.33	8.97	8.92	9.10	9.61

*Six hundred fifty-six miles were proposed as intermediate type facilities.

the added investment—a very large saving to the region's travelers. The rates of return on the marginal investment required to build Plans K, L-3, I and J, each successively more complete than the preceding plan, are shown in Table 12. Plan K returns a savings and travel cost equivalent to a 22.5 per cent profit over Plan B. Plan L-3 is estimated to return 17.8 per cent over Plan K. But Plan I returns only 7.5 per cent, while Plan J is apparently more expensive and less efficient than Plan I and so has a negative value.

TABLE 12
MARGINAL COSTS OF EXPRESSWAY PLANS

Plan	Annual Savings in Travel Costs Over Preceding Plan (In Millions)	Marginal Investment Over Preceding Plan (In Millions)	Marginal Rate of Return
A.........	....	....	.....
B.........	$115	$367	29.3%
K.........	$118	$523	22.5%
L-3.......	$ 38	$210	17.8%
I.........	$ 40	$450	7.5%
J.........	$-11	$723	*

*Rate of return would be negative.

As indicated in Chapter II, it was decided that ten per cent was the minimum rate of return which would justify investment in additional transportation facilities. This rate of return was set partly to eliminate high risk investment and partly to arbitrate between competing demands for the public investment dollar.

Using this criterion, Plan L-3 stands out as the best plan. It has the lowest total transportation cost. Moreover, it still provides a rate of interest on the additional investment over Plan K of more than the required ten per cent. Plan I, on the other hand, has a less than adequate rate of return on the additional investment over that needed for Plan L-3.

In summary, Plan K, whose scale was fixed originally by optimal spacing considerations, was subjected to a variety of tests. Its traffic performance and economic characteristics were evaluated in the light of other possible plans. It was found that, while the general scale of the plan and its general design were satisfactory, improvements could be made by designing a slightly larger and somewhat different system. This more complete system was studied with great care and a number of design modifications were tested. From this work and evaluation, the members of the Design Subcommittee and the Policy Committee concurred in selecting Plan L-3 as the one to be recommended.

THE EXPRESSWAY PLAN

The recommended expressway plan is shown on Map 13. This is the culmination of years of work, of many tests, and of the experience gained in reviewing other plans. It has been reviewed by engineers of the City of Chicago, Cook County, State of Illinois and the U. S. Bureau of Public Roads. It is their considered opinion, as indicated in the letter of transmittal, that this plan should serve as a guide for future expressway construction programs in the Chicago area.

This is not a plan of detailed locations—it is a system or network plan. Proposed new routes are shown diagramatically—straight lines or sweeping curves. The plan could not pretend to be otherwise, since detailed planning is impossible without considering specific land uses, subsoils, acquisition costs, and without making structural and geometric engineering studies. These are matters that must be left for design engineers and city planners to work out as the time for building each individual route arrives. The framework for such detailed studies, however, is fixed by the plan.

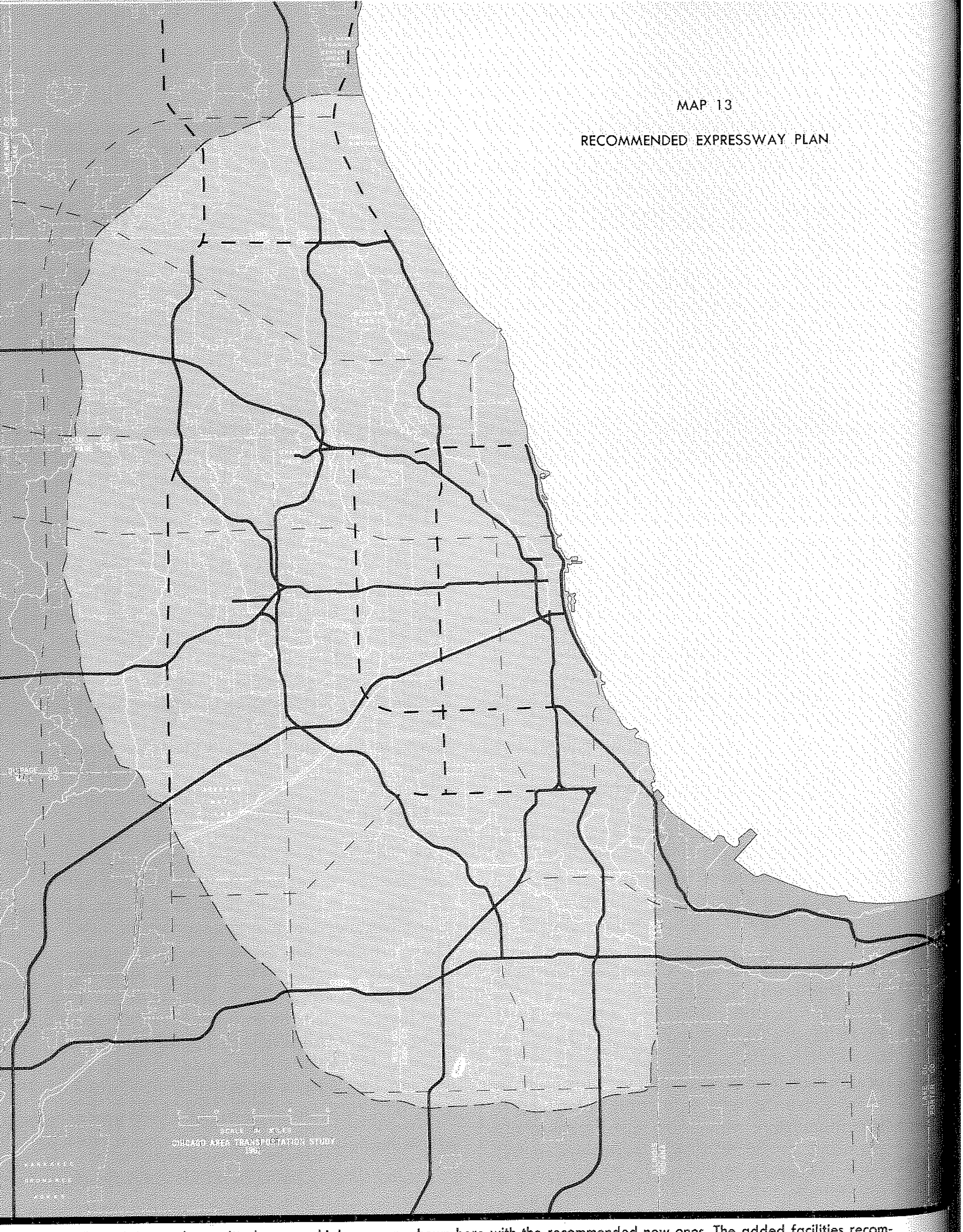
As with any other plan, this one is subject to review and revision over the years. No one can foretell the future with certainty, nor can all eventualities be foreseen. Neither highway administrators nor elected officials can commit themselves beyond a certain point in time. These are problems which plague any plan. But this does not deny the need for planning. As Burnham wrote, "A diagram contains its own logic and tells its own story. If it is close to the truth, it will persist as a guide for future builders. If not, it will be revised as it passes through the various stages of review which come with time and political processes."

Major Features of the Plan

The expressway plan (Plan L-3) is a network containing 520 miles of expressways within the Study Area. This network is nearly twice as

MAP 13

RECOMMENDED EXPRESSWAY PLAN



The existing and committed express highways are shown here with the recommended new ones. The added facilities recommended for a complete network are shown in dashed lines—heavy dashes representing the first stage and thin dashes those [illegible] corridors of location. Final locations must be made on large as the 288 mile system which is presently committed to be built. It must serve a population which is expected to be half again as large as today's, and which will drive nearly twice the vehicle miles daily. So, the size of the system is in scale with the projected travel demands.

The total cost of building the additional 232 miles of expressways and of completing all other work on committed routes is estimated at about $1.7 billion. This, together with $350 million for improving arterial streets, would bring the total cost to slightly over $2 billion, or about $100 million per year for twenty years. The current rate of expenditure for new highway facilities is more than $100 million per year. As is indicated in Chapter VI, the region can, barring war or depression, readily afford to continue road construction at this rate.

Under the plan, expressways are spaced about three miles apart in the city of Chicago and from four to six miles apart in the suburbs. As a result, few people living in the Study Area in 1980 will be as far as three miles from an express facility, and a large portion will live and work within one mile of an expressway. This is one of the reasons why thirty-five per cent of all trips and slightly over half of the 1980 vehicle miles of travel are found to travel over these expressways.[5]

Because expressway driving is safer, the number of accidents and fatalities in the area will remain at approximately the present level, even though nearly twice as many miles will be driven each year. The accident costs, then, will be reduced for the average driver—virtually halved. The pedestrian also will run much less risk of accident.

Besides being safer, driving will be much faster as more expressways are built, especially for the longer journey. Virtually no part of the Study Area will be more than one hour from another part by car or truck, while a journey of twenty miles normally will take less than a half hour. Today, such trips usually require forty-five minutes to one hour.

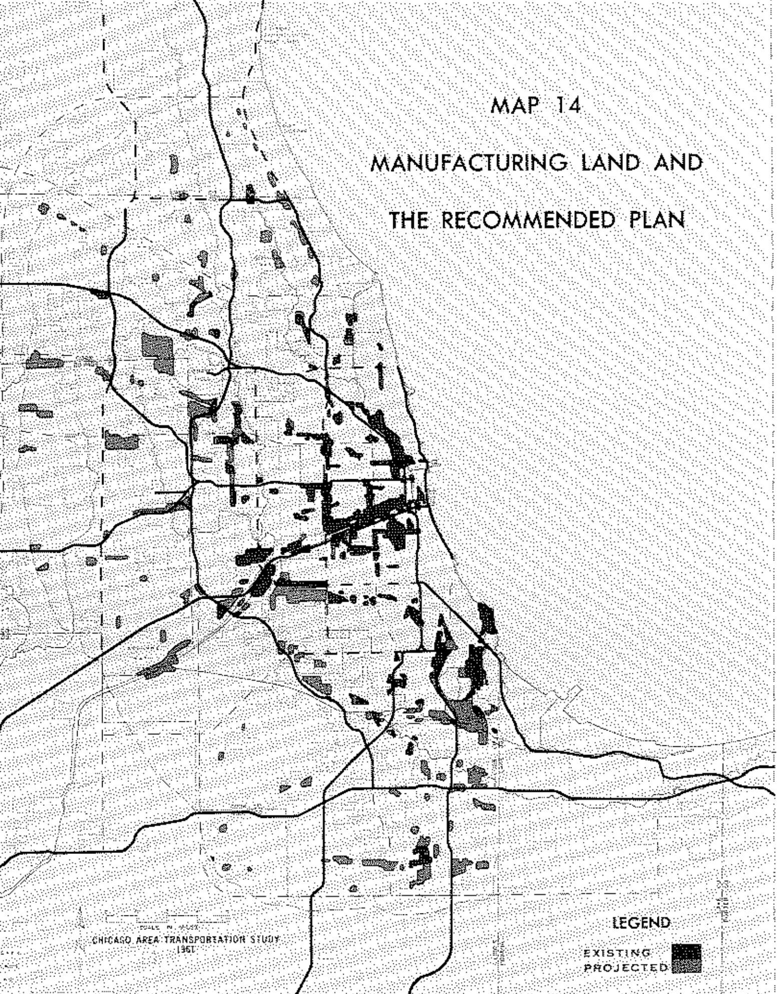
Total mileage driven on arterials will not be reduced, but loads will be distributed more evenly. Arterial volumes in the city of Chicago will average less than today's heavy loads, whereas in the suburban areas, where new growth is greatest, the average loads on arterials will rise quite sharply over present volumes (see Table 13). In these suburban areas arterial speeds will decline as rural segments become urban service roads, and as increased land development produces more and more traffic. Taken as a whole, then, arterial streets will carry just as much traffic in 1980 as at present, but there will be far fewer cases where such roads are overloaded. This will lessen the congestion and accidents which overloading implies.

The expressway plan has been carefully worked out in relationship to present and future industrial sites. Industry is a land use which attracts trips from greater distances than do other land uses. Likewise, industrial sites are more attractive to trucks. As indicated on Map 14, in the plan most sites now zoned

[5]See Table 30 in the Appendix.

TABLE 13
VEHICLE MILES OF TRAVEL AND MEAN ARTERIAL VOLUMES BY RING
(Alternate Plans For 1980, Compared To 1956 Actual Usage)

Ring	Miles of Arterials	Daily Vehicle Miles of Travel on Arterials (Thousands of Vehicle-Equivalent Miles)			Mean Arterial Volumes (24-Hour Volumes in Vehicle Equivalents)		
		1956 Existing	Plan A	Plan L-3	1956 Existing	Plan A	Plan L-3
0+1..........	93	1,960	1,490	1,203	21,000	16,000	13,000
2............	130	2,710	2,051	1,581	20,900	15,800	12,200
3............	184	3,960	2,863	2,064	21,500	15,600	11,200
4............	314	5,730	4,512	3,132	18,300	14,400	10,000
5............	365	5,250	6,021	4,244	14,400	16,500	11,600
6............	667	5,690	10,821	8,073	8,400	16,300	12,100
7............	1,070	4,820	17,278	12,852	4,500	16,100	12,000
All Rings....	2,823	30,120	45,036	33,149	9,400	15,900	11,700



The location of expressways adjacent to industrial sites will facilitate the flow of goods and at the same time improve the efficiency of arterial streets.

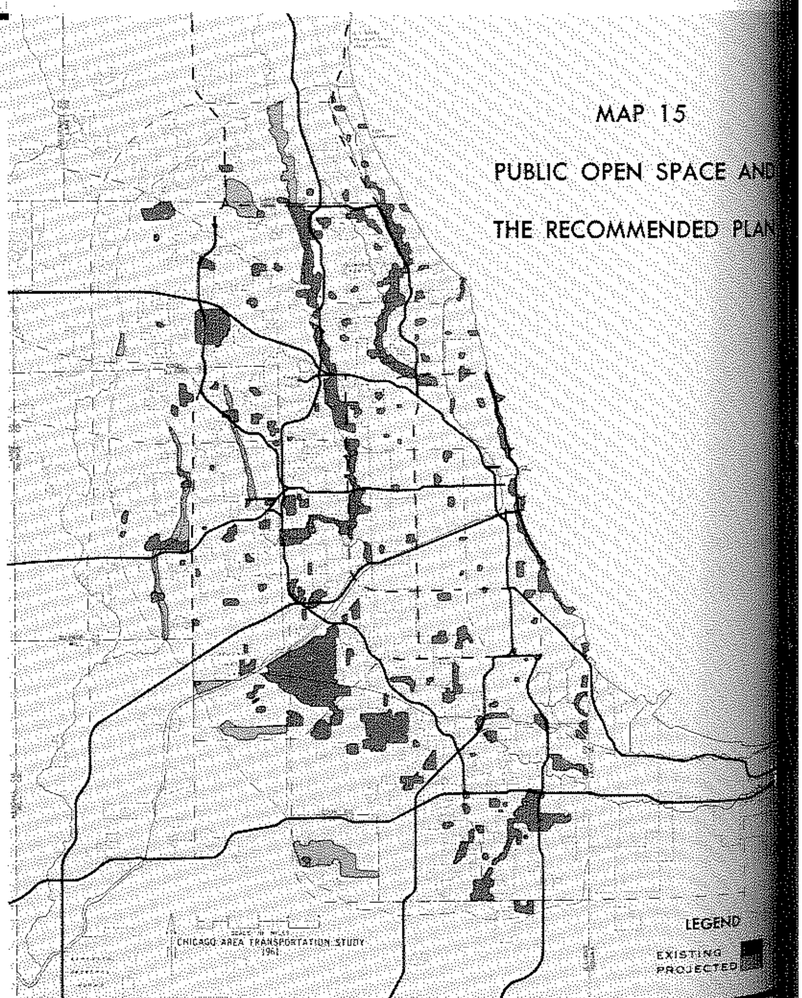
The service provided by these roads is distributed much like the population, with roads being closer together in parts of the area where population is dense, and farther apart where people live at low density.

Over-all, the recommended network of expressways will create substantial savings in travel costs—savings which will more than justify the capital costs involved. The total annual reduction in travel costs of Plan L-3 from the costs which would occur if only the committed system were built would, in 1980, be valued at $271 million. This annual saving would provide a 24.5 per cent return on the total investment needed to enlarge Plan A to the proposed size. These measured rewards are a most compelling argument for building the proposed system. The size and socially wide coverage of benefits is the greatest war-

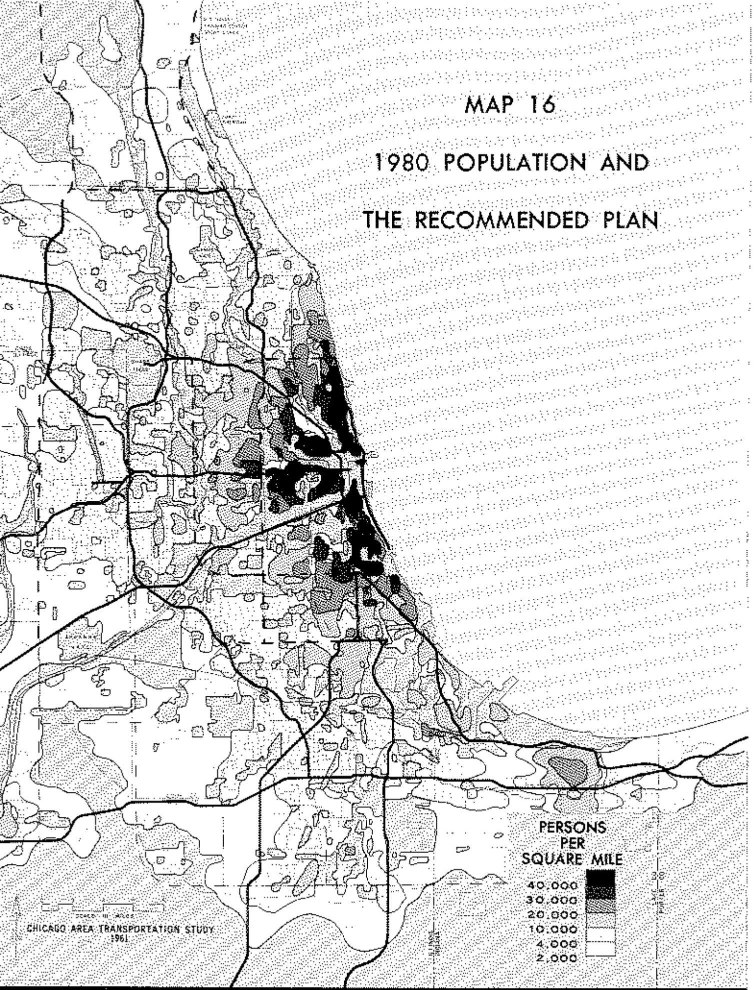
for industry are situated adjacent to an expressway. By this means, most of the long trips coming to these places will be kept off arterials. Likewise, the heavy trucks can go directly to and from these places without having to use the arterial streets.

As will be seen from Map 15, the expressway plan should require little or no land from the major parks of the area. In some cases, present and proposed future expressways border on forest preserves and other public open spaces. This is to be desired—especially for regional parks and preserves because the speed of the expressways will make these major parks more accessible to the people of the region. The roadway network will do much to bring more recreational opportunities within range of the average resident.

The plan of expressways is shown against the backdrop of 1980 population densities on Map 16. This illustrates how, twenty years hence, the entire urbanized area can be united into a single functioning unit by the network of high speed roadways. The relationship of network spacing to the variable development den-



Ease of accessibility to parks and forest preserves provided by the recommended plan will enable more people to



The recommended plan is so arranged that the population of 1980 will have almost equal travel capabilities in any direction of the urban area.

rant for such improvements in a democratic society.

Relationship to Transit Lines

The expressway plan has been designed to complement the planned rail rapid transit system described in Chapter V. This is the principal form of coordination between the two systems. In fact, it is the most important form of coordination, realizing that eighty-five per cent of all trips by persons will be made via private passenger car.

A glance forward to Map 32 on page 114 shows how expressways and rail facilities have fairly distinct trade areas. This is clearest in suburban areas where proposed expressway facilities pass between suburban rail lines and do not parallel them closely.

The proposed new expressways accentuate crosstown routes rather than radial routes. This is a deliberate policy, designed to preserve, insofar as possible, the radial routes for the rail transit facilities—both suburban railroad and elevated-subway. The radial expressways included in the plan already are committed.

In some of the dense parts of the urban area, economy makes it desirable to use expressway median strips for rapid transit facilities. This certainly does not increase noise or nuisance problems. While it may increase walking distances (which would be less if the rapid transit lines went through areas of apartment houses in their own rights-of-way), the economy of land acquisition makes such location advantageous. Perhaps the overriding advantage of these locations for transit is that of completely grade-separated rights-of-way. Using the median of the highway, room for the rail service is more readily offered. A final virtue is that radial highways can, in this way, help to furnish radial rail (or other rapid transit) service into the more densely developed heart of town.

The non-radial expressways may be used for a system of express crosstown bus routes. Where the expressways pass over or under a subway or elevated line, transfer stations could be built. By this means, the traveler without a car could use local buses as feeders to express buses traveling in all directions. Such non-radial travel by bus is now very slow, averaging only six miles per hour for journeys from door to door.[6] Express buses could substantially reduce journey times of the longer-than-average trip. The availability of these routes enlarges the range of potential service improvements of the transit operator and can serve, also, to improve the quality of transit services.

ARTERIAL HIGHWAY AND STREET PLANNING

To this point, little attention has been directed to the less spectacular work-horses of the urban traffic scene—the arterial streets. This has been done purposely, because the role of the arterials is changing. The crushing work of hauling large volumes is removed to the far more capable express highway. With expressways built, the arterial system is free to do the necessary task of carrying short trips or feeding longer trips to and from the expressways.

[6]Actually bus running times are closer to 12 mph, but the walk

The arterial streets remain a most important part of the highway system. They will carry almost half of the vehicle miles of travel for 1980—some 33,000,000 miles per day or about ten per cent more than they carried in 1956. There are nearly three thousand miles of these streets, with all of the problems of maintenance and management that go with them. About thirty per cent of all trip destinations are to addresses on arterial streets. Most of the commercial land uses are arranged along the arterial streets. For any highway plan to be complete, the function of the arterial street must be defined, and the future planning targets for this part of the highway system must be identified clearly.

Planning an arterial network is far different from that of planning for expressways. The arterial network is more finely grained. There are about six times as many miles of arterial streets as there are of expressways. Each small segment of arterial street is a part of a plan. Yet each is a small part. In this report, then, the arterial streets are dealt with as general classes of problems, with general treatment.

This general, rather than specific, treatment of arterial street plans is essential if the scale of the Study is to be maintained. Plans for arterial designation and treatment involve statements about specific, local problems in over one hundred incorporated places. Knowledge about adjacent parcels of land use, specific community plans, and many other exact ingredients are essential background for any specific proposals. These are worked out best through cooperative planning by the governmental agencies involved.

The chief contribution of this report to the more specific and local problems of arterial street improvements is towards building a framework within which solutions can be worked out. Each local problem is set in a regional frame. The solution is reached most wisely if all parties have a common perception of the environment within which the problem is nested. The continuous and interlocking nature of traffic flows make arterial highways particularly sensitive to influences at work at some distance from the site of any particular problem.

For these reasons, this section will be restricted to marking out the regional problems of arterial streets and street planning. It will be concerned with general policies and major planning and programming strategies. No attempt will be made to specify a particular arterial street plan in this volume.

The Arterial Street Traffic Demands of 1980

The arterial street must serve adjacent land and must move traffic. These are often conflicting functions. Both are important. From the viewpoint of regional network design, however, traffic service is the more significant factor, because it is the ingredient that determines the interconnectivity and many of the design requirements.

What about the future traffic demands on arterial streets? Two major changes have been identified. The first is a geographical shifting of traffic demands. The second is a substantial change in the type of traffic served as a result of building the new network of express highways. Both of these are spelled out by using the 1980 community as the backdrop.

The traffic demands of 1980 show the greatest growth in the suburbs. This is where land development and population will increase most. And these are the two factors which produce more traffic. The increase in measurable vehicle miles of travel varies from a fairly small thirteen per cent at the center of Chicago to a 262 per cent gain in Ring 7. If no further expressways, other than those of the presently committed system, were constructed (i.e., Plan A), the growth in arterial street traffic in Ring 7 would be 360 per cent.

This would be a formidable increase for arterial streets to absorb, but, fortunately, the extended expressway network changes this. Much of the increase in traffic is drawn into the new and enlarged expressway network, thus substantially lessening the demands on the arterial streets. For purposes of comparison, the existing arterial street usage can be shown and contrasted with the expected loads on arterials in 1980 and with the expressway plan (L-3) complete.

Both effects of growth are apparent in Table 13. The outward extension of traffic is evident from the increased volumes on arterials in the outer rings. The effect of the new expressway system is also apparent in the leveling of demands on arterials until near uniform loads are expected throughout the region. The overall load on arterial streets increases from about thirty million vehicle miles a day to over thirty-three million vehicle miles per day, with reductions in arterial demands at the center partly offsetting the suburban increases.

The arterial traffic of 1980 will be different in many significant ways from the arterial traffic of today. By understanding these differences, the task of service required by arterials becomes clearer. And it is on this revised type of service that the proposed strategy for arterial improvements is founded.

What is different about arterial service demands in 1980? The more even loads have been noted. But what about the traffic characteristics of the users? First, it is obvious that the journey length on arterial streets will be shorter. Since the long trips will be moved to the expressways, only short trips or short segments of longer trips will remain on arterial streets. A vehicle on an arterial street, in 1980, will be much more likely to be close to its origin or destination point than it is at present.

Secondly, these short trips or trip segments shift the patterns of arterial usage. The probability of turning at an intersection will increase. Today's traffic, being a mixture of long and short trips, has a substantial through movement potential at any arterial intersection. But shorter lengths increase the probability of turning. This increased frequency of turns places emphasis on somewhat different traffic engineering treatment of intersections. Split phase signals, turn bays, rounding of corners and many other improvements will be required.

The expressways cause another significant change in traffic usage of arterial streets. The ramps leading into the expressways represent a new focal point of trip attraction. Traffic flaws are reoriented to expressway ramps. The arterial streets which run parallel to new expressways tend to sustain the greatest losses, whereas traffic on streets leading to and from ramps have the greatest gains. The effect is a substantial redirection of flows.

Figure 32 illustrates this point of flow redirection by describing an actual "before and after" situation in Oak Park, a suburb adjacent to Chicago. The Oak Park portion of the new Congress Street Expressway was opened in 1959. Traffic counts were obtained on the adjacent arterial streets before and after the opening of the expressway. These counts show, very clearly, the reorientation of flows. Austin and Harlem Avenues, which intersect the expressway, have greater traffic volumes as a result of the expressway ramps. Jackson Blvd. and Madison St. show significant declines because they parallel the expressway and some of the traffic they once served has moved to the superior facility. It is apparent that the traffic service demands placed on arterials will be changed substantially by the introduction of one expressway or a system of expressways.

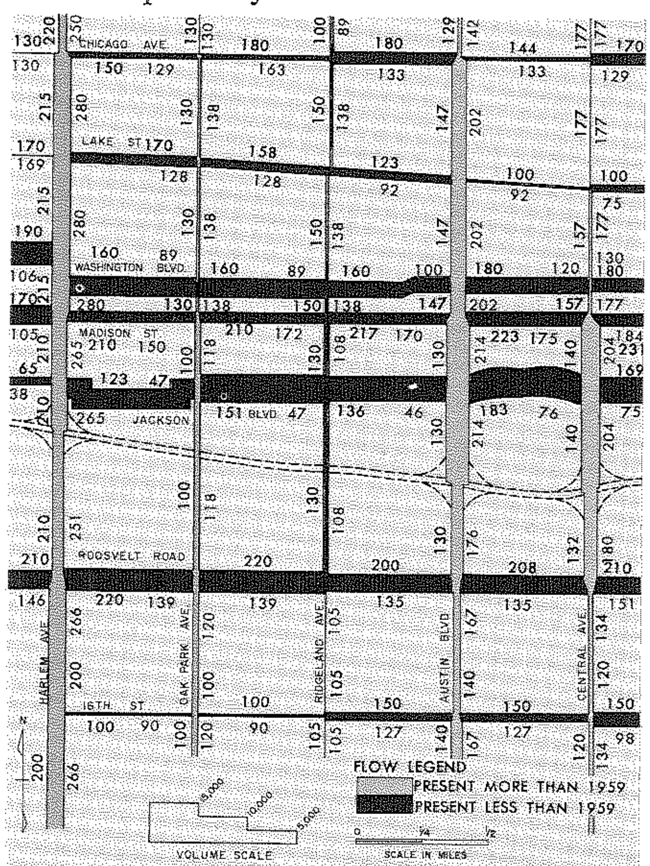


FIGURE 32—CHANGES IN TRAFFIC FLOW ON ARTERIALS IN THE OAK PARK AREA DUE TO THE OPENING OF THE CONGRESS EXPRESSWAY

The flow bands indicate the net change in volume on the arterial system. The black numbers show the actual volumes in 1959 and the red numbers the present volumes. Both volumes are shown in hundreds of vehicles.

A Recommended Policy for Arterial Improvements

What, in the light of the projected changes, will be the most effective policy for making arterial street improvements? The goal is apparent—it is to produce changes that gradually will readjust the arterial system from its present function and loading to that expected by 1980. This means that changes must generally be paced according to growth in land development on the one hand, and the construction of expressways on the other. The annual improvements in arterial streets should ultimately accumulate to produce the revised arterial system.

There are a variety of treatments which may be used, depending upon the particular arterial problem. Over the course of the next twenty years, all will have to be brought into play to bring about the arterial transformation. They are listed and discussed below.

a) Building New Arterials.

It is true that some twenty-eight hundred miles of arterials are presently identified.

TABLE 14
NEED FOR NEW ARTERIAL STREETS BY RING

Ring	Existing Arterial Street Mileage	Present Average Spacing (In Miles)	Additional Street* Mileage Needed
0+1..........	93.4	.290	...
2.............	129.7	.402	...
3.............	183.8	.448	...
4.............	314.2	.541	...
5.............	364.6	.709	2
6.............	667.0	.881	11
7.............	1,069.9	1.211	237
Total........	2,823		250

*If no zone has arterial spacing greater than one mile on the average.

Not many more miles will be needed in 1980. But new arterials will be required as agricultural lands become absorbed into urban development. It is important that all potentially developable areas in the hinterland have an arterial street plan. Dedication of rights-of-way, as well as proper land access designs, should be specified for new developments. Proper width and setback features will have to be anticipated, and proper connections to existing arterial streets must be assured. These new arterials must be added (an estimated 250 miles, if the spacing requirements are met) as the means for accepting the projected growth. The additional arterial street mileage needed in each study ring, if mean spacing of one mile is to be achieved by 1980, is indicated in Table 14.

b) Widening Existing Street Pavements.

In addition to wholly new arterial streets, old ones must have their pavements widened. This will occur most frequently in the outer suburban areas where an estimated eight hundred miles will have to be widened from two to four paved lanes. The average volumes of ten to twelve thousand vehicles per day could not be carried on two-lane roadways. In almost every instance there is sufficient room in the existing rights-of-way to add the additional paving. Care should be taken to insure that such paving is not absorbed by parking. Similarly, there may very well be cases, in Chicago and other incorporated places, where either pavement widening or parking restrictions, or both, will be required on existing arterials.

c) Arterial Changes Concurrent With Expressway Construction.

As new expressways are built, there must be a careful and concurrent program of arterial improvements. The first priority will be those arterial improvements required to feed the expressway ramps. Next in priority would be the re-timing of signals and de-emphasis of parallel arterial streets. In some instances parallel routes may either be dropped from the system or may be planned for use as local shopping streets.

d) De-emphasis Of Surface Radials.

Traffic engineers have long been plagued by the difficult task of adjusting the timing of signals and the organization of an arterial network where a grid system is crossed by radial routes. Not only does the radial route cut the land and street system into awkward pieces, it is particularly difficult to cut out portions of the available time. If a radial route should intersect the two grid arterials, the signal timing of the intersection must be split three ways. This re-

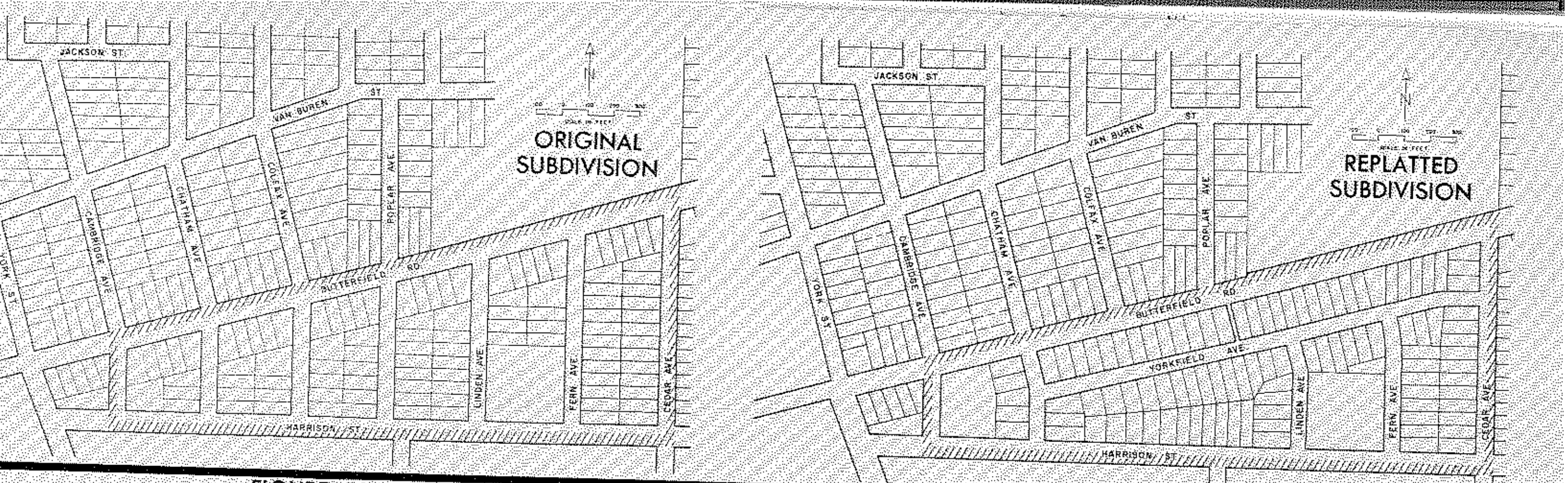


FIGURE 33—IMPROVEMENT OF ARTERIAL TRAFFIC THROUGH SUBDIVISION REPLATTING

Land presently subdivided but vacant can be replatted thus enhancing traffic flow on adjacent arterial streets and at the same time making more efficient use of the land. This replatted subdivision reduced the number of intersections with an adjacent arterial in the village of Elmhurst. Lots now front on Yorkfield Ave., eliminating the potential of a driveway every fifty feet on the arterial street.

duces the capacity of each street and creates a natural spot for a bottleneck. If the new expressway capacity will permit giving up some surface radial capacity, the traffic engineer is given a powerful tool for improving the progression of signals, and thereby the capacity and performance of the grid arterial.

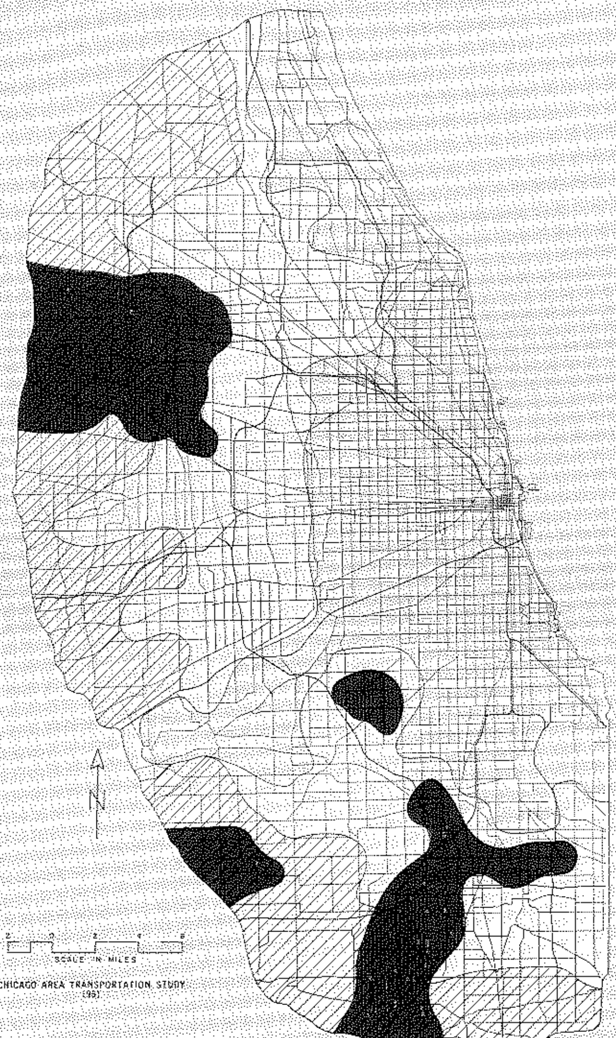
e) Improved Roadway Designs.
The arterial street will continue to serve both traffic and the adjacent land parcels. Different arterial streets may have different emphases—some will be most concerned with serving traffic, others, such as local shopping streets, will emphasize land service. New roadway designs can be very helpful in resolving these sometimes conflicting roles. Where traffic demands are greatest, service drives can be developed, and special median treatment can be provided. Conversely, where local service is paramount, the allowance for frequent turns for access to parking lots and for pedestrian activity will be of greater importance. Because nearly a fifth of all frontage will be on arterial streets, and because these streets will continue to serve the more intensive commercial uses, substantial effort toward design modification aimed at improving the functions of traffic service and land use is justified.

f) Converting Some Arterials To Locals.
There will be instances where the demands of traffic have required traffic engineers to convert streets into one-way pairs. In other instances, previously local streets have been upgraded to arterial rank. While these have produced problems with respect to land use, they have been essential for traffic service. In many cases, the relief provided by the expanded expressway program should allow a gradual withdrawal of such streets from the arterial group. This can increase the potential of some areas for new housing or other redevelopment. It also can be of substantial assistance in cutting down accidents and improving signal progression.

The summation of these many different possible actions will be required if the new role of the arterial and the orderly development of land are to be achieved. Taken together and developed as a program, they gradually will transform the overstrained arterial roads of today into the balanced network of tomorrow.

The development of precise treatment and timing is a matter of specific programs in specific jurisdictions. The efforts of the planners to bring about healthy, dynamic land uses and the capabilities of the highway and traffic engineer must be combined in devising specific programs for arterial street improvement. In the rural areas, the problems are those of traffic growth; in the developed areas, those of readjustment.

All of these programs must be sensitive to the timing of expressway construction. As routes are planned in an area, initial attention must be directed to readying the arterial streets serving the ramps for their new task. Where there is no expressway construction planned for some time, substantial investments may well have to be put into the existing arterial streets. This should be evaluated to be



MAP 17

ARTERIAL CAPACITY REQUIREMENTS

1980

The results of comparing existing arterial capacity with 1980 arterial demand, assuming that Plan L-3 is completed, are shown on this map. Even with the completion of the planned expressways, the rapid urbanization of the outlying agricultural areas will require additional arterial capacity. This capacity can be added by traffic engineering improvements, widening existing arterials or by new construction. However, in the crosshatched areas, new highways must be constructed in order to meet the minimum one mile spacing criterion for arterials.

Capacity equivalent to one mile of two lane highway must be added in each square mile.

Capacity equivalent to two miles of two lane highway must be added in each square mile.

Areas where capacity must be obtained through new construction in addition to any engineering improvements in order to meet spacing standards.

sure that the benefits over the term of use justify the investment.

These have been general policies. The basic strategy has aimed at the gradual modification of the present street network to adjust to two forces of change: population growth and the insertion of an expressway network. These two forces will produce a predictable change in the demands made on arterial streets. Adjustments can be made according to specific plans.

Because of the very sensitive problems of jurisdiction; of financing; of local interests; no attempt has been made in this volume to make proposals for changes in specific arterial streets. This is, nonetheless, a matter that must be given more thorough and specific review by the responsible governmental agencies. This can most effectively be accomplished when public policy with respect to expressways is firm.

SUMMARY

By 1980, an estimated 67,000,000 vehicle miles of travel will be driven on arterials and expressways within the Study Area. This growth in traffic demand will substantially increase accidents, delays and vehicle operating costs in all parts of the Study Area if measures are not taken to provide additional roadway facilities. Growth in traffic demands will be greatest in the suburbs where volumes four and five times as great as those now experienced will be found. In Chicago, where street capabilities have been strained by existing volumes, the expected twenty to twenty-five per cent increases in traffic will, if no preventive actions are taken, create an intolerable level of congestion.

To accommodate this growth, new systems of roadways must be built. The strategy is to build specialized facilities—expressways—which can skim about half of the daily vehicle miles of travel from the arterial system, leaving that system better able to serve shorter trips and land uses. Relieving the arterial system even has repercussions on local streets which will not have to carry such high volumes in areas of high population density.

Planning the new network of expressways starts with the partial network which already is in existence or is committed to be built. This is a significant constraint on design possibilities, since the old and the new must become one integrated system. The scale of the new improvements—that is, the number of new routes planned within the Study Area—is dictated by the objective which was established previously: to build that road system which will have the least total transportation cost, including both capital and travel costs.

Five different plans were constructed and were subjected to testing. Computers were used to estimate the traffic volumes on each segment of the various plans. Points of stress and of underloading were examined. The cost and performance of each plan was studied, weighing the returns in improved traffic performance and safety against the capital costs. In all, nineteen separate assignments were made to test various plans or variations of plans, or to provide information to the staff or engineers of the highway building agencies.

Gradually, out of this work, the field of choice was narrowed until only one plan—Plan L-3—remained. This plan, more than any other, measurably satisfied the main requirements: providing a least cost transportation system, incorporating the committed network into a smoothly flowing network design, minimizing disruption of existing land use, and providing adequate and well distributed capacity against estimated future demands for services. After careful review by engineers of the sponsoring agencies, this plan was designated as the one to be recommended in this report.

Once the expressway network was fixed, attention was given to identifying the proper policy towards a program of arterial improvements. Using the detailed traffic assignments of 1980 traffic, it was found that, with this system in place, arterial loads would generally be evened out in all parts of the Study Area to a level which would provide good traffic service. Changes in traffic flow and many adjustments in arterial streets would be needed to parallel the development of expressways. The expanded expressway system would, however, relieve the severe overload pressures on much of the arterial system, and would thereby increase the range of applications possible by the traffic engineer in raising the performance of these streets for traffic and land service.

The plan for highways fixes the scale of improvements needed to serve the bulk of the person trips and all of the future vehicle trips. It now remains to consider mass transportation which, in 1980, is expected to carry a significant percentage of the person miles of travel. Mass transit plans are described in the next chapter.

Chapter V

PLANS FOR PUBLIC TRANSPORTATION FACILITIES

Any realist can see that planning for future mass transportation facilities—buses, subway and elevated lines, and suburban railroads—is a particularly difficult task. Historical trends continue to show passenger losses. Risk capital is scarce. The increasing dispersion of riders and the harsh economic fact of serving a more dilute market area cannot be ignored.

Yet the need for mass transportation and the problems created by increasing use of the automobile cannot be ignored. Many people in the Chicago area are completely dependent upon public transit for transportation. The economic well being of large parts of the central city—particularly the core area—is at stake. Any accelerating decline in the availability of public transportation would be reflected in lowered property values and increased congestion.

Strong efforts are needed to maintain and to improve public transportation services. This is the policy of the plan presented here—a policy concurred in by most public officials of this area. This policy must be effectuated, however, in full view of the difficulties, and with a realistic appraisal of problems and opportunities.

This chapter begins with a review of the history of transit planning in the area, tracing out a sequence of transit plans proposed by successive planners from 1909 to date. This history provides background for a more detailed inspection of the nature and function of mass transit services. These, in turn, bear on the nature and size of the transit market. The questions of planning strategies are reviewed, and policy alternatives are considered. Objectives and criteria for a sound plan are laid out, and a plan for improved transit facilities is presented and appraised.

THE HISTORY OF TRANSIT PLANNING IN CHICAGO

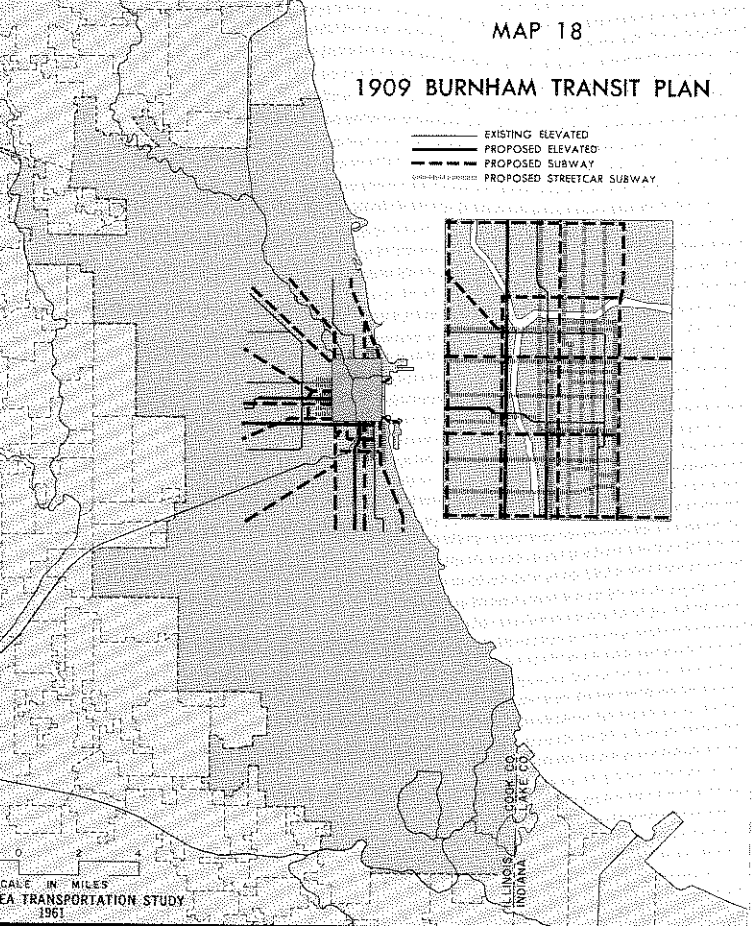
Since the turn of the century there have been numerous plans for transit facilities for Chicago. A review of these successive proposals provides a perspective from which to appraise current suggestions and so to devise a better set of plans.

In 1909 a grand plan for the future development of Chicago was prepared by architect Daniel Burnham.[1] Driven by great civic pride and concern, Burnham prepared a sweeping and extensive proposal for the ultimate development of the Chicago region. This remarkable document is a part of the background of all Chicagoans and is a classic of city planning. Burnham concentrated much of his attention on transportation facilities and on parks, reasoning that these were the prime ingredients for effective function and for aesthetic living.

With respect to transit facilities, his main attention was directed to enlarging the central business area and increasing the transit routes both above and below ground. The large number of routes shown on Map 18 illustrate the optimism of those times. This probably is to be expected. The streetcars of 1890 and the elevated lines constructed from 1895-1900 all represented the eager participation of private capital in street and elevated railway companies. There was competition and high bidding for route franchises, and the steady growth in people and in traffic made these investments popular.

An example of Burnham's optimism was his expectation of ultimately having a million workers employed in the Central Business District. This never came about. The 1956 survey showed about 280,000 persons working in the Loop area, and an additional 320,000 in the area bounded by North Avenue, Cermak Road and Ashland Avenue. Burnham did foresee and emphasize the rewards obtainable from fully grade separated facilities. His design for multilevel service showed the extensive im-

[1] *Plan of Chicago*, prepared under the direction of The Commercial Club by Daniel H. Burnham and Edward H. Bennett, Architects. Chicago: 1909.



he future of transit certainly was bright at the time of the urnham proposal. The Central Business District would have een honeycombed with elevated and subway facilities.

provements needed if a million workers were to be delivered into the Central Business District each day.

In 1915[2] a special commission was appointed to study and propose long range plans for the integration of transit systems in Chicago, the needs for new subway or elevated construction, and ultimate public ownership. The Traction and Subway Commission's plan is shown on Map 19. In contrast to the Burnham plan, this covers a more extended portion of Chicago—obviously directing attention towards the spreading population of over two million people.

The growth of Chicago and of travel needs over the transit systems were the dominant requirements which the plan sought to serve. The motor car was not even mentioned in this report, although some 35,000 passenger carrying motor vehicles were registered in the city in 1915. The main concern of the commission was to find a way to develop a unified system

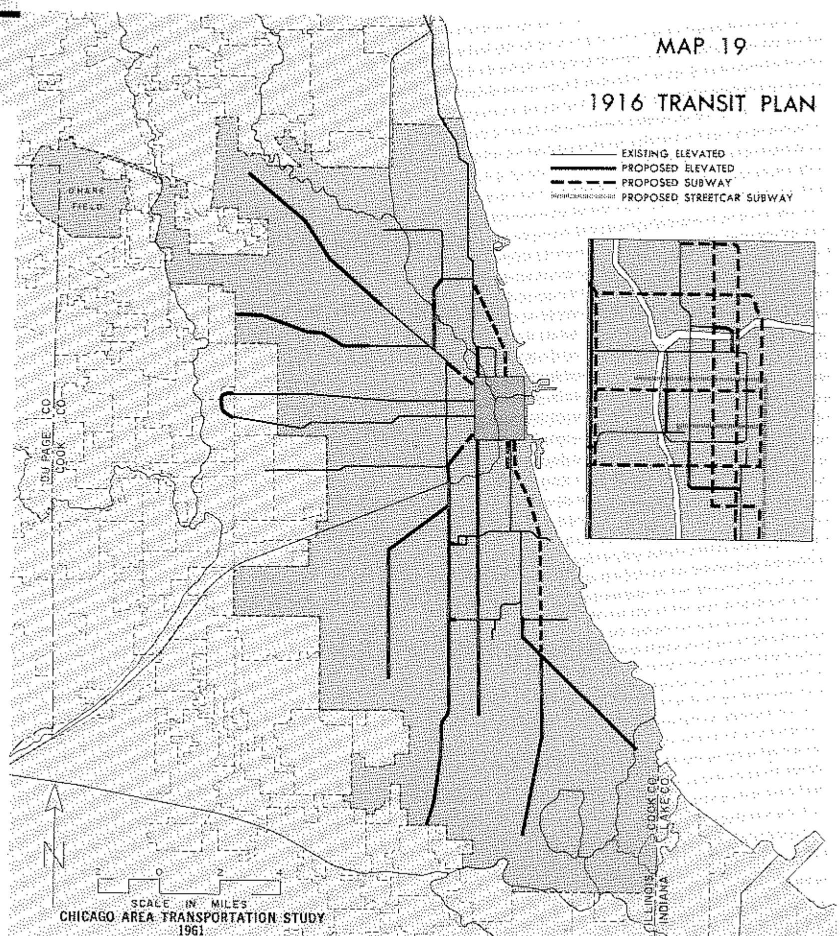
[2]*Report of the Chicago Traction and Subway Commission* to the Honorable, the Mayor and City Council of the City of Chicago on a unified system of surface, elevated and subway lines. Chicago: 1916.

—to consolidate ownership; to protect the public interest; to expand service.

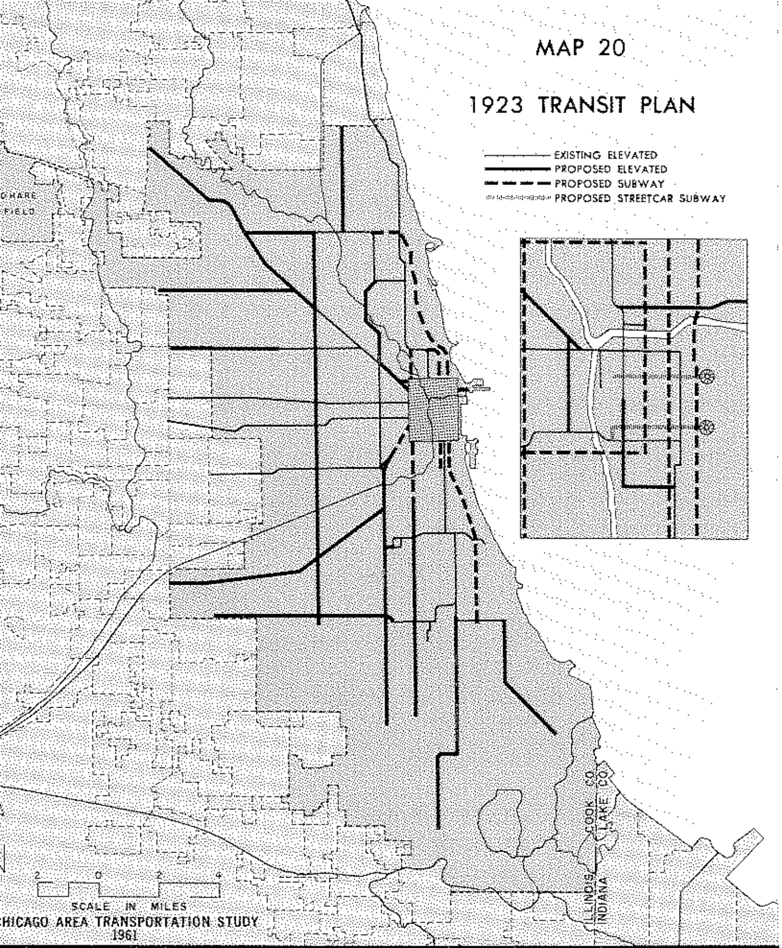
Soon after the First World War, additional problems prompted a further study and plan. In 1923, R. F. Kelker, Jr., a full time engineer for the Committee on Local Transportation of the Chicago City Council, prepared a report and plan[3] (Map 20). As with the earlier report of the Traction and Subway Commission, his main attention was directed towards unification of the several companies.

Kelker was more explicit than the others with respect to the suburban rail service. While he did not incorporate these facilities in his plan, his last comment (p. 175) was that growing suburban areas and traffic would choke

[3]R. F. Kelker, Jr., *Report and Recommendations on a Physical Plan for a Unified Transportation System for the City of Chicago*, (Made to the Committee on Local Transportation of the City Council of the City of Chicago) 1923.



This plan reflects a greater expansion into the non-central parts of the city than the Burnham Plan. It has a more realistic scale to Central Area improvements. The basic treatment is to enlarge the existing system.



This is a larger and more extensive plan than that of 1916. It represents the rising optimism of the Twenties, but still fails to reckon with the growing force of the private passenger car.

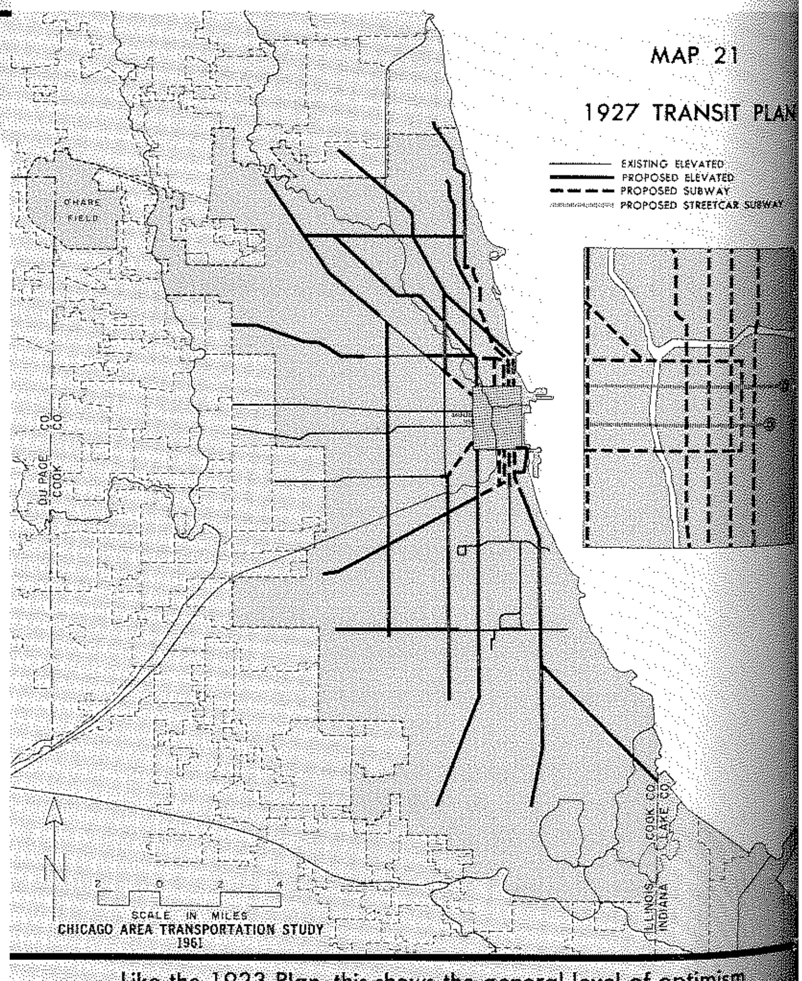
the downtown terminals, and that an eventual "solution lies in decentralizing the collection and delivery of suburban traffic . . . by making the steam railroad service a part of the city service." Rapid transit lines would be connected with steam lines about "five miles from the center of the city and the necessary tracks electrified from those connections to points about fifteen to twenty miles further out or to the edge of the commutation zone."

Kelker's report reflected the pressures from Chicago's substantial growth in the preceding seven years, with but little accomplished in the way of enlargement of public transit facilities. Accordingly, the Kelker plan proposed a larger system than that of the Traction and Subway Commission report. Yet, in most respects, it was quite similar to the earlier plan. One unique feature in the Kelker plan was the incorporation of bus routes in some parts of the city. This was the first mention of the motor bus as an important part of transit systems.

In 1927, a third plan—similar in scope to the 1923 proposal—was presented by the president of the Chicago Surface Lines, Mr. Henry A. Blair[4] (Map 21). The Blair plan was quite similar in general scale and coverage to the 1923 and 1916 plans. Differences were those of detail and priority. Problems similar to those of the preceding plans lay behind this proposal—the problems of consolidating surface and rapid transit systems and of financing expansion. It was apparent now that further transit expansion required cooperative public and private investment and that a substantial public works program would be needed to construct the proposed subways.

The series of plans proposed over the years from 1916 to 1927 by three separate engineering groups illustrate the depth of agreement with respect to the physical arrangement of recommended transit improvements. This

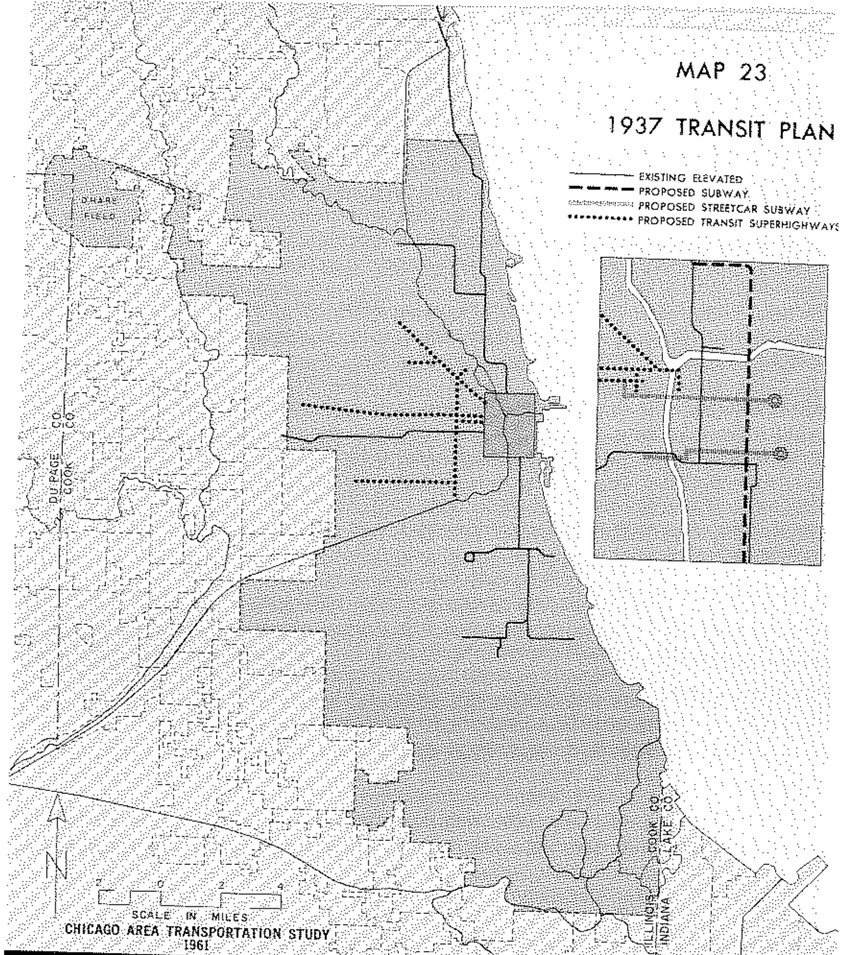
[4]A Plan for a *Unified Transportation Plan* for the City of Chicago submitted to the Mayor and City Council by Henry A. Blair. Chicago: 1927.



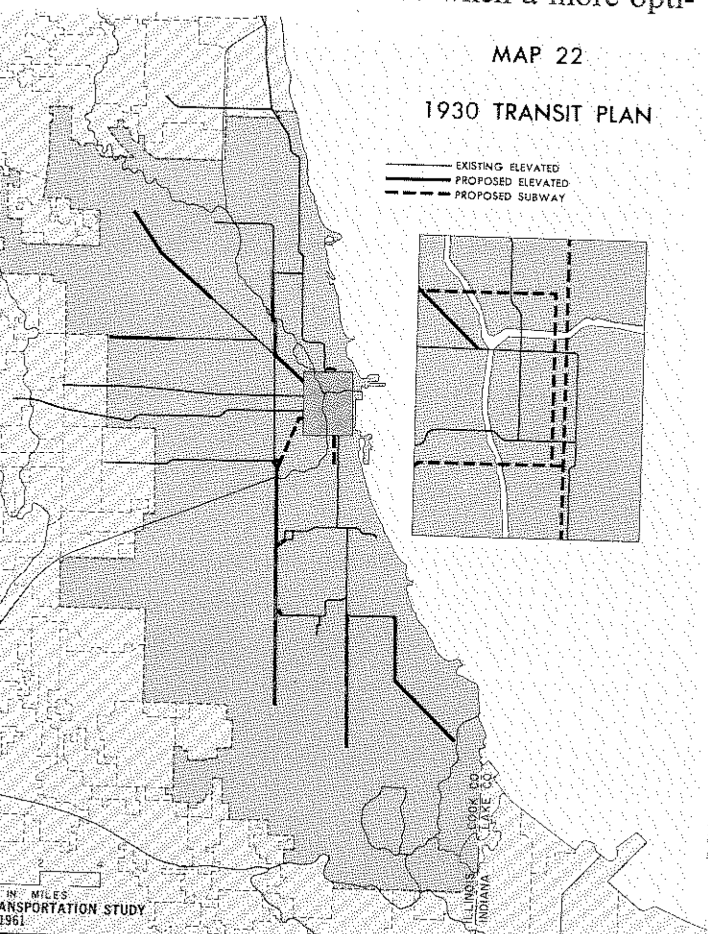
Like the 1923 Plan, this shows the general level of optimism despite the fact that no transit company felt that the fares would justify such an expansion. This plan was prepared in a bid for public financial support.

agreement is reflected in action, in 1930, by the Chicago City Council. In that year the Council enacted an ordinance which officially approved specific plans for rapid transit improvement. The adopted ordinance represents a kind of composite selection of the stage one recommendations of the previous plans (Map 22). This action by the City Council underscored official concern for improved transit and recorded public policy with respect to transit improvement goals.

This action was taken in 1930, the first year of depression. Yet the tone was still optimistic —no one then anticipated the length or depth of the depression of the thirties. The continued business decline made any substantial investment program by the city or the transit companies completely unrealistic. Thoughts of major public improvements remained frozen by the recession until 1937 when a more optimistic outlook and the active public works programs of the federal government once again made it possible to think of investing in new construction.



This plan, reflecting the extended depression, calls for a reduced rail transit system. Conversion of West Side elevated structures to elevated transit superhighways was proposed.



plan was adopted by the Chicago City Council in 1930. ealistic in choosing only those routes which are logically ed as extensions of the existing system. The State Street ay was finally begun in 1939.

By 1937, however, there had been substantial changes in transit prospects. The registration of passenger cars had grown at a rate which could not be ignored. Whereas, there were 35,000 passenger motor vehicles registered in Chicago in 1915, the number had increased to 335,000 by 1927 and to 501,000 by 1937. (Currently, nearly 900,000 passenger cars are registered in the city.)

Both the depression and the rise of the automobile influenced a plan and report prepared in 1937 by Harrington, Kelker and De Leuw[5] (Map 23). In the letter of transmittal that accompanied their report, the engineers stated that the objective of their study was "to point the way to prompt relief from the unsatisfactory and progressively declining character of

[5]Harrington, Kelker & De Leuw, *A Comprehensive Local Transportation Plan for the City of Chicago*, submitted to the Committee on Local Transportation of the City Council of the City of Chicago, November 22, 1937.

transit service which the city is now enduring; to stress . . . the important role which the private automobile has assumed as a utilitarian transit vehicle;" and to stress the need for "extensive modernization of both surface and rapid transit facilities—all to be operated without competition as a unified system."[6] The engineers did propose a unified transit system operation, but their plan was far different from those of their predecessors. The effect of much greater ownership of private automobiles, together with the more pessimistic outlook engendered by seven years of depression, must have been major factors in fixing the proposals arising from this study.

The elevated system proposed actually is smaller than the one in existence at that time. The report suggested tearing down part of the Loop elevated structure and proposed a north-south subway in State Street as a replacement. The real reduction in elevated railroad service, however, came from extensive proposals to convert certain elevated structures to elevated highways. The Douglas Park, Lake Street, and possibly the Logan Square elevated structures were earmarked for paving, with conversion of service to express bus. Additional and extensive proposals were made for more express and surface bus lines.

Why this plan differs from the others will immediately be apparent from a glance at Figure 34 which was taken from that report and brought up-to-date. This figure shows the level of transit activity from 1901 through 1937. It also illustrates the significantly different traffic outlook of 1937. While the Harrington report was optimistic, it took a far different view of future transit travel than did any of its predecessors. It is clear that the estimates of potential future traffic play a most significant part in setting the scale of planned improvements. This figure is history. It may be questioned whether the execution of earlier plans might not have had an effect on transit usage. These values would undoubtedly have been affected by the level of transit services. Yet it is clear also that these facilities alone would not have prevented what is perhaps the most important cause of the structural shift in travel habits, the purchase and use of automobiles.

[6] *Ibid.* p. 3.

Changes Since 1937

There have been three significant changes in the status of transit systems since 1937. All are significant in the unfolding history of rapid transit in Chicago.

The first change is the great increase in ownership and use of automobiles. The effects of this change are reflected in Figure 34, which shows the downward trend in transit usage. The number of automobiles owned by Chicagoans has increased from 500,000 to 900,000 and even greater increases have occurred in

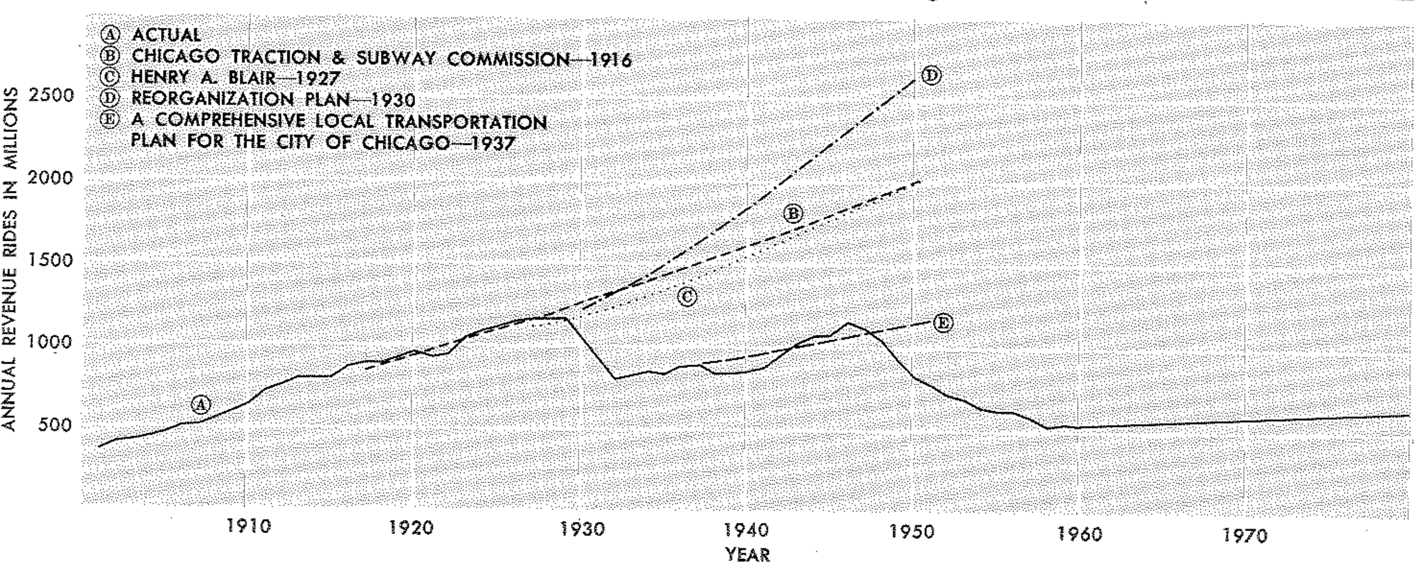


FIGURE 34—ACTUAL USE OF TRANSIT FACILITIES FROM 1901 TO 1960 AND ESTIMATED TO 1980, COMPARED WITH VARIOUS PROJECTIONS OF ESTIMATED USE

See Table 32 in Appendix.

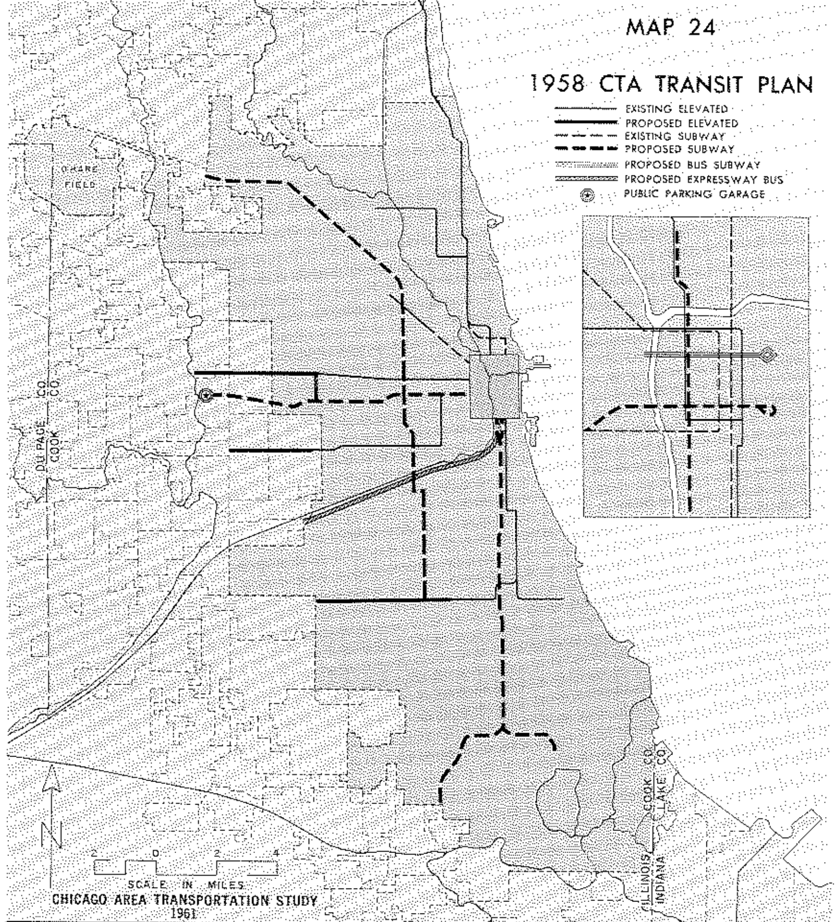
the suburbs. This increase has affected the use of public transit so greatly that there were fewer total revenue passengers in 1960 than there were in 1910. Moreover, this has happened while the population of the city was climbing from 2.3 million to 3.6 million.

The second significant change is that subways have at long last been built. Although recommended in every plan, it was not until 1943 that the State Street Subway was completed. After the war, the Dearborn Street Subway was added. This was fed by a Milwaukee Avenue Subway and, in 1958, by the former Garfield Park (route) which now operates in the median strip of the Congress Expressway.

The third major change came about in management. Consolidation of the Chicago Surface Lines, the Chicago Motor Coach Company, and the Chicago Rapid Transit Company into a single agency was completed between 1947 and 1952. This occurred, in large measure, because of the financial difficulties of the Chicago Surface Lines and the Chicago Rapid Transit Company. The consolidation was effected by means of special legislation setting up the Chicago Transit Authority. By law, the Authority is required to supply modern convenient transit services at cost. The fares charged must be sufficient to cover the full cost of providing the service, plus an amount necessary for debt repayment and depreciation reserve allowances.

After the initial stages of coordinating operation and establishing operating procedures, the CTA directed full attention to equipment modernization. This program was largely accomplished by 1957. Attention then was turned towards system enlargement and modification. At this time the CTA prepared a new transit plan.

This latest transit plan in a long series reflects the current awareness of the automobile. The proposed program of improvements allocates substantial effort towards supplying automobile parking garages at rapid transit stations—particularly at the outermost terminals. In addition, extended rail rapid transit facilities were proposed for the center of three of the planned new expressways. Bus service is



This plan was prepared by the CTA as evidence of its need for governmental support for capital investments. It reflects the trend towards use of median strips in new expressways.

proposed in the Southwest Expressway where passenger loads are expected to be lighter. Finally, there is a revival of the plan for two east-west subways downtown—one, beneath Jackson Boulevard, being for rapid transit and the other, under Washington Street, for buses. In addition, a north-south subway is proposed beneath Wells Street.

This group of projects, combined with other system improvements, comprises, in effect, a twenty-year improvement program. This plan illustrates the needs of the CTA for financial help to undertake capital improvements. With the exception of a rapid transit facility proposed as a near-in crosstown route, most of the proposals are intended to improve the quality and range of rapid transit service to the Central Business District. The major deviation from earlier proposals lies in (1) a less extensive set of lines and (2) the shift of attention of route extension to the median strips of new expressways. Map 24 illustrates the main features contained in the CTA plan as illustrated in the brochure, "New Horizons for the Chicago Metropolitan Area" published by the CTA in 1958.

At this point in transit development, the CTA had used its fiscal resources to modernize equipment and to improve shops and existing ways. Therefore, there was little additional capital capacity from earnings with which to enlarge the system. Actually, riders by 1958—the date of this plan—were less than half as numerous as they were in 1947 at the time of the CTA takeover. Financial assistance from general tax sources was believed essential, if fare increases, which, of course, were not wanted by the CTA management or the public, were to be avoided. The plans were prepared by the CTA to illustrate the improvements most likely to be economically feasible and were designed as a "package" for the public to purchase from tax revenues. This, then, is a culmination of the gradually evolving pattern behind preceding plans.

Summary of History of Transit Plans

Fifty years have seen great changes in the mood of transit planning. In Burnham's day, mass transportation held a near monopoly in providing transport for persons within the city, consequently, transit growth could be equated with urban growth. It was on the basis of such optimism that individual companies obtained their franchises. As a result, the heritage of operating rapid transit lines—and suburban railroads, too—was one with a number of lines under separate ownership—often built so that two lines were competing for the same trade territory.

Almost unnoticed, in 1915, the automobile gradually began to take over the task of moving people. Today, approximately the same number of riders use transit as did fifty years ago, although the Chicago region has more than doubled its population. Consequently, transit planning became successively more conservative, yet with a determination to maintain service. Rather than see abandonment of lines or further deterioration of service, the public has acquired them. Consolidation of management was achieved. The demand for better quality of service—a condition of transit survival—has produced new subways, new rolling stock (on suburban railroads as well as CTA lines) and a number of other technical improvements.

The suburban railroads which, because of their separate ownerships, were seldom treated in the many plans, also have passed through a significant service change over this period. From the heyday of interurban electric lines in 1907, the suburban railroads have felt the surge of suburban development which gave them an increasing volume of riders. Yet at the same time, the losses of off-peak users and the problems of labor costs and rising equipment costs have combined to make it increasingly difficult for the suburban railroads to haul the commuters economically. The consequence has been a gradual revision of service, with abandonment of close-in stations. The interurban electric lines have displayed greater weaknesses than the Class I steam railroads, with the Chicago, Aurora and Elgin line already out of business and the North Shore line petitioning for abandonment.

The commuter services are not a major part of the total operations of many of the railroads serving the city. Yet the increased peak requirements and the longer average haul have presented these lines with difficult operating and equipment problems. Many eastern railroads have advocated the need for tax support to maintain commuter services. While the principal roads hauling commuters in this area are not actively asking for tax support, they do press for readjustment of property taxes and increased freedom from regulatory controls. Clearly, some attention is needed if further deterioration in the suburban rail services is to be prevented.

DEFINING THE SCALE OF THE PLAN

Plans for a future transit network must be tailored to the expected traffic or usage. To design too extensive a system entails the risk of having idle or unused capital. Too restrictive a system will have the effect of gradually losing patronage and eventually causing severe changes in urban land values and land use densities. The expected usage has been carefully detailed in Volume II where future transit trips were predicted.

The estimates of future usage were based on current behavior and certain land development projections, together with projections of car ownership. These estimates were somewhat higher than those obtained by extrapolation of current trends. To realize the estimates, then, the transit services of the future would have to be improved. They would have to be improved because highway improvements and increased car ownership are expected to provide a better service via private automobile.

Many questions are raised over this approach to transit planning—i.e., making transit usage forecasts before designing a system. It seems reasonable that most travelers are potential transit users if only transit services are upgraded sufficiently. This leads to the view of an "elastic" travel market—i.e., one in which people can use either private or public transportation. The view advanced here, however, is that this market, in view of transit technology versus that of the private car, is not elastic and can be predicted. This important question is examined in greater detail in the following sections.

THE CHARACTERISTICS OF TRANSIT SERVICES AND THE DIFFERENCES FROM PRIVATE AUTOMOBILE SERVICE

The method of estimating transit riding potential prior to the plan of transit facilities is objected to on the sensible grounds that the facilities proposed affect the usage. Within a given metropolitan region, with a specified population, the greater the extent and coverage of transit services, the more users there will tend to be. But it is likewise clear that all travelers are not equally likely to switch to transit. Therefore, as the transit services are progressively extended, new riders will be added at an ever slower rate. At some point the further investment needed to increase system size will not be justified by the number of additional persons served.

This theoretical point is probably what is meant by advocates of a "balanced" system. Yet it is precisely about this point that most opinions differ.

The notion of a balanced system immediately suggests the idea of balance between usage of the automobile and of the public transit services. And the balance of usage will depend upon the quality and characteristics of service that can be supplied by the public transit services in contrast with that which can be supplied by automobile.

Transportation provided by public transit is inherently different from that provided by automobile in many ways and is not, therefore, a direct substitute. The problem of supplying transportation services is not simply a matter of packaging and selling seat miles of transportation to a relatively uniform market of consumers. When a consumer uses seat miles, he uses a particular sequence or series which constitutes his particular trip. Each person's trip is unique in space and in time. So it is clear that simply providing more seat miles of transportation of one uniform kind could easily fall short of meeting the diverse needs of a large population of travelers. To suit the wants of the consumer, seat miles must be in the right place at the right time.

Mass transit users must have relatively similar trip characteristics because they must get together in consuming seat miles of travel. This is necessary because public transportation produces seat miles in bulk. Public transit is supplied today in the Chicago area by buses—fifty seats or so—or by trains containing from one hundred to fifteen hundred seats. These large blocks of seats are moved over a fixed path or route. As long as public transit has this wholesale property, it will be successful only if the users can combine their various travel requirements to use it.

Grouping travelers so they jointly can use public transit facilities requires assembly of riders in time and space. But, since each traveler's needs are unique, it is obvious that increasing the number of riders on any line requires increasing the compromises or adjustments that are made on the part of the marginal (borderline) user. The marginal traveler at a rail station or bus stop would be the one who had walked farthest or, perhaps, waited longest. So, to increase the number of passengers at a station, it would be necessary to draw them from greater distances or to collect them over a longer time period. In either case, an increase would be required in the effort put forth by the marginal man to board that particular train or bus. This increasing difficulty acts as a brake on the number of travelers who may be expected to use transit facilities.

Mass transit, as it presently exists, is inhibited by the size of the vehicle from adjusting towards more individualized trip requirements. Public transit conveyances are relatively large and are driven by paid drivers over fixed routes. Because of the cost of the crew and, in the case of rail facilities, the fixed cost of rights-of-way, the cost of adding one more seat in a vehicle is quite low. The high fixed costs make it more efficient to haul rather large vehicles at greater headways than are preferred by the individual passengers. The preferences of travelers would more nearly be met if each bus or rail car could be halved and brought to the station at half the headway. Yet the present characteristic of mass transportation, enforced by the nature of the technology and fixed costs, dictates the practice of supplying seats in rather large, chauffeur driven passenger containers.

This characteristic is at once the strength and the weakness of the transit system. The bulk or wholesale character of transit gives it large capacities, so that it has excellent reserves for peak requirements. On the other hand, thinner trade areas cannot be serviced because costs cannot be dropped proportionally to service drops—particularly when private passenger cars are so easily acquired and used.

To increase the number of transit riders would require substantial increases in service. This would mean more routes and shorter headways on existing lines. Such expanded service would become increasingly expensive because it would not be expected to add riders fast enough to use up the additional service. Clearly, good management will continually be looking for "profitable" new routes and will be trying to eliminate "unprofitable" service. So, if service is expanded to increase the total users, someone will have to pay for the additional costs.

From these arguments it becomes clear that the market of future transit users is limited by economic constraints. The role of transit in the future must be aimed at areas and times where its particular services are especially suited and productive. This means substantial emphasis on the Central Area and on service during periods of peak demand. The forecasts of transit users of 1980 call for only slightly more riders than currently are carried. These forecasts have been based on estimates of peak hour travel and travel to the Central Business District. They were constructed in an attempt to outline the approximate market to which transit services should be pointed and planned. In the work to follow, then, these estimates are taken as general determinants of network size and function.

GENERAL POLICY CONSIDERATIONS

Even with the approximate market defined according to the above argument, there remain two very difficult policy issues. One involves the future technology of transport and the other the general policy of the community with respect to subsidy. Both are dealt with briefly before proceeding to plan-making and testing. Explicit views on these points are essential background for planning.

Technological Changes

There are many ideas for new forms of transport. They range from personal flying platforms to monorails, and they have excited public interest and have received much publicity. To make sensible plans, a careful appraisal must be made of potential new forms. This allows an assessment of the risk of obsolescence in current facilities and an appraisal of the possibility of substantial shifts in usage which might result from major innovations.

None of the new forms of transport presently in use or in experimental designs appear to offer an important solution to the problem of moving people more efficiently within the metropolitan region. Monorails have the same grouping of seats and the same fixed investment problems of traditional rail transit. Helicopters would soon outrace the automobile in noise, accident and congestion problems if their number rose to anything near that required to serve the millions of metropolitan travelers. Ground effects vehicles—vehicles which use power to build their own roads by forming a thin air cushion between themselves and a running surface—are presently expensive and highly specialized types. There is no reason to expect such inventions to be of major help in solving the urban traffic problems.

Automation of rail transit facilities offers hope in overcoming the fixed costs of supplying operators for vehicles or trains, but this cannot overcome the high capital costs of rights-of-way and of installation and maintenance of the electronic control facilities. Continuously moving belts or sidewalks have overcome the unit size problem, i.e., people can get on and go as they arrive, but still there are the very heavy capital charges per unit of route and the location of the route is still fixed. Moreover, speed of travel on these facilities is quite slow.

It is clear that a major technological breakthrough capable of causing a significant change in usage can occur only if some new means of moving people, which is more uniquely adaptive to individual needs than the automobile, is developed. This would require very small units which could be programmed easily from point to point with the sureness and safety of today's transport system, but without drivers. In addition, travel would have to be swift. These are market requirements which reflect consumer preference. For true penetration into this market of travelers, there is substantial evidence that performance and costs must be superior to those of the passenger car.

There do not appear to be any working designs of new modes which have all of these desirable characteristics. Until designs suggesting a far greater capability to outperform today's facilities are developed and available, planning should continue for usage of proven system components and with attention to existing system problems.[7]

[7]Perhaps the most promising investigations are directed toward the automatic control of private vehicles on roadways. Electronic management of vehicles in line in one lane already has been successfully proven, and full control for multi-lane operations soon may be possible. This may effectively double capacities, yet increase the safety of travel without reducing speeds. It might also have the effect of magnifying the present difficulties of local transit, or it might be a way of moving smaller vehicles from point to point on narrower roadways and using them as public conveyances.

Community versus Customer Financing

The scale of plans is affected by financial measures as well as by passenger potential. There are many who believe that the market will allocate resources most effectively if the consumer pays the full cost. These people advocate full and accurate charges to users of public transport as well as to automobile drivers and other travelers. They reason that only under such a procedure will the most economic decisions be achieved. Such an argument allows no room for introducing more general community values. Neither does this view admit the possibility of public support for essential services.

The history of community actions has shown a tendency to provide support for transit services from general revenue when such action is believed to be in the public interest. The major transit companies have been purchased by a public corporation, so taxes on properties are voided. Some facilities have been built from general revenues, and currently there is some aid available from the federal government in the form of loan guarantees as well as federal support of experiments with some "risk" money. Evidence over the years has shown that there is a very delicately balanced financing problem for transit services. Fares paid by passengers appear to be barely sufficient to cover all of the costs. Thus, any future proposal for improvements runs the risk of increasing costs without increasing revenue and, therefore, placing financial responsibility on the community at large. Of course, the greater the charges the community has to bear, the greater must be the benefits or rewards for doing so.

If the rider pays the cost, there is little question as to benefit and reward; the connection is direct. However, as costs are shifted to the public tax base, the problem of community benefits is raised, and no accurate way to measure all benefits is known. The assumption behind the plan presented here is that a plan suited to the passenger estimates should be paid for from passenger charges, but that the system will receive essential support from general taxes if such support proves necessary. The very great importance of mass transit to a healthy metropolitan region cannot be ignored. Certain basic services are essential if a region of this size is to survive and function effectively. Particularly important is the need to sustain transit services to the Central Business District.

The passenger shifts of the past years from transit to automobile have been selective. The transit users remaining most often are school children and other non-drivers, people in households without cars, or people going downtown. These remaining users need these services. It is believed that elected officials will not hesitate to provide some financial support for such service because this travel is important and there is ample precedent for supporting these needs.

MASS TRANSPORTATION PLAN

The transit plan has the same over-all objective as the plan for highways—that of providing a system of transport that will carry the future travelers at the least total cost. Certain factors are given and have been accepted as fixed conditions within which a solution to the planning problem can be found. They are as follows:

First, as has been pointed out previously, is the estimated number and character of riders that are anticipated in 1980. While one may argue the logic of fixing these riders as a precondition, and while there is no easy way to fix an exact market size, it has been reasoned that this is a good and fair basis for constructing plans. It represents an approximate target and gives a specific performance task for a new system.

Secondly, it is a condition of transit planning that the city of Chicago and the leaders of the region will support and encourage execution of the Central Area Plan. The size of the Central Area is a most important factor in fixing the number of potential future transit riders and the task of a future transit network. The targets of the Central Area Plan are incorporated as factors in any transit plan.

Thirdly, the present network of facilities and rights-of-way, together with the operating owners, are an important factor. Whereas, in a city with no existing transit system it is possible to consider many locations and classes of service, in this metropolitan region the existing system cannot be economically disregarded. Every use must be made of existing facilities. Naturally, this will constrain the extent to which innovation can be undertaken.

These three factors provided the framework within which experimentation could be carried out to design or evaluate possible different plans. In proposing and in listing different ideas, care had to be taken to specify those changes that were most likely to be an improvement in total system performance. So, while the dominant goal of least total cost is paramount, a further list of sub-objectives was developed to provide direction to the search.

There were six of these sub-objectives. They are listed and described below. There is no particular order of importance, nor even weights which can be applied. All that can be said is that each is of importance in devising system improvements. Taken together, they provide a picture of what it is that the plan maker should look for.

1. *High speed, grade separated facilities are crucial.*

   Much like expressways, the grade-separated rapid transit facilities are the safest, the swiftest, and they also have the highest carrying capabilities. From a regional viewpoint, emphasis must fall on these facilities because they are the strength of any network and also because they generally require a special and distinct right-of-way. Virtually all surface routes in the region are served by buses. Such routes can be changed with little or no capital costs and must be adjusted continually to serve an always shifting market. Service provided on special rights-of-way can handle large volumes safely and economically. They are the backbone of any system.

2. *Concentration on the Central Business District.*

   The prime target of the grade-separated express transit network is the Central Business District. These are mutually dependent functions. A densely developed Central Area

FIGURE 35

ALL RAPID TRANSIT TRIPS

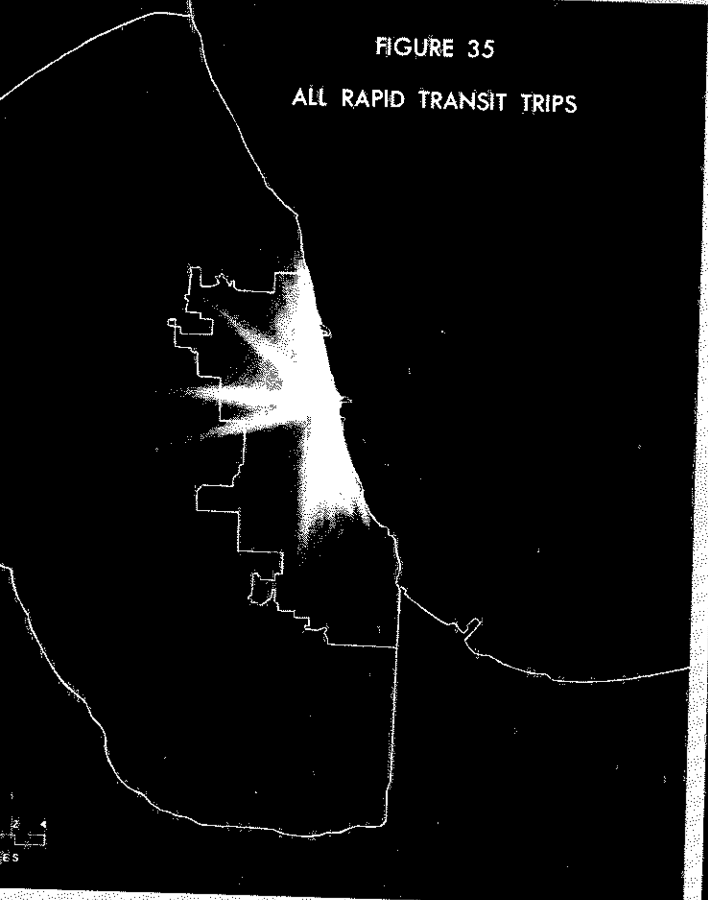
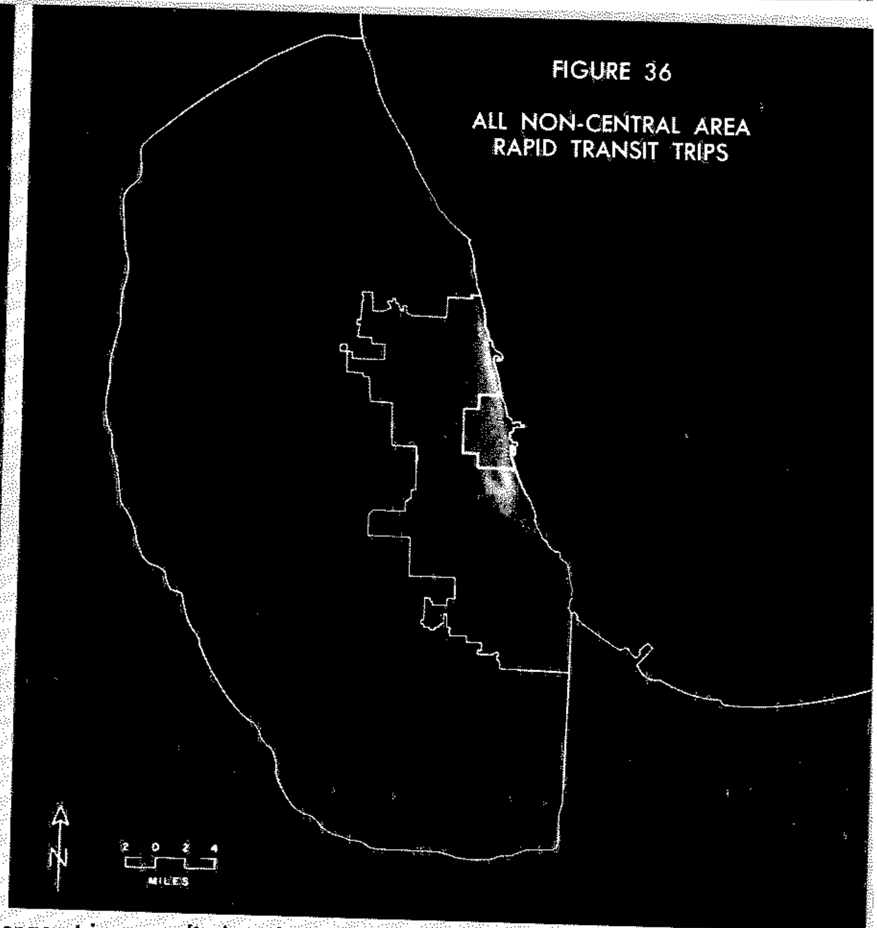


FIGURE 36

ALL NON-CENTRAL AREA RAPID TRANSIT TRIPS



All internal suburban railroad and elevated-subway passenger trips are displayed on Figure 35. Less than 20 percent have both origin and destination outside of the Central Area. Many of these trips, as shown on Figure 36, traverse the Central Area.

cannot exist without rail transit, but neither can a rail transit system be expected to survive without the passenger focusing potential of a major Central Business District. While there are, naturally, travel requirements for journeys to other than the central business areas, the ability of the rails to serve such journeys depends solely upon their fixed location corresponding to the journey maker's needs. In nearly all instances, non-central journeys are served by rails as a by-product to their main task. Figure 35 illustrates the desire line traces of all rail users and, beside it, Figure 36 shows the traces of the seventeen per cent who neither begin nor end their trips in the Central Area. Many north-south subway users and quite a few intra-line transfers are represented in Figure 36. There is very little concentration of demand away from the Loop.

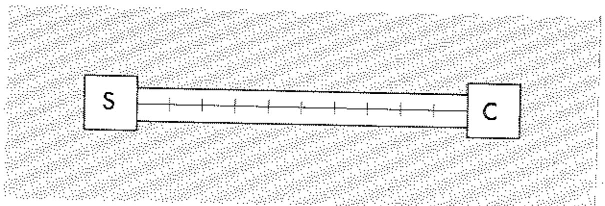
There are many other reasons for specifying a central focus. The great investment in Central Area buildings, the obvious policy of city authorities to emphasize healthy new activities in the Central Area, and the very great person-delivering capabilities of the rail lines make this central emphasis a mandatory consideration.

3. *Cooperation and Elimination of Duplication.*

While much has been accomplished in the past to insure effective cooperation among several types of transit and also to eliminate competing services, substantial room remains for further coordination of the suburban rail services and those of the transit agencies. Like the transit companies, railroads growing in the nineteenth century competed violently for trade areas and often built competing facilities. In a more mature traffic situation, it is clear that there is not enough traffic for all of the rights-of-way and service potential in the Chicago area. Moreover, there is a constantly changing array of travel demands. Many otherwise sensible adjustments to these changed conditions may be blocked by the fact of multiple ownership and operation. No suggestion is made that a common ownership be achieved, but there need be no bar to cooperative division of labor and that much more effective collaboration can be attained.

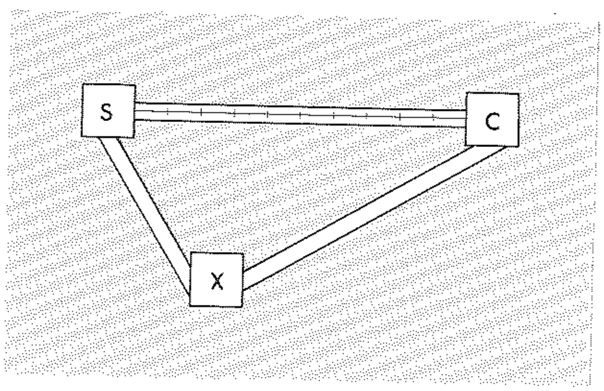
4. Improve Ease of Access to Rail Facilities.

The grade-separated rail facilities provide safer and swifter travel than surface facilities, and so their usage is preferred. However, the limited number of lines serving an ever growing metropolitan region has the effect of reducing the potential journeys lying within walking distance of the rail lines. To illustrate this point, assume that only two zones exist at time 1. These consist of Zone S, a suburb, and Zone C, the central business district of the city.



The travel from S is directed largely to C because there is no other place of such attraction.

But now, we add a new suburban community—Zone X, with factories and shopping centers and people.



Some of the travelers from S now will go to X and some of the travelers from X will replace the S travelers to C. Since C, or the center, remains fairly constant in terms of its daily intake of travelers, it can be seen that additional growth has the effect of weakening travel between two stable areas (S and C). This is why new suburban growth has a tendency to reduce travel between existing, built-up suburbs and the CBD.

To maintain riders along existing rapid transit lines, action must be taken to increase the tributary or feeding area for rail stations. To the extent that potential trip makers can reduce travel time between origin or destination point and the rail stations, the service area potential of the rails will be increased. Therefore, substantial attention should be devoted to ways in which time can be shaved between door and station—or station and desk.

5. Balancing of System and Travel Demand.

While a plan for rapid transit right-of-way does not have the capacity characteristics of a plan for highways, the balancing of loads against service is of great importance. If one accepts the basic premise advanced by this study that there is a limited and relatively inelastic pool of transit riders, then it is of great importance to place the rail transit facilities so that they are well adjusted to the developing market of riders. It is wise to have neither too many nor too few lines because, given the estimated 1980 traffic, it is clear that a system where each facility carries a reasonable load, yet none is overloaded, will be more successful.

This goal subsequently is tested by assigning traffic loads to any proposed new system. First, the known and inventoried travelers are routed over the network and then the same is done for the projected 1980 transit travelers. Appraisal of these results illustrates the extent to which travel requirements and the new system are in agreement.

6. Progressive Experimentation.

A final objective is one calculated to provide for variations in actual development which are different from the estimate made now. This is the flexibility which should be allowed for in any plan.

As an example, rail service to the Loop from the southwest is lacking. At the same time, this is a less densely developed sector of the region. To attempt to initiate suburban rail service might appear ill-advised or even rash, especially to the railroads presently serving this part of the region. Yet it is clear that express bus services can be scheduled with very little risk when the Southwest Expressway is completed. Careful measurement—both before and after—will tell much about the success of such an experiment and whether it may be tried successfully on other express highways. Or it could lead to evidence that increased rail service is warranted nearby.

In the same fashion, many detailed features of the plan can be tested and proved before being widely used. Such experimentation will insure orderly enlargement and modification of the plan. This should also assist in devising ways to adapt the valued rail services to the other transportation forms.

These six objectives have entered into the plan illustrated in Map 25. This map shows the recommended 1980 regional transit plan. No local bus lines are shown, since their exact routing must, by 1980, be worked out by the transit management. With roads everywhere, there is no problem of capability of bus service. It can be seen that the plan emphasizes the role of rail borne transit.

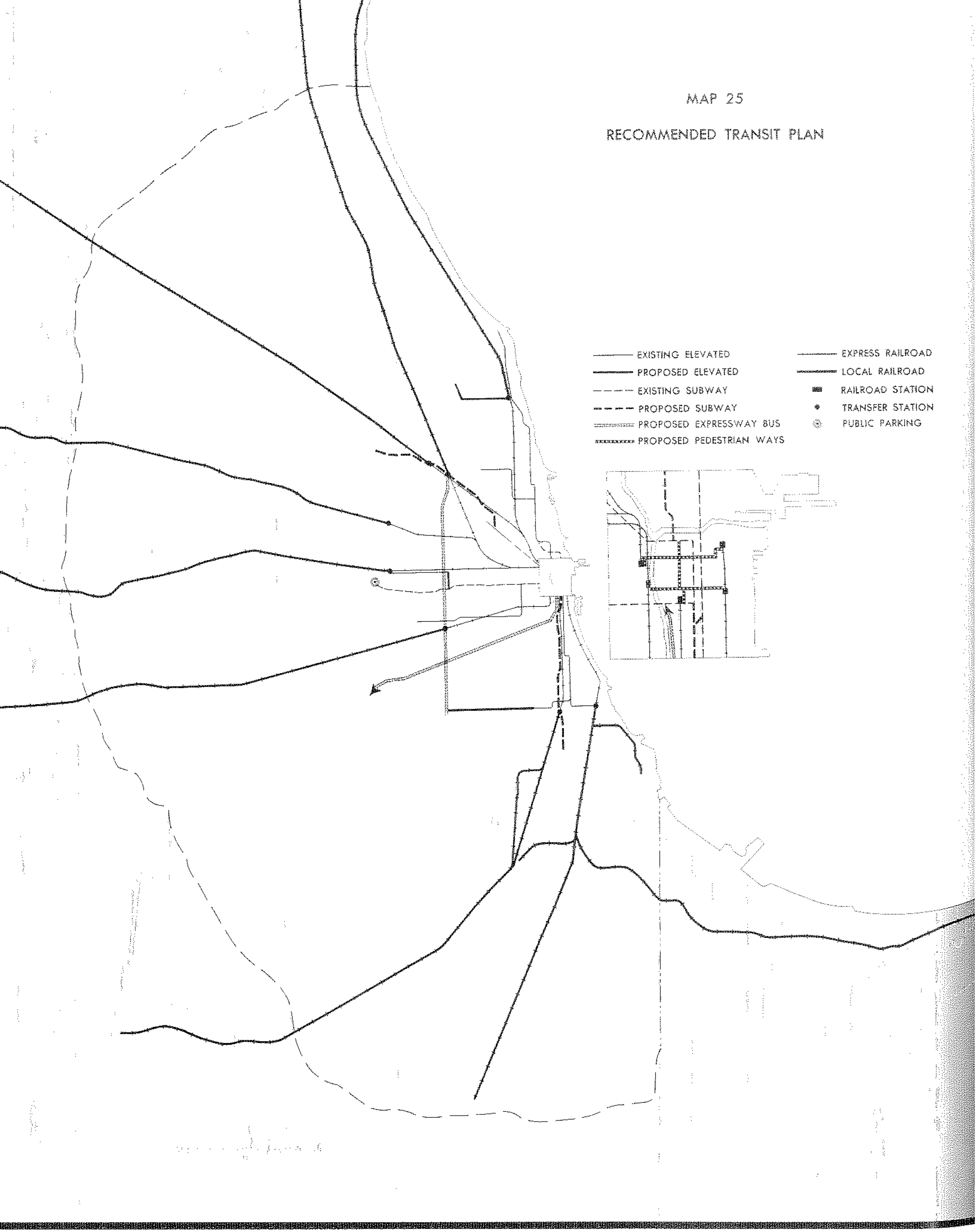
The plan likewise meets the second goal of Loop service. Like spokes in a wheel, all routes go directly to the Loop. This system of rails can be likened to the root system of a tree. They are the extended paths through which nourishment, in the form of customers and workers, is delivered to and withdrawn from the business center each day.

No crosstown routes have been proposed—only radial routes. Several studies were undertaken to examine the usage to be expected if a north-south line were developed along Paulina Street, using the existing elevated structure, or along the general lines of the new crosstown expressways indicated by the highway plan. In the case of Paulina Street, there was enough traffic assigned to warrant further study, but it appeared that the line would have to be extended well south of 21st Street and probably north of Division Street to develop loads of sufficient magnitude to keep rail service running.

Nowhere else did there appear to be sufficient traffic to justify a recommendation for non-central rail facilities. Non-central travel is the kind where the private automobile seems to be greatly preferred by more people. Plants or stores away from the center are more likely to have parking facilities. Congestion and costs of automobile storage are certain to be less in non-central locations. Moreover, in these locations, origin and destination points are never as densely packed along the line as they are at the Central Business District. It is reasoned that express bus services can readily and inexpensively be initiated on proposed crosstown express highways. Service of an express nature would be one way of providing better information as to passenger potential. While this caution might affect the design of new express highways, it is an approach that is more in keeping with the experimental methods advocated in connection with this plan.

One of the important operating proposals reflected in the plan is the integration of rapid transit with railroad commuting services. The principle followed here is a most important aspect of the plan. Rail service is radial. More and more travelers are coming to the Loop from the outer suburbs as these places grow. They tend to replace or displace some of the close-in travelers. Railroads for some time have been aware of customer losses at their close-in stations, but with offsetting gains in the outer suburban zones. This is attested to by the elimination of stations situated nearer to the Central Area.

One reason the close-in stations were dropped was that the additional stops at these places increased costs unduly. The costs in train time, in crew time, and in passenger dissatisfaction were judged to be greater than the rewards from adding a small number of riders. It is clear that the greater the loading on the suburban ends of the lines, the greater the number of people who *don't* want to stop at close-in stations. This can be extended to the obvious view that train service to the Loop will be best if a train can be fully loaded at a few stations and then expressed to the Loop. All railroads now follow this practice by scheduling express services during the morning and evening rush hours.



The commuter railroads serve the fastest growing parts of the metropolitan region. To do this well in the future, they will have to give up some of their close-in traffic. The CTA can handle the closer-in travelers by expanding the rapid transit system and by close coordination of bus and rail lines. Chicago's Loop—the prime target of rail service—will need improve-

The CTA offers a different service because it runs smaller and lighter equipment at slower top speeds, but with faster acceleration in order to make more frequent stops. Thus, the CTA can keep a number of small trains moving at reasonable headways throughout most of the day.

It becomes clear, however, that if the CTA were to extend such service farther out into the suburbs, it would soon have to add tracks to permit express and local service, because, otherwise, a passenger traveling fifteen miles and enduring some twenty stops would hardly find this a "rapid" transit route.

This operating problem illustrates a basic pattern of cooperation proposed in this plan. It is proposed that service territory be divided between the CTA's rapid transit and the commuter railroads. Calculations which take into account operating costs, passengers' travel time costs, and capital investment costs have been made.[8] These have shown that there is a most efficient point at which a railroad line can proceed non-stop into the Loop and at which a CTA local, rapid transit service can better serve the remaining Loop travelers. This so-called breakpoint occurs at about six to eight miles from the Loop today, but will be even farther in 1980 when more travelers come from the suburban zones.

To illustrate, Figure 37 shows the accumulation of daily inbound passengers from a typical sector of Chicago and suburbs. It will be seen that Loop bound passengers accumulate slowly at first, then more rapidly as the more dense part of the city is approached, and then once again quite slowly at the close-in stations.

Now, if all of these people are handled by one train, the number of cars pulled from thirty miles out would have to be great enough to handle the maximum load at the Loop. So, many of the seats and much of the capacity would be hauled to no purpose.

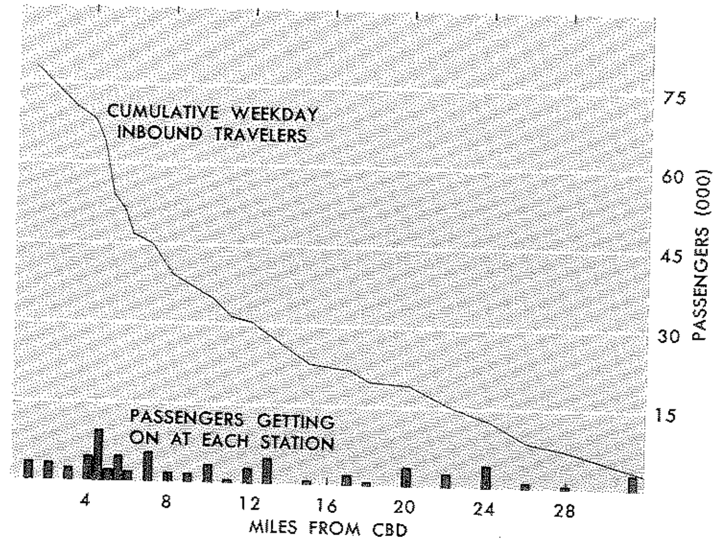


FIGURE 37—DAILY CENTRAL AREA TRAVELERS OF 1980 ASSIGNED TO RAIL FACILITIES FROM ONE SECTOR OF THE REGION.

See Table 33 in Appendix.

If, on the other hand, a second service were available, fewer cars would be required at thirty miles out. Enough would have to be provided to carry only a portion of the travelers. The other travelers—all starting closer in—would be carried by the second service which would have a much shorter run. This would be an obvious economy—requiring fewer cars and also providing better services to the passengers. Figure 38 shows the computation of total travel costs in a typical corridor of Chicago. It illustrates how the sum of all costs associated with express and local

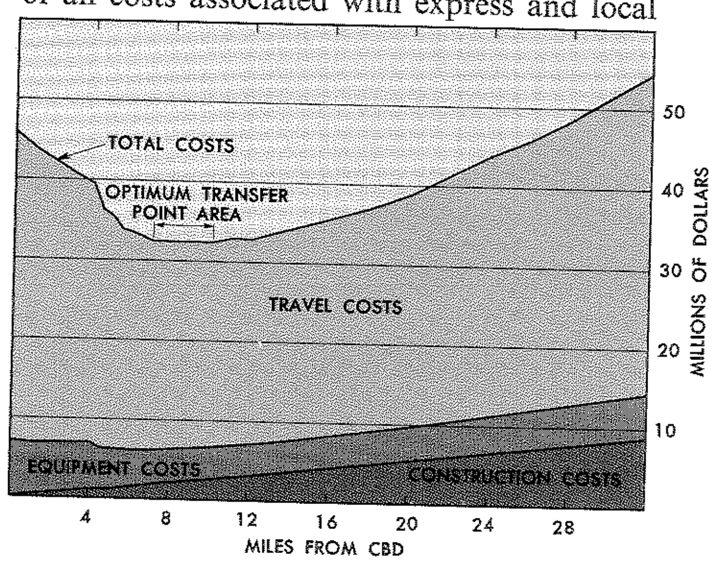


FIGURE 38—COSTS ASSOCIATED WITH ALTERNATE POINTS FOR DIVISION OF EXPRESS AND LOCAL TRANSIT SERVICE IN 1980

See Table 34 in Appendix.

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[8]See Black, Alan, "A Method for Determining the Optimal Division of Express and Local Rail Transit Service," a paper prepared for presentation before the Origin and Destination Surveys Committee at the annual meeting of the Highway Research Board, Washington, D.C., January 8, 1962.

service produce an optimum point for efficient division of traffic.

A result of this kind can be accomplished effectively by cooperation between the CTA and the suburban railroads. The principle is illustrated by having a symbol on Map 25 at the point where the suburban railroad and the CTA can usefully divide the work of serving the region. At this point, the plan proposes easy and economical transfer. The transfer privilege will allow people with origins and destinations on opposite sides of the break-point to transfer. This should serve to increase the passengers on both facilities, while still more economically dividing the work of pick-up and delivery.

More than that, the railroads' remaining passengers will have a rapid, non-stop run into the Loop from this point, thus bringing suburban travelers closer in effective travel time to the Central Business District. An example of effective CTA-railroad cooperation is in Oak Park where the Northwestern Railroad is allowing the CTA to modify the rail lines so that the elevated trains can run directly on the rail right-of-way beside the commuter railroad for a portion of its route.

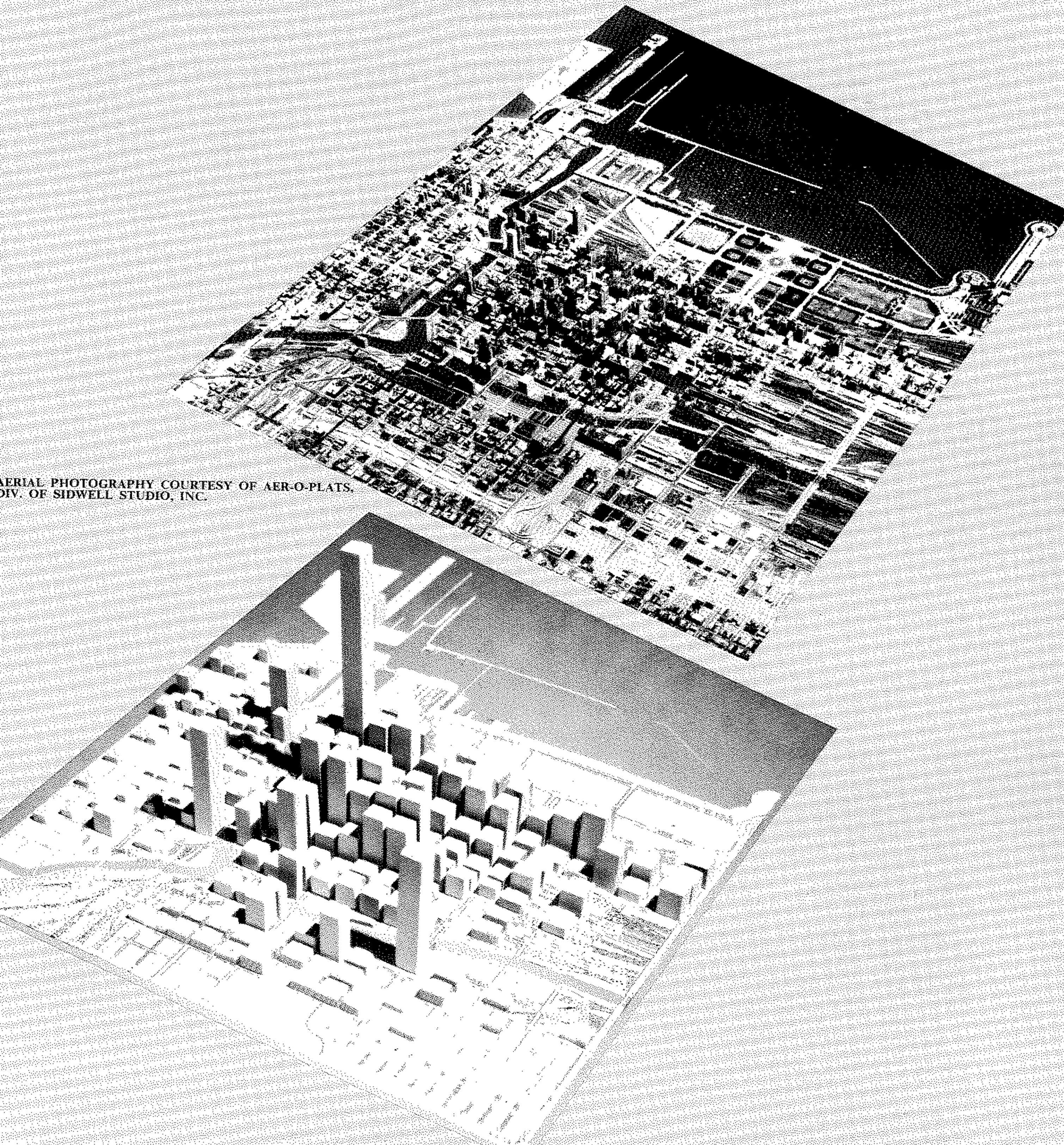
Such cooperative procedures are a crucial step toward erasing duplicate services while, at the same time, improving the total service to the customer. There are many possible significant gains obtainable from more effective coordination of service. In some cases, this may involve better use of trackage. In other cases, it will involve consolidation of schedules and service. Seen from the viewpoint of providing the most efficient service with the existing inventory of rails and equipment (as though all facilities could be programmed by one agency), there will be many ways both to encourage and to reward more cooperation.

It has been proposed that, in the Central Area, the distance from railroad station to desk be significantly reduced. This could be accomplished by means of a moving belt or some type of continuously moving system serving as a high capacity horizontal elevator. The density of traveler destinations, by block, in the CBD is illustrated in Figure 39. The height of each block reflects the average number of daily travelers who reported that block as their destination. There was some tendency among shoppers to report Marshall Field and Co., (this location produces the highest block) as their destination, but generally the values on the model agree with floor space measurements. This distribution of destinations does much to influence the location of a horizontal pedestrian system, for it shows where people are concentrated.

Such a system not only would bring the railroad stations closer to the Loop buildings, but would, in effect, bring the buildings closer to one another. Improved travel time within the Central Area has the potential of reducing the area's time size or of enlarging its physical size.

These pedestrian ways are proposed either above or below street level. They will, thereby, withdraw much of the pedestrian action from the surface streets. This has the virtue of separating pedestrian and vehicle traffic by putting the lighter, more easily managed traffic (the pedestrian), on raised structures or into tunnels. Having only to carry pedestrians, structures can be very light and graceful. The walks could move at slow, safe, yet very effective speeds. Being covered, they will improve mobility in inclement weather. Perhaps most important, however, is the fact that such strategically placed walks will enhance the over-all performance of rail travel to the Loop.

The CTA trains are, in the plan, all routed through the two existing Loop subways. While trains at ninety second headways may be required to handle peak fifteen minute—or even hour demands, the transit systems can provide balanced service in the two subways. In State Street, the north side lines are connected to both south side lines. The Dearborn Street Subway connects the expanded northwest service, plus the Ravenswood line, with the west side lines. In this fashion, rapid transit riders are all carried through the Loop on two lines which are within one block of each other. Any transit rider thus has an excellent distribution system to the Loop and he is convenient to nearly all major traffic generators.



AERIAL PHOTOGRAPHY COURTESY OF AER-O-PLATS,
DIV. OF SIDWELL STUDIO, INC.

FIGURE 39 — MODEL OF ALL PERSON TRIP DESTINATIONS AND AERIAL PHOTOGRAPHY FOR THE CENTRAL BUSINESS DISTRICT OF CHICAGO.

The model represents all person trip destinations to the Central Business District for an average weekday in 1956. The 1961 aerial view of the same area shows the concentration of buildings to which these trips were destined. The highest volume was reported for the block in which Marshall Field & Co. is situated — nearly 30,000 trips. Blocks with fewer than 500 trips are not shown.

The traffic estimates suggest that all rapid transit trains can be handled through two subways, but that both will be forced to the limit of their capacity. This is a close estimate and requires careful review in time. If the traffic volumes are greater than anticipated, use can be made of the existing elevated Loop. It may also become possible, with automated service, to increase subway capacities. This might be accomplished by increasing the length of trains, breaking them up after they leave the Loop into smaller units which divide as the line branches divide. Thus, a ten car train in the Dearborn Street Subway could include four cars for the Douglas Park route and two for the Lake Street Extension, and with the four remaining going to the Desplaines Avenue terminal in Forest Park. All switching could be accomplished by automatic controls at the point where the routes diverge.

At outer stations along the CTA, new loading arrangements are proposed in which surface buses will have special loading and unloading docks close to train platforms. Construction is warranted also for easy delivery of automobile passengers to heated stations. Substantial experimentation should be undertaken to determine where public investment in parking facilities would be most effective. The parking facility development would appear to require some payment by the parker to cover costs. This being so, it is difficult to estimate exact demand. Therefore, further development of such facilities should be accomplished, one facility at a time, until a proven pattern develops.

Comparable aid at outlying stations should be afforded the suburban railroads, and every attempt should be made to encourage feeder bus service to railroad stations. If there is no local, franchised bus, the railroads might be encouraged to enter the business of providing station delivery by operating their own bus service.

Many of these seeming embellishments are simply illustrative of the experimental atmosphere that government can and should encourage. Successful experimentation is probably the wisest warrant for additional public or private investment.

A final criterion of the plan was that the services should be reasonably distributed so that loads on all routes would justify reasonable headways, yet not present problems of peak overloading. In order to apply this test, all travelers of both 1956 and 1980 were allocated to the redesignated system. The allocation of travelers to routes is accomplished by a large computer. The entire network of transportation facilities is coded, referencing each segment of the network by its connective points and by the time necessary to go between those points. Time values are allowed for walking, waiting and transferring between lines.

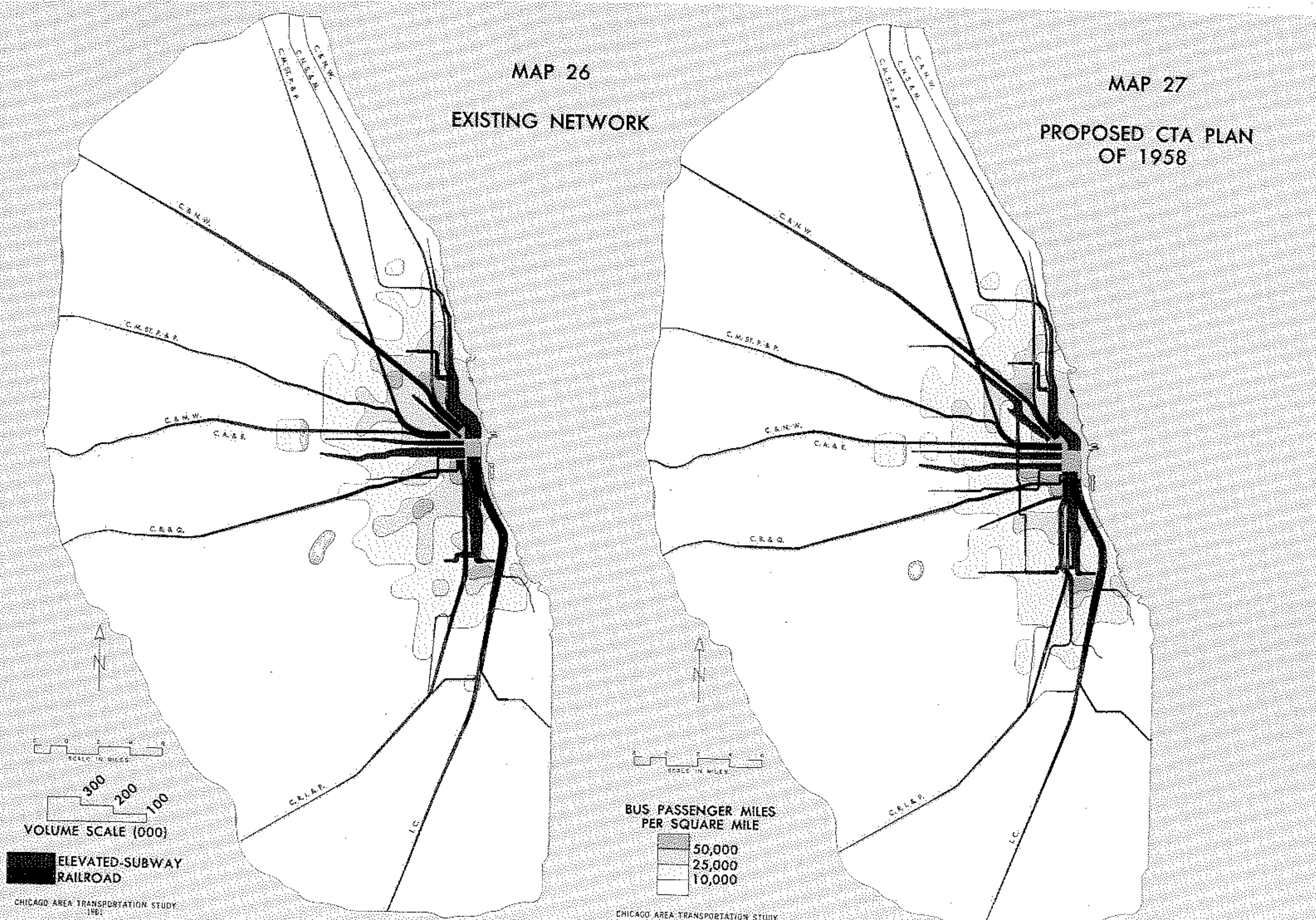
With this network data stored in its memory, the computer finds the shortest route between every combination of origin and destination points. In this fashion, all travelers are routed over the quickest path to their destinations, and their trips are remembered and stored until all trips have been routed. The results show the flow of travelers from all origins to all destinations.

As was the case with highway networks, this assignment procedure provides great assistance in evaluating plan performance. The first questions it helps to answer are those of evenness of load distribution. The assignment discloses quickly whether there is an over or under-load on any route. This is one of the prime objectives of network planning—i.e., seeing that the facilities are distributed in the same way as the travel demands.

A second and more measurable evaluation can be made by means of cost analysis. In much the same way as "best" was defined as the least total cost network for highways, so the several transit plans can be evaluated as to comparative total costs.

Four complete plans to which 1980 traffic assignments were made may be used to illustrate evaluation techniques. While many lesser plan variations were studied, these four constitute the essential range of alternatives that were tested. The flows of travelers assigned to the rapid transit routes in each traffic assignment are illustrated in a series of Maps, 26 through 29 inclusive.

The first three of these networks represent key schemes which were of importance in



1980 TRANSIT TRIPS ASSIGNED TO THE EXISTING TRANSIT NETWORK AND TO THE NETWORK PROPOSED IN THE 1958 CTA REPORT "NEW HORIZONS"

These maps show, graphically, the results of allocation of projected 1980 transit trips to different networks. The flow bands represent suburban rail and CTA facilities. The toned background colors provide a general index of bus usage—the darker the color, the more passenger miles assigned to local bus routes.

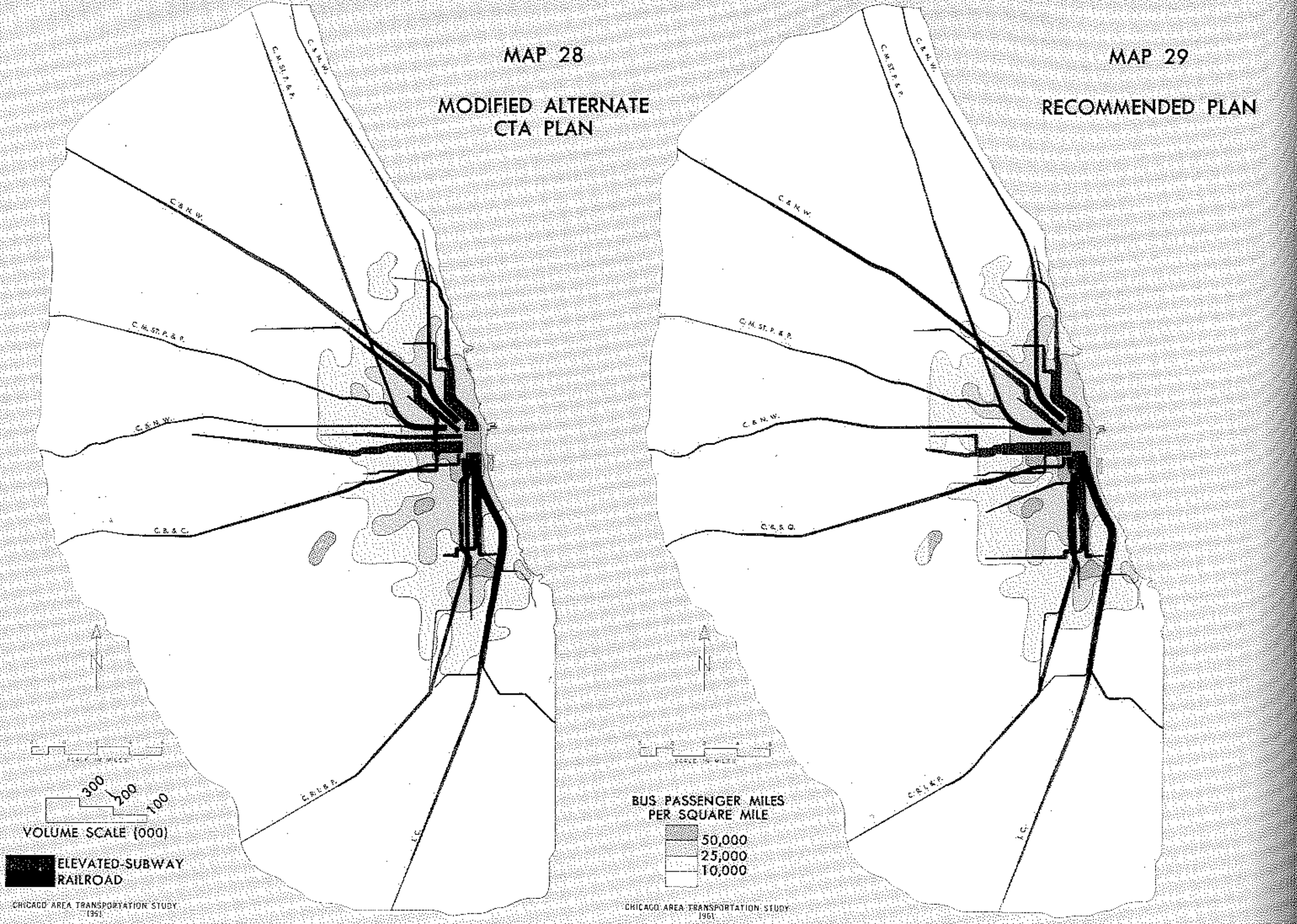
arriving at the proposed plan. The first is the basic network that exists today, with no modifications. This may be equated to doing nothing—simply keeping everything operating as at present. One may seriously question whether this is, in fact, a sort of minimum plan. The minimum scheme might be reasoned to involve some pruning back of facilities. This possibility, however, was rejected as being an untenable public policy. Therefore, the basic system consists of the present day routes. Each of the other three networks have added facilities to this basic system.

The second network includes the changes proposed in the CTA plan (see Map 27). Included are the rapid transit extensions as proposed in their report "New Horizons."

The third network (Map 28) is a modification of the CTA proposal in which extensions of service on the old Chicago, Aurora and Elgin route and out the North Shore Line to Skokie are explored. The main radial services in expressways are retained in this network, but the crosstown route of the other plan is dropped. Instead, service along the Paulina Street elevated route is assumed to be re-activated. This is a less expensive scheme which places more emphasis on radial service.

The fourth network is the one proposed by this Study and detailed on Map 29. It looks much like the others. This must be so because the growth in projected traffic is not sufficiently great to support a radical departure from the existing network.

In none of these flows is the traffic pattern within the Loop detailed. The density at the center is so great that it cannot be shown at these scales. In any event, the problems of transit at the CBD terminal end are quite different from the regional network problems



1980 TRANSIT TRIPS ASSIGNED TO A MODIFIED ALTERNATE CTA PLAN AND THE RECOMMENDED PLAN

The flow lines show the assigned daily travelers—2 directions—based on 1980 traffic estimates and on allocating travelers to the shortest route measured in travel time. Bus trips are represented here only as general density tones even though more detailed assignments were actually made to specific routes.

illustrated here. The central distribution system is a matter of very great importance and it deserves more detailed feasibility studies.

The allocations of traffic to the several networks are not to be taken as exact, since it is impossible to represent all of the refinements of the geography of location of travelers, or all of the refinements of schedules at different times of the day, or all of the individual attitudes and preferences of the many riders. Yet, in the aggregate, this approximate distribution of travelers is a very helpful way to examine how a network might function under 1980 travel volumes. Also, the changes from one network to another are relatively more accurate than the load on any single network and so they are helpful in evaluating the effects of differences in the several plans.

Much can be read from these traffic allocations. For example, it can be seen that the potential traffic for a crosstown route located somewhere just west of Western Avenue is probably not sufficiently great to justify the investment in cars, stations and trackage. Without a minimum volume of users, the high investment costs of rail facilities can't be justified, even though operating costs may be lower than for buses. The point at which fixed costs of new rapid transit lines are justified has been estimated at about 40,000 travelers per day. When projected volumes are less, as in the case of this crosstown route, it would appear more prudent to provide express bus services until sufficient proven traffic justifies further investment in separate rights-of-way.

Other questions will arise where it is of interest to know whether the re-arrangement of traffic flows is sufficiently beneficial to the travelers and to the local economy to justify the public investment needed to achieve that network. Here, comparative measures of the results of the traffic allocations to the several networks is of greater importance. These are reported in Table 15.

TABLE 15
WEEKDAY USE AND ANNUAL COST ALL CHICAGO AREA TRANSIT SYSTEMS—1980

	Basic Plan	CTA Plan	Modified CTA Plan	Study Proposed Plan
Average Weekday Passenger-Miles				
CTA Bus	4,918,202	4,065,622	4,588,228	4,381,520
CTA Rapid Transit	4,154,002	5,567,291	5,328,221	4,915,577
Suburban Railroad	7,361,900	6,532,660	6,262,439	6,852,619
Suburban Bus and Other	1,824,884	1,969,330	1,899,199	1,860,784
Total	18,258,988	18,134,903	18,078,087	18,010,500
Average Weekday Passenger-Hours	1,807,823	1,771,551	1,783,132	1,780,302
Total Annual Operating Cost				
CTA Bus	$ 63,347,000	$ 52,366,000	$ 59,097,000	$ 56,435,000
CTA Rapid Transit	39,026,000	52,303,000	50,057,000	46,180,000
Suburban Railroad	69,791,000	61,930,000	59,368,000	64,963,000
Suburban Bus and Other	23,505,000	25,365,000	24,462,000	23,967,000
Total	$195,669,000	$191,964,000	$192,984,000	$191,545,000
Total Annual Time Cost	$485,581,000	$475,839,000	$478,949,000	$478,189,000
Total Annual Cost	$681,250,000	$667,803,000	$671,933,000	$669,734,000

From this set of measurements, it is clear that the greater the extent of rapid transit facilities, the lower the total operating costs. These costs drop with each extension of rapid transit service because these facilities tend to attract the trips that can save time by using them. Travel time is thereby reduced and over-all costs drop.[9]

Operating costs (i.e., the total costs to all companies for providing basic services exclusive of debt repayment or interest) likewise tend to fall with more extensive use of rapid transit. This occurs because the average cost of hauling a passenger one mile is currently about three cents on a rapid transit line in contrast to about four cents on a bus. In the crude estimates used here, it is assumed that every person mile so shifted will represent a reduction in operating costs. This is only approximately true, since the ability to provide service at such costs will depend upon the specific usage of seats on any run. Nevertheless, the use of such averages is a defensible means of estimating whether the improvements or benefits measured in this fashion would appear to justify the investment needed.

This problem is appraised directly in Table 16. Here the combined savings in operating and time costs are compared to the cost of the improvements.

The evaluation provided is the same as that used to gauge the quality of express highway plans—i.e., the one with least total cost. It can be seen that there is really little difference between transit plans when this measure is applied. The plan recommended does provide benefits when a requirement of ten per cent return on public investments is imposed. This ten per cent figure is used to account for the possibility of other, possibly more rewarding, investment opportunities for the public dollar. If either this earnings requirements or the pe-

[9]A detailed report appears in *Economic Evaluation of Transit Plans*, (36,501) (Chicago: CATS, 1962).

TABLE 16
ECONOMIC APPRAISAL OF ALTERNATE TRANSIT PLANS

	Basic Plan	CTA Plan	Modified CTA Plan	Study Proposed Plan
Capital Required	....	$156,000,000	$ 84,700,000	$ 94,800,000
Annual Capital Cost*	....	$ 17,187,000	$ 9,331,000	$ 10,444,000
Annual Operating Cost	$195,669,000	191,964,000	192,984,000	191,545,000
Annual Time Cost	485,581,000	475,839,000	478,949,000	478,189,000
Total Annual Cost	$681,250,000	$684,990,000	$681,264,000	$680,178,000
Gain or Loss Compared With Basic Plan	....	−$ 3,740,000	−$ 14,000	+$ 1,072,000

*Assuming ten per cent interest.

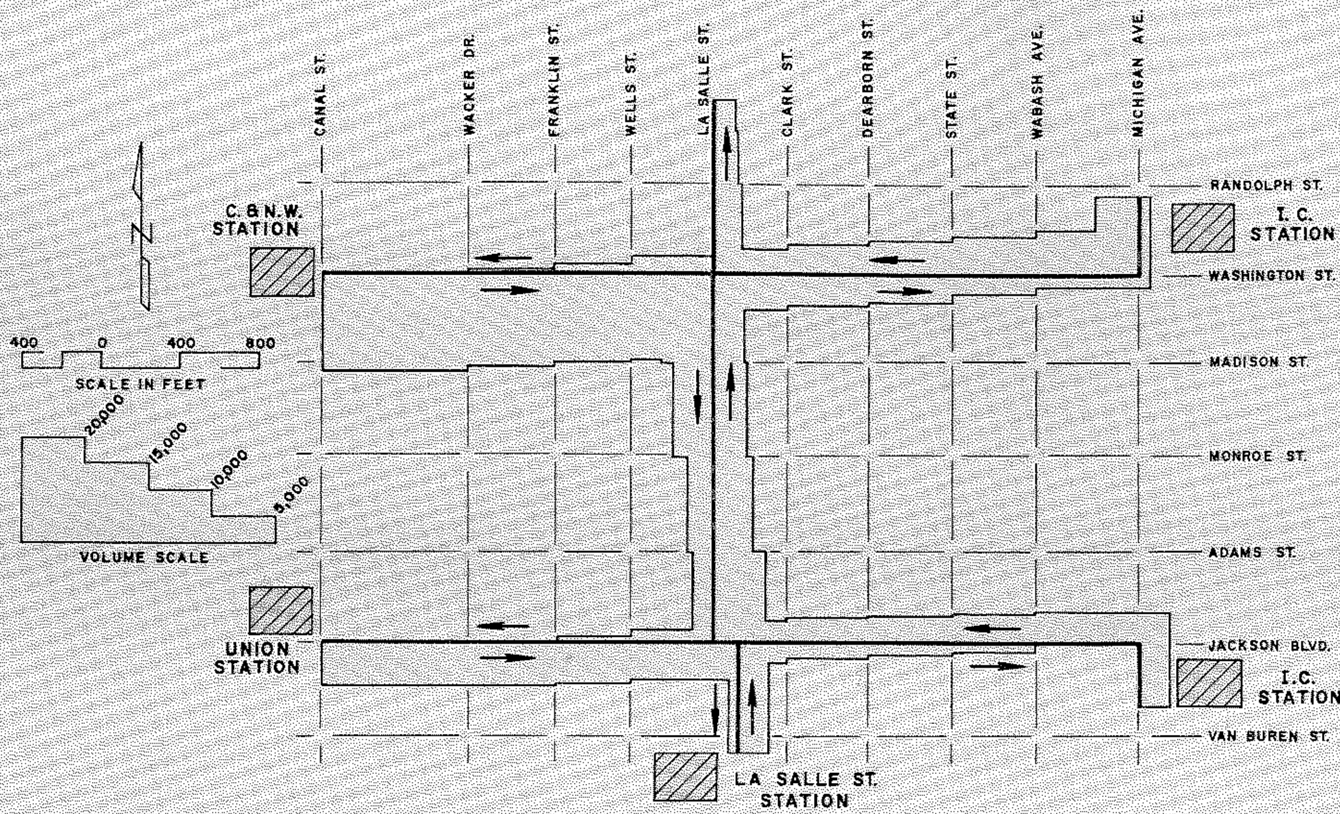


FIGURE 40—INBOUND MORNING RAIL COMMUTER TRAFFIC ASSIGNED TO ROUTES OF DOWNTOWN PEDESTRIAN SYSTEM

This figure illustrates the 7:00 AM to 10:00 AM peak directional demands from inbound train travelers only. There would, of course, be many other travelers from autos, transit or from pedestrian movements between loop buildings using this system. The afternoon movements would naturally be the reverse of these, but somewhat heavier.

riod of amortization of the new improvements were relaxed, then all, according to these measures, would be profitable plans.

The measures are crude and they cannot account for some of the community values for simply having such services. Nor should they be the final arbiters of plans so nearly alike. Other, less measurable, factors must enter the total appraisal.

One such factor is the improvements proposed for the internal distribution within the CBD. The CTA plan calls for a new north-south subway and two east-west subways—one for trains and one for buses. These would improve speed of delivery of passengers and would help to avoid inefficient use of equipment because of traffic delays. Yet they would also be expensive—a rough cost figure of twenty-five million dollars for each subway is estimated.

The plan proposed in this report has advocated a limited system of moving belt walks. Their cost has been variously estimated at from $8 million to as much as $20 million per mile. Much would depend upon whether they passed through existing buildings or whether they could be constructed over or under existing public ways. In the Loop area, the problem of the design and appearance of any such structure is very important. This is a problem that cannot be treated in this report—geared, as it is, to a regional over-view. Sufficient information can be brought to bear to demonstrate potential benefits from such an improvement and this is an essential step before detailed engineering studies are undertaken.

The virtue of such a system lies in its ability to cut travel time and to increase personal safety and pleasure. The system is laid out particularly to connect with commuter rail stations and thus would be geared to aid those persons who must walk the greatest distances from rail terminals to many of the Loop buildings. Figure 40 illustrates the inbound morning rail commuter traffic assigned to the routes of the downtown pedestrian system.

Taking only the current rail commuters and routing them from their stations to their destination buildings, if they arrive in the three morning hours from 7:00 AM to 10:00 AM, it is possible to visualize potential loads during times of maximum demand. Since only inbound morning travelers are shown, a greater volume, moving in reverse, can be expected during the PM hours. Also, many other users would be on the system in the course of a day to complete intra-loop trips, or to move from parking lots to their destinations.[10] Finally, both rail travelers and total persons in the Loop are projected to increase slightly between now and 1980. All these potential travelers are estimated to make 250,000 person trips over such a system daily. Using an estimate of $.85 per hour as the average value of personal time and assuming three minutes average time saving per trip, these people would obtain time savings worth $12,500 per day. This daily savings can be capitalized at about $40 million.

These time savings and capital costs are not included in the comparative cost estimates of the alternate transit plans treated above, but they are an important part of the economic appraisal of the proposed plan. They are of sufficient magnitude to support a large investment, so engineering feasibility studies should be accomplished to see whether these walks might be supported out of user charges.

One final feature should also be mentioned. Time savings of about an additional three thousand hours were found to result from the provision of railroad-CTA transfer privileges at breakpoints of service. These would be sufficiently great to support, at these points, stations valued at $600,000 each. Such additional time saving suggests the merit of pursuing this feature of the plan further.

All in all, the transit plan offered does suggest economies and improved performance of sufficient value to justify execution of the plan. The ultimate realization of the passenger potentials that have been estimated will require substantial improvements in transit services. Whether the proposals outlined here will both attract the riders estimated and, at the same time, yield the total benefits estimated, remains to be seen. It does provide a starting point for improving service and network efficiency and so for improving the total transportation capability of the region.

SUMMARY

This has been a conservative plan. It is conservative in its objective of conserving existing values in central properties and also with respect to the effective use of an existing resource —the rail transit facilities. It would not be sound to propose extensive new improvements when there is no reason to expect a sudden return to transit riding. But neither would it be sound public policy to allow a rapid decline in the community's capital investment in structures, facilities and rights-of-way.

Therefore, a plan was devised to support use of rail facilities, to serve the Central Area, and to avoid duplication of services. A prime feature of the plan is the number of experimental aspects that can be undertaken on a small scale before expending substantial capital investment. This transit system is geared increasingly towards delivering travelers to the Central Area, and towards providing essential feeder and local services for the travelers who have no cars.

Tests of the system illustrate that substantial capital investment cannot be directed into transit services where the market is relatively inelastic. It is hard to obtain gains from such improvements unless there are many more users. For the responsible public officials to undertake those improvements, benefits to support capital expenditures must be presupposed. Benefits accrue rapidly only when there is a very large number of travelers, each of whom is benefited.

[10]It is true that moving belt systems are slow, as they must be, to permit all types of persons to board and alight from them and to permit such persons to ride standing up. Speeds in excess of two mph appear to be too fast, and no system currently in operation is moving at more than 132′ per minute (1.5 mph). Further development of ways to adapt such systems to the full span of potential travelers' needs and to increased safety requirements will be necessary. It may be questioned whether the urge for speed and the increasing need of an aging population for more comfortable and mechanized transport may not produce a most satisfactory design in a relatively slow, but comfortable type of carrier.

The history of transit usage and planning points firmly to the increasingly specialized role that transit must assume. So long as this form of transportation consists of bulk provision of services, it requires concentration of its passengers. The ability to concentrate travelers, who wish to go to the same destination at the same point and at the same time, is gradually lessening. This is due, partly, to the tendency to build at lower densities, but it stems also from the sheer fact of growth, which occurs at different rates in different parts of the area. Growth of this fashion dilutes the concentration of similar trips. This, naturally, forces an increasingly specialized role for transit services.

While this is acknowledged in the plan, substantial attention is devoted to terminal service devices designed to enlarge the service areas of the rail transit lines. This effort to broaden service areas is an effort to insure effective use and continued operation of rail lines.

The proposal offered contains a judgment that the community must support a certain level of transit services. To enlarge these services beyond the levels proposed, it is believed, would require the diversion of moneys from other public activities which are of substantial community value. Anyone attempting to define such a boundary line must, in the light of today's knowledge, use keen judgment. Therefore, the exact proposal incorporates a certain amount of personal judgment. Final decisions must be made by the responsible public officials. Yet, in this plan, there is latitude for expanding or contracting the public investment in support of transit services depending upon experimental or pilot projects.

These proposals raise numerous questions of financial support, management incentives, ownership and public control. Performance or plans never can be separated completely from these problems. In spite of this, the work in this volume has remained concerned with the problems of regional design. The strength of approach supplied by the background studies lay in the increased attention given to passenger potential or traffic. The very real limits imposed on this score have dictated the kind of plan and the kind of tests to which it has been subjected.

Chapter VI

FINANCING AND PROGRAMMING

Two essential tasks remain before the regional transportation plans are complete. The first is to compare the cost of the plan with the ability of the region to pay (and to do this in realistic terms). The second is to specify the sequence of priorities of construction.

The question of the ability of the region to afford the program is approached from several directions. The total productive capacity of the region is important. But of importance, also, is some measure of the current tax structure and rates. It will not be enough to say, "You can afford this plan." Some answer must also be given to the question, "Will tax rates have to be raised?"

The matter of priorities is significant because of the time period over which such a large program must be extended. During this period, the population of the region will be increasing, and the pattern of land development and traffic demands will be shifting. It is neither reasonable nor possible to complete massive programs in a short time span. A steady and stable program of work should be settled upon, so that the demands on the construction industry are not excessive, and so the program can be paid for without unnecessary dislocation of resources from other uses. There is, obviously, one particular ordering or sequencing of the new facilities that will yield the greatest benefits to the growing region. The task here is to consider how best to schedule this work.

Both the financial review and the identification of priorities are accomplished at the regional scale. This tends to omit many important and interesting problems because they occur at a scale below that of the regional overview. These are the problems of a specific political jurisdiction, of a small time period, or of a particular kind of tax. The attempt here is to maintain the whole regional viewpoint, leaving the more detailed questions to later exploration and decision. In keeping with all previous effort, the purpose of this work is to define the regional context for specific future actions.

FINANCING THE PLAN

Financing a plan for a metropolitan region is much like any other problem of financing capital improvements. For the family about to buy a home or for an industry planning a new plant, a series of questions must be answered before financing can be accomplished. The first of these questions is, "How much does it cost?" The estimates of cost have been discussed in evaluating plan performance. They must remain as estimates until the facilities are finally built and paid for, but there is a solid basis for these estimates and they do provide working price tags for the several parts of the plan.

Estimating the Costs

Total cost estimates of major plan items are shown in Table 17. These estimates are based on recent experience in the Chicago area and they are scaled in 1960 dollars. In the cases of expressways and arterial streets, actual construction of substantial magnitude has been completed in the last five years. The detailed figures for this completed construction, plus the estimated costs of finishing the remaining segments of the interstate highways, provided the basis for the expressway cost estimate.[1]

[1] See Orzeske, J. D., *Financing A Highway Plan For The Chicago Area* (37,300) (Chicago: CATS, 1962).

TABLE 17
ESTIMATED COSTS OF PLAN COMPLETION

Purpose	Total	20 Year Annual Rate
Expressways	$1,748,000,000	$ 87,400,000
Arterial Street Expansion	300,000,000	15,000,000
Rapid Transit Route Construction	94,800,000	4,740,000
Additional Rapid Transit Cars	22,000,000	1,100,000
Pedestrian Ways	40,000,000	2,000,000
Parking At Outlying Rail Terminals	30,000,000	1,500,000
Total	$2,234,800,000	$111,740,000

The arterial street costs are based on an estimate of mileage of such future improvements and are not detailed, in this report, as to location or type. All highway cost estimates have been reviewed by engineers of the highway agencies of the sponsoring governments and are considered to be representative of present day costs.

The estimates of transit costs are derived from published proposals by CTA engineers, and these, in turn, are reinforced by actual experience in building the West Side Subway. Cost estimates for moving walkways are less firmly based. No systems of the extent proposed are in existence, nor are final specifications available. Engineering studies have been undertaken and are but a partial reference.[2] Investigation of installations in other places and consultation with manufacturing concerns provided an informed basis for the estimates used.

Total requirements for enlarged terminal parking facilities are predicated on demands growing out of the projected increase in commuters from the outer areas (a gain of 69,000 rail users is expected by 1980). It has been estimated that 20,000 parking places costing $1,500 each will be required. These estimates are not refined because the development of parking facilities must proceed somewhat experimentally to determine what the market demands are and how such facilities will be paid for. Obviously, many other investments in parking facilities will be needed if the greater population of persons and vehicles is to be well served. These are not included as a public charge because it is presumed they will be met principally by private investment. Where public investment is called for, it is presumed that revenue bonds and current parking revenues will be used, so that such facilities will not represent a special problem for scaling financial requirements.

Altogether, the highway improvements are estimated at $2 billion and the transit related proposals at something in excess of $186 million. These are the cost estimates of the elements of the plans, but they are not the total capital requirements for highways or for public transit. Expenditures will be needed for other improvements of a capital nature. Roadways will have to be modified in redevelopment areas—some rail crossings will have to be separated, and much reconstruction of existing facilities, as well as investment in new traffic control systems, will be necessary. There are nearly ten thousand miles of existing local and arterial streets. Needs for reconstruction or improving these facilities present regular annual demands on highway agencies.

Expenditures for block signals and for increased automation of controls will be required if the transit system is to achieve the improved safety and economy that are in the public interest. Modernization of shops, together with other capital costs, will increase the annual needs of the public carriers beyond the levels needed to complete the key features of the plan.

Thus, there are many capital needs not specified by the plan, yet the elements of the plan do indicate the main transportation facility investment demands that will have to be considered by public officials over the next twenty years. A total price estimate being established, the next question is, "Can we afford it?"

The Financial Resources of the Region

Whether the plan is too costly depends upon the total financial capability of the region. Like the income of a family buying a home, the region's aggregate income is measured and can be described. The wealth, productivity and income of the metropolitan region increase each year. These increases run parallel with the continuing growth of the national economy and they come from the same two basic growth factors: growth in individual productivity and growth in the number of producers. Figure 41 projects one measure of the region's wealth to 1980. It illustrates how both population and increased per capita productivity are expected to raise the region's income between now and 1980.

The growth in individual productivity comes from a variety of changes or improvements in the economy. First, training and education are upgrading the capability of the labor force.

[2]Tholin, A. L., *An Initial System Of Elevated Pedestrian Ways For Downtown Chicago* (Chicago: City of Chicago, 1956).

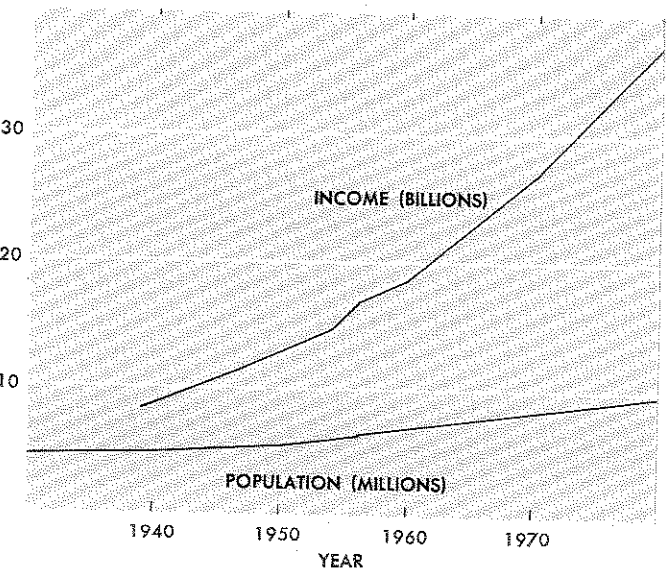


FIGURE 41—POPULATION AND AGGREGATE CONSUMER INCOME FOR THE METROPOLITAN AREA IN CONSTANT 1956 DOLLARS, 1930-1956 AND ESTIMATED TO 1980

See Table 34 in Appendix of Volume II.

Secondly, the increased number of people and jobs encourages greater specialization—specialization of industry and specialization of jobs within any industry. Job specialization in turn fosters greater per capita productivity. A third factor is the increasing amount of capital per worker. More power and more tools enlarge the capabilities of each employee. Investment in new plants, machinery and also in the public facilities of the community must likewise be made if worker output is to be increased.

The projected growth in population is an important source of increase in productive capacity and also is a source of demand for capital investment. More people mean more workers, and more workers will increase the total goods and services the region produces. A greater total output is, of course, greater wealth or greater ability to pay for the capital facilities of the plan.

Increased population not only increases the capability of paying for an enlarged and improved transportation system, it also creates demand pressure for these and other improvements. More people require more houses, schools, utilities and transportation facilities. These are needed if the region is simply to stay abreast in its real wealth per worker. But, if the region is to move ahead—i.e., to gain in wealth and productivity—capital formation must proceed more rapidly than population. Economic growth requires that the capital resources per worker must increase.

This argument, then, not only bears on the ability to pay for the plan—it begins to show that the development of transport improvements on the scale proposed in the plan will be a vital factor in creating the capability to pay for it. Economic evaluation shows that the plan does, in fact, more than pay for itself. And it is clear that the quantity and quality of transportation improvements must proceed at an ever faster pace. If we must do more in the next twenty years, then one way of calibrating the size of the plan is to see how much is being spent today.

Current Levels of Capital Investment in Transportation Facilities

Assembling the full story of current annual transportation investment in the region is a difficult process. Many separate governments, as well as private companies and governmental authorities, are involved. The accounting records are difficult to read accurately because expenditures by one government may be recorded as receipts by another. So care must be taken to prevent counting the same dollar twice as it filters through the series of transactions leading to a final disbursement.

In Table 18, the total expenditures for highways for the three most recent years for which

TABLE 18
TOTAL EXPENDITURES FOR HIGHWAY PURPOSES IN COOK AND DU PAGE COUNTIES, 1957-1959

Agency	Year		
	1957	1958	1959
State	$ 31,632,410[a]	$ 67,992,485[a]	$ 77,518,227[a]
Counties	43,274,485	59,171,305	74,104,313
Townships	1,618,858	1,945,204	2,193,727
Cities and Villages	66,845,699[b]	83,412,468[b]	74,313,793[b]
Toll Facilities[c]	47,322,347	29,610,610	7,573,947
Special Districts	6,805,438	11,255,980	4,038,665
Total	$197,499,237	$253,388,052	$239,742,672

Source: Illinois Division of Highways, Bureau of Research and Planning.
[a]Includes reimbursements to Cook County and Chicago for expressway construction.
[b]Additional expenditures for allied street functions during 1957-59 were $27,086,252, $36,131,895, and $33,501,957, respectively.
[c]Chicago Skyway only.

data were available—1957, 1958 and 1959—are shown. The data are for all highway expenditures by all levels of government in Cook and Du Page Counties. These two counties are nearly equivalent to the Study Area. One segment of Du Page County and a bit of Cook County lie just outside the Study Area, but these pieces are about equal in size and character to the small segments of Lake and Will Counties which are within the Study Area. Thus, data for the two counties provide an adequate approximation of Study Area totals.

The table shows that an average of more than $200 million was spent annually for highway purposes in those three years. Moreover, of this, more than sixty per cent went into construction and right-of-way purchases.

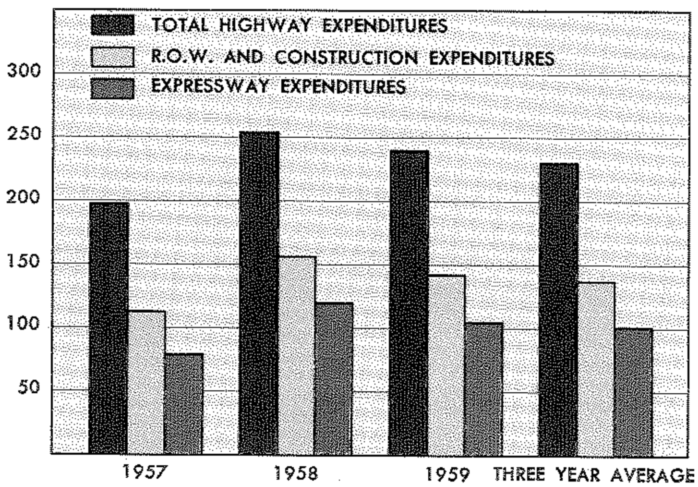


FIGURE 42—HIGHWAY CONSTRUCTION AND EXPRESSWAY EXPENDITURES IN COOK AND DU PAGE COUNTIES BY ALL GOVERNMENTS FOR 1957-1959

See Table 35 in Appendix.

Figure 42 illustrates how the total highway disbursements were divided as to capital expenditures and also what portion of capital expenditures went for the metropolitan expressway system for the three years 1957-1959. The average annual expenditures on expressways are in excess of the amount ($87.4 million per year) needed to complete the plan over the next twenty years. In fact, by the end of 1960, expressways whose cost totaled $970 million had been built, and most of this building had been accomplished within the past eleven years, at an annual construction rate about equal to that needed for the next twenty years. This means that the manpower necessary for the designing and building of these roadways is available and that sufficient material is obtainable. No larger program than that presently in progress is being called for. Thus, the execution of the plan should not strain the labor force nor require unusual withholding of labor from other activities.

Spending on transit improvements has been substantial over the past fifteen years. Table 19 lists the reported capital expenditures on ways, structures and equipment for improvement of local passenger transportation by the suburban railroads, the Chicago Transit Authority and the other local transit systems in the Study Area. These recorded capital expenditures are more inclusive and, therefore, not strictly comparable to those called for in the plan proposals. They are recorded merely to provide evidence as to the scale of the transit proposals and not to suggest how the plan can be financed, for this is a more difficult problem.

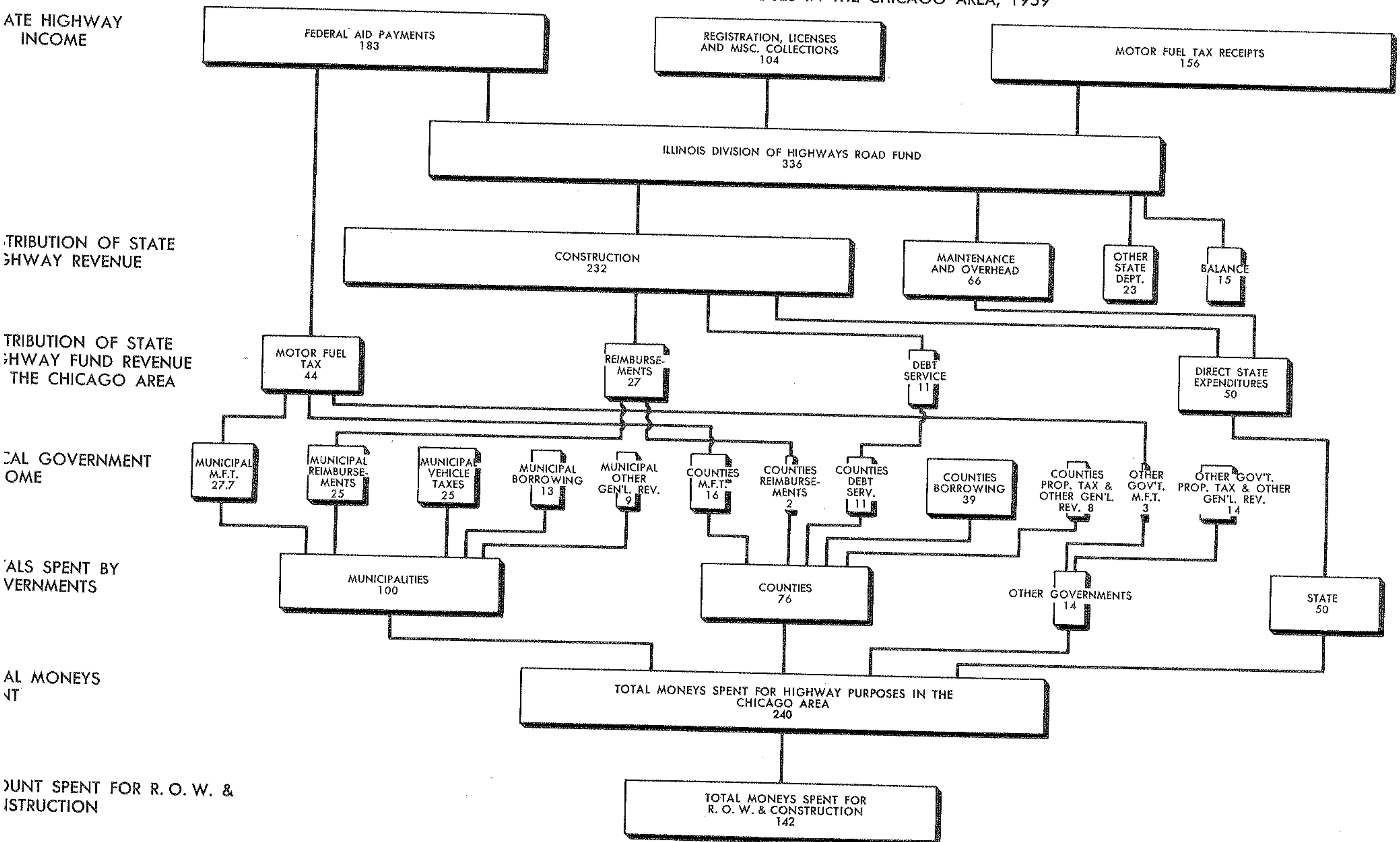
TABLE 19
CAPITAL EXPENDITURES CHICAGO AREA TRANSIT SYSTEMS, 1946-1961

Chicago Transit Authority[a]	$175,000,000
Suburban Railroads[b]	90,000,000
Suburban Bus and Other[b]	5,000,000
Total	$270,000,000

[a] *1960 Annual Report*, Chicago Transit Authority (Chicago: Chicago Transit Board, 1960), and *Chicago's Mass Transportation System* (Chicago: Chicago Transit Authority, 1959).
[b] Study estimate.

From the history of the past decade, it is clear that little more than current rates of construction are necessary to insure completion of the plan within the next twenty years. Thus, no more engineers, designers or contractors are called for than have been needed in recent years. Yet, the question of whether adequate finances are in sight to support this proposed work may legitimately arise. Cook County has issued more than $200 million in expressway bonds and the Illinois Toll Road Commission borrowed more than this amount to pay for routes within the Study Area. In addition, nearly $100 million was borrowed to build the Chicago Skyway. The CTA apparently has used its cash savings also and has stretched its borrowing power to the limit. So the question of whether taxes may have to be raised remains.

FIGURE 43—FUNDS EXPENDED FOR HIGHWAY PURPOSES IN THE CHICAGO AREA, 1959



*IN ADDITION, MUNICIPALITIES EXPENDED AN ESTIMATED $33,500,000 FOR ALLIED STREET FUNCTIONS DURING 1959 INCLUDING PARKING FACILITIES, SNOW REMOVAL AND LIGHTING. THESE WERE PAID FOR FROM GENERAL REVENUE OR SPECIAL FEES, ETC.

See Table 36 in Appendix

Are New or Larger Taxes Necessary for Highways?

In reviewing taxes, the inquiry is restricted solely to describing the yield of current taxes and projecting them over the next twenty years. The many issues, such as appropriate tax structure, equity as between users and the general public, or proper exercise of tolls to control roadway usage, are avoided. The issue being investigated is whether the highway plan is in scale with the community's tax yield—not how best to levy charges or taxes.

The available moneys for highways come partly from federally levied taxes, partly from state levied taxes, and partly from local taxes. Moneys from state and federal taxes are returned to the Chicago region in two ways. The first is by means of grants and shared taxes—i.e., in the form of cash. The second is in the form of work or construction performed by and paid for by the state. All of these revenue sources are illustrated for a sample year—1959—in Figure 43.

It can be seen that substantial moneys are available from highway user taxes. The bulk of these taxes is levied by state and federal governments, so the principal source of funds must presently be shared taxes or grants-in-aid. All federal aid reaches the local governments through the State Division of Highways. Thus, looking at state income for the Highway Fund is one way of estimating the potential tax dollars that may be available for new highways in the Chicago region. Figure 44 illustrates the main sources of revenue for the Highway Fund, together with the projected future income from the same sources with no change in current rates.

It can be seen quickly that the total funds available for highways are expected to increase as a consequence of increased motor vehicle registrations. The total revenue from motor vehicle users has increased to nearly $450 million in 1960, whereas never, before 1948, had total income exceeded $100 million. The projections, according to current rates, will produce total income to the state of more than ten billion dollars over the twenty years from 1961 through 1980. This is more than twice

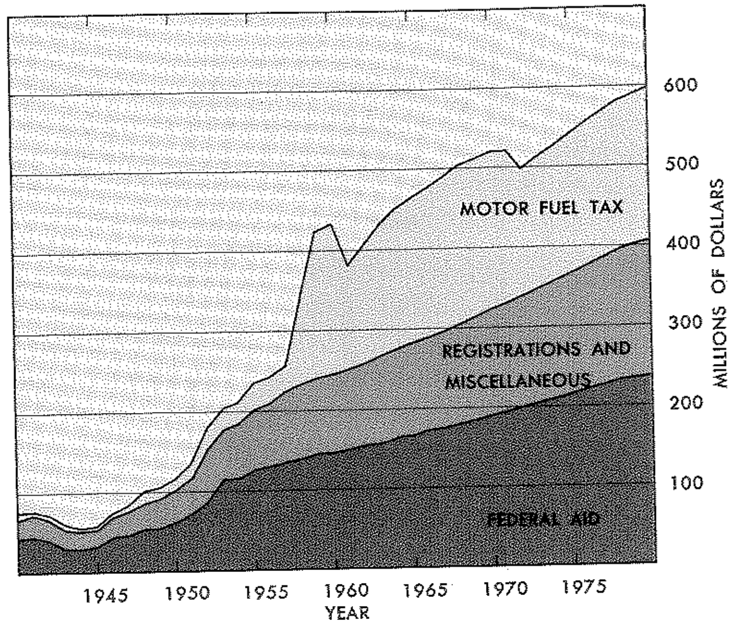


FIGURE 44—STATE HIGHWAY REVENUE, 1940-1960 AND ESTIMATED TO 1980

See Table 38 in Appendix.

the total revenue received for highway purposes in the entire history of the Illinois Division of Highways up to 1960. Total resources available to the state certainly will be greater, so it is reasonable to expect the local highway expenditures to be greater.

The estimates of potential revenue available to the Chicago region are detailed in Table 20. First, local revenues are estimated. Then, state revenues are estimated and the assumption is made that about thirty-two per cent, on the average, will be spent in the Chicago region. This has been the recent actual proportion and is assumed to represent a reasonable average expectation over the next twenty years. Given total revenue estimates for the twenty-year period, the total is further divided about sixty per cent for construction and right-of-way expenditures.

These estimates involve assumptions which may not hold in the future—i.e., the needs for the entire state may not justify the proportion assumed for Chicago; also, the ratio of maintenance expenditures to capital expenditures may change. Finally, there are future burdens on road funds over and above plan requirements.

For example, much of the recent construction was financed by bond issues. Cook County authorized, for expressway construction pur-

TABLE 20
ESTIMATED FUNDS AVAILABLE FOR HIGHWAY PURPOSES IN THE CHICAGO AREA, 1961-1980

Major Sources of Funds	Estimated Total Receipts
Revenue—Local Governments	
Chicago Wheel Taxes	$ 460,000,000
Suburban Wheel Taxes	100,000,000
Local and County Property Taxes Spent for Highways and Streets	260,000,000
Total Taxes Levied by Local Governments	$ 820,000,000
State Revenue	
Motor Fuel Tax	$ 3,877,000,000
Registrations, Licenses, and Misc. Fees	2,693,000,000
Federal Aid	3,548,000,000
Total State Revenue	$10,118,000,000
Annual Average Proportion Spent in Chicago Region	$ 3,250,000,000
Local Taxes	820,000,000
Total Funds Available	$ 4,070,000,000
Estimated Amount for Construction	$ 2,442,000,000

Source: Orzeske, J. D., *Financing A Highway Plan For The Chicago Area* (37,300) (Chicago: CATS, 1962).

poses, one bond issue of $70 million and later another for $245 million. This money has been used to speed up work in the last five years. Much of it will have to be repaid from future tax receipts. There will be other road and highway needs for capital expenditures—reconstruction, new grade separations, additional new local roadways, and the like. Also, future highways may increase in cost. Electronic signals and even lanes with guidance and vehicle controls are possible. These new features, while improving performance, will increase costs.

Even with some margin for reasonable contingencies, the plan must be counted as fitting into the current financial structure of the metropolitan community. Within this framework there is the possibility that the work may be speeded up. But it also is possible that other demands will be so great or costs may rise so that sufficient funds will not be available for accomplishment of the work in the projected time. In such an event, the work program can be adjusted to a slower construction pace. An expanded population owning more vehicles creates needs, but, fortunately, it also creates more taxpaying capability. Thus, seen as a twenty-year program, the plan is achievable and not unrealistically optimistic. This appraisal of financial feasibility becomes even more persuasive when it is recognized that no state presently has a lower fuel tax rate than Illinois.

Transit Financing

With respect to transit facilities, matters are different. Revenue must come from the passengers or from some form of governmental assistance. The CTA has just completed a substantial modernization. Since acquisition of the private companies just after the war, $175 million were spent for capital improvements. The expenditures are itemized in Table 21.

TABLE 21
CAPITAL EXPENDITURES CHICAGO TRANSIT AUTHORITY, 1946-1961

New Surface Vehicles	$ 69,000,000
New Rapid Transit Vehicles	43,000,000
Garages, Fixed Transportation Equipment, Etc.	38,000,000
West Side Subway	25,000,000
Total	$175,000,000

Sources: *1960 Annual Report*, Chicago Transit Authority (Chicago: Chicago Transit Board, 1960) p. 15. *Chicago's Mass Transportation System* (Chicago: Chicago Transit Authority, 1959) p. 8.

These expenditures were financed largely from earnings of CTA and the predecessor companies. These investment funds were made possible partly by relief from certain taxes and street maintenance expenditures, and partly from economies resulting from consolidation of service. In addition, the modernization of equipment and the construction of new facilities have used virtually all of the borrowing power of the Authority. Future investments must either be financed very slowly from fares or there must be some help from governments. Another alternative—raising fares—results in an offsetting reduction in riders, so that this course of action would not seem to be a feasible alternative.

The commuter railroads, too, have invested in more modern equipment. The Chicago and North Western Railway recently has spent $43 million in modernizing its commuter service and new equipment has been added by the "Milwaukee," the "Burlington" and the "Rock Island" railroads. Total capital improvements in commuter equipment and facilities for all

Chicago area lines have amounted to over $90 million in the past fifteen years. These improvements were long overdue and appear still to fall short of fully modernizing the commuting facilities in the Study Area. The plan does not call for specific new investments for commuter railroads other than those needed to keep the level of service high. Yet, these may be substantial if the remaining old equipment is to be replaced. Structures, rights-of-way and terminal facilities also may require substantial modernization, and this will have to be accomplished if the projected share of 1980 travelers is to be carried by the railroads. There does not appear to be sufficient earning strength from commuter fares to pay for all costs of commuter services.[3] So, while the plans do not call for more than the continuation of commuting services much like those of today, meeting this requirement still will be a problem.

In sum, the railroads and the CTA, since the war, have incurred about as much indebtedness as they reasonably can. There is little additional investment money in sight because of stable or declining markets and consumer reaction to fare changes. The improvements in CTA facilities probably will have to be supported by the community's tax base.

The improved downtown pedestrian circulation system might be supported by user charges. Assuming that a system with speeds of operation sufficient to produce time savings of about four minutes for the average traveler can be designed (i.e., an average increase of two mph over walking speeds), there appears to be a market of 250,000 riders who would pay five cents per trip. This would produce $12,500 in daily revenue—enough to warrant a $40 million investment. If detailed engineering estimates of cost and operational characteristics show the system to be doubtful of full support from fares, it must be recognized that additional benefits would accrue to the downtown vehicle user because separation of pedestrian and vehicular traffic would improve the capacity and performance of downtown streets. Moreover, buildings would benefit directly and so might bear part of the cost through special assessments. Final measurement of financial feasibility will depend upon final cost estimates.

Summary—Financial Feasibility

A review of the costs of the plan in comparison with the available moneys showed the highway plan to be in scale. There is less optimism concerning financing for the transit improvements. Present fares appeared to be sufficient only to cover the costs of service. Little or no resources are left for the recommended capital improvements. It is quite probable that to finance some of the proposed transit improvements, help from sources other than the fare box must be found. There is good evidence to expect that user charges would support a system of downtown pedestrian facilities if reasonable designs can be worked out.

ADVANCE RIGHT-OF-WAY PURCHASE

Financing is a critical aspect of the plan as is timing of the work. Yet, in many ways, the truly big problems of current highway building are not those of money. Perhaps the greatest problem is that of specific land taking for highway purposes.

A familiar saying is that no one wants an expressway on his property—just near it. Naturally, few people relish selling their property at someone else's insistence even though they are "fairly" compensated. Designation of a final right-of-way requires the taking of a number of land parcels. There is a natural and immediate set of reactions as people and businesses are forced to move and readjust. These disruptions and shifts of people and businesses are problems which good planning should minimize.

There are many ways to improve this process, but one of great importance is that of advance designation and purchase of rights-of-way. With a plan of this scale laid out, it is possible to work out final locations of routes and to plan future land developments around these commitments. Designation of future locations allows consolidation of local land planning and zoning. In areas of new and fast

[3] Berge, Stanley, *Railroad Passenger Service Costs and Financial Results* (Evanston: Northwestern University School of Commerce, 1956).

growing suburbs, land development and highway development can proceed together. Such definite commitments enable the adjustments of people and land uses to be geared to the revised highway system, thus avoiding much uncertainty and distress.

To make this process of advance designation of specific expressway locations both fair and effective, the highway building agencies should have funds for buying the required land in advance of construction. While it may be possible to obtain dedications of some land, the extra-wide rights-of-way needed for expressways are generally considered beyond the requirements for local subdivision dedication. Zoning and other legal tools may be used to control land development, but they cannot be used to earmark land for ultimate highway purchase and so prevent the owners from building on the land. The fairest and most practical way of making advance unit location designation effective is to purchase such right-of-way parcels as far in advance of construction as is consistent with the public interest.

Advance purchase of land for rights-of-way will require a revolving fund of sufficient size to enable highway departments to stay well ahead of their building or construction programs. Such a fund could be reimbursed as the roadways were built. This would enable highway departments to preserve route alignments in fast developing suburban areas. It is probably the fairest and most direct method for land taking and it could reduce much of the distress arising from the necessity of acquiring improved property.

PRIORITIES

Of most immediate importance in executing any plan is the question of what to build next. Not infrequently people will subscribe to the eventual need for a large construction program, but much of it is so far off as to seem relatively unimportant in contrast to the very real program for next year. So the problem of sequence of priorities is of compelling importance.

The sequence of construction that is chosen should reflect the governmental policies and objectives. Different building sequences will be required to meet different objectives in the best manner. Policies and objectives may change with changes in administration, with changes in national needs and problems, or with many other events. Thus, priorities also are subject to change.

It would be presumptuous to anticipate and weigh all of the factors that responsible governmental officials consider in fixing their annual budgets and work programs. This is a political as well as a technical problem. The approach adopted here in proposing priorities is to try to define the preferred sequence of construction if growth occurs as forecast and if benefits to travelers are maximized. This will, hopefully, provide a useful statement to the governmental leaders who must make final decisions on annual programs of public works.

Transit Versus Highways

Transit services are fighting to hold their passengers and to maintain service levels. Yet, to attract the number of projected transit users and to achieve the development levels planned for the Central Area of Chicago, transit service must be improved. Time is short and delay in execution of transit improvements could inhibit full usage of transit and the full development of land in the Central Business District. So one precept is that those proposals most likely to improve transit services to the center of the city be instigated first.

What are the improvements in this category? First, perhaps, will be the rapid transit extension to the northwest. This territory is without rapid transit service today, excepting by bus to the Logan Square terminal and limited service within the city by the North Western Railway. While there is current disagreement as to the exact division of services between CTA and the North Western Railway, this should be resolved and service of a high quality established if the large population in this part of the city is to be served well. The extension of rail service to O'Hare Airport is less urgent, since this traffic has not reached its full development and it may be served better at present by providing feeder buses to transport travelers and workers from O'Hare Airport to either railroad or CTA facilities.

Other rapid transit improvements are in the top priority class because they, too, provide improved service to the Central Business District. The express bus service proposed for the Southwest Expressway fits into this category. Currently under design, this route provides space in the median for bus stations and for express bus lanes west of Damen Avenue. There is no rapid transit service in this sector of the city. Only one or two railroad trains a day provide suburban passenger service. Rapid transit in this corridor should be inaugurated as soon as construction has advanced far enough to permit it.

The development of express transit services in the Dan Ryan Expressway and the extension of rapid transit service west on 63rd Street from Loomis Boulevard are two other extensions which will improve service to the CBD. All are needed to serve the intermediate distance travelers who live in more dense parts of the city.

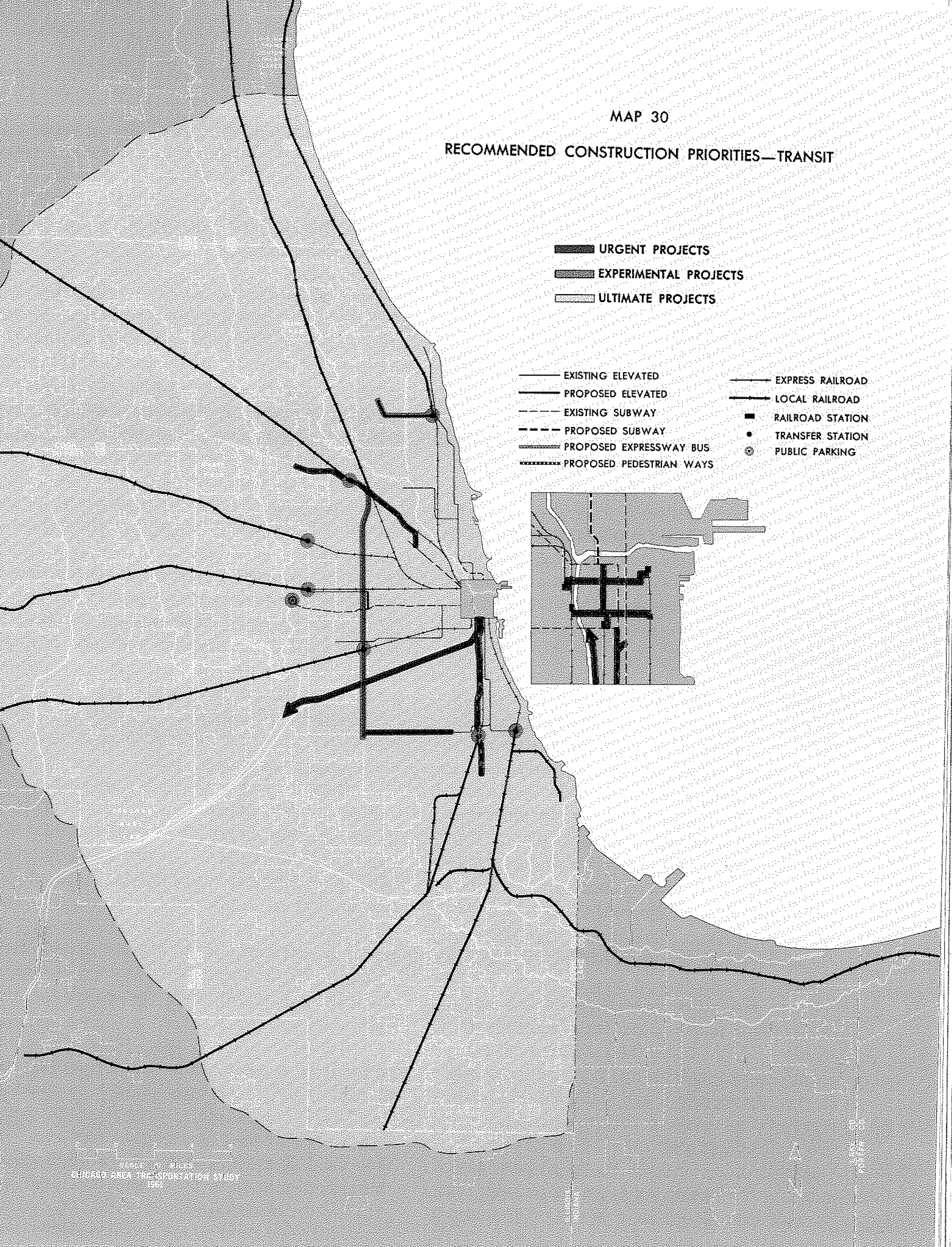
At the same time, substantial effort should go towards development of pedestrian walkways from railroad stations to Loop buildings. Hopefully, these will be moving conveyor systems which can speed such journeys. But in any event, protected, grade separated walkways could be designed, with some sections served by moving belts. These improvements are essential if the attraction of railroad services as a most significant factor in delivering peak hour commuters is to be preserved.

Transit improvements which are more experimental should proceed on a "try and see" basis. Included here are improvements at both rapid transit and outlying commuter railroad stations for the benefit of passengers who park at these outlying stations and continue to the CBD on public transportation facilities. Parking lots with no charge, or with very nominal charges, should be installed at the busiest terminals, such as the Desplaines Avenue station (in Forest Park) of the West Side Subway. Likewise, improvements in the design of rapid transit and railroad stations should allow for easy drive-in delivery of passengers both by private car and by feeder buses. The first installations should be evaluated carefully to establish size and design specifications for similar treatment at other terminals.

In the same category of experimental designs will be the provision of express bus service in newly opened expressways. Different designs for loading and unloading passengers must be developed and tried on the new expressways. Experiments must be carried out to determine how and when buses can best be mixed with the regular traffic or when special lanes may be justified. Such experiments should lead to a much better technique for expressway usage and to validation of passenger usage estimates. Certainly, tests should be carried out to assess whether designation of lanes during rush hours may not be superior to construction of wholly separate lanes.

A third category of improvements includes those that must proceed when operationally suitable. This group centers around the possible abandonment of all or part of the downtown elevated structure. To dispose of this structure, three conditions must be met. First, the traffic must be such that it can be handled in the two subways. Second, there must be a connection for the North Side lines into the Dearborn Street Subway and the Lake Street Elevated must be re-routed so as to enter the CBD by way of the West Side Subway. Third, there must be public demand to remove the elevated structure. This combination of conditions will be expected to obtain at some time before 1980, but these changes do not urgently affect the quality of service to the Loop at this time and so are placed in a lower priority.

While highway improvements are necessary, they must be extended over a period of years if they are to be built within the limits of current income. Transit improvements, on the other hand, are needed now to preserve access to the Central Area and to retain the levels of ridership estimated in the 1980 travel projections. These transit improvements are shown on Map 30. This identifies the urgently needed improvements; those that must proceed as operationally suitable; and those which are



MAP 30

RECOMMENDED CONSTRUCTION PRIORITIES—TRANSIT

ransit improvements must be accelerated in order to support the changing developments and growth in Chicago's Central rea. These have a number one priority. Other improvements depend, in many instances, on other actions: highways sometimes considered to be part of the experimental or "try-and-see" improvement schedule.

The lack of ready capital for these transit improvements can prevent quick action. Yet, delay here could be serious because transit services are delicately balanced against a shrinking market and every effort is needed to restore the vigor of this system.

Highway Improvements

The priority system for highway facilities presents quite different problems. Here the best building sequence is presumed to be that which yields the greatest benefits over time. Building the highway plan not only enlarges the highway system, it also will modernize it. The plan takes advantage of the expected growth in demand to supply substantially improved facilities. By emphasizing the more modern and efficient expressways, the entire network is upgraded in performance. Thus, new construction must meet the demands for greater quantity and higher quality of highway facilities.

From the standpoint of modernizing the highway system, the sooner new elements are built, the better. But from the standpoint of increasing highway capacity, it is important to build only as fast as traffic growth demands increase. The highway system, in meeting a large, future growth problem, is different from the transit plan. There are valid reasons for sequencing improvements over time in annual work programs. If the entire highway system were built at one time, there would be underuse of facilities because much traffic growth lies ahead.

There are other good reasons for gearing the construction of planned highways to a steady building pace. One is that such a program can be paid for from current revenues, thus avoiding the large debt that otherwise would be incurred. Another is that the engineers, designers, contractors and all other personnel would be kept more smoothly and steadily at work. This is an increasingly important aspect of public works programming —i.e., the steadiness of work to dampen cyclical fluctuations in employment. This leads to more economical employment of men and machines and so to lower unit costs—always an important consideration. For these reasons, it is assumed that the work of completing the plan would best be spread evenly over a twenty-year period.

If one considers that approximately the same amount of work can be accomplished each year, then the problem of programming or priorities is to find that sequence of annual work which is most likely to maximize the benefits to travelers. Perhaps an ideal solution could be visualized in which the annual growth in persons and traffic was estimated first. Then, different combinations of building sequences might be considered, with a complete calculation of costs and benefits for each year for the twenty-year period. After an extremely laborious search, it would be possible to define that particular sequence whose accumulated benefits would be greatest over a period of twenty years. But this would entail a great amount of work with little assurance that the annual growth estimate was correct or that all values could be precisely measured so as to assess maximum benefits. In fact, the method would be much finer than the information used to make the detailed calculations. So a more general attack on the problem is indicated.

Some obvious rules, which should insure a more efficient sequencing of construction, can be made. Knowledge of the projected patterns of growth, together with knowledge about the distribution of traffic and how benefits are obtained, will indicate the most rewarding building sequence. The objectives are presumed to be the same as those used to design the system—i.e., providing the least total cost system over time.

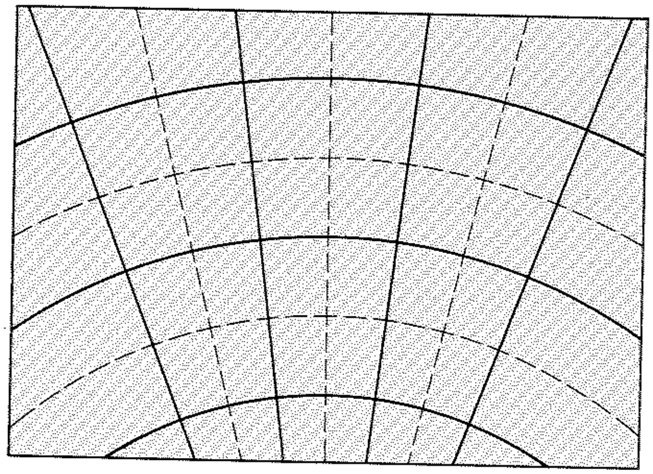
Any new expressway will attract traffic because it is a more economical roadway for users. If only so much money can be spent in one year—i.e., if the construction program were to be extended over about twenty years—then the dollars spent in one year should, other things being equal, be for construction in those areas where the total vehicle miles traveled on new facilities would be the greatest. Since one-twentieth of the total cost could be spent in any one year, this means finding that sequence of investment which would result in the greatest total miles of vehicle use. This would mean building new facilities from the center towards the periphery, or from city towards suburbs, as a general rule. But, of course, construction is more expensive in the denser parts of the community and so, while more traffic is attracted per mile of route, it remains to be seen whether the greater traffic volumes still would justify this policy.

The usage remains greatest per construction dollar at the center only if certain conditions prevail—i.e., with no expressways at all, this would be the proper starting place. But, since a construction program would soon serve the center, the outer areas would become increasingly more profitable locations. So a better building sequence would be to begin at the center, work outward and repeat.

But at all times an attempt must be made to keep the spacing between expressways as even as possible in regions of common density. For example, it obviously would be uneconomical to begin work in the northernmost sector, completing all facilities in that sector before moving to the next. Such a sequence would concentrate facilities in one area, leaving others congested and poorly served. So, while there is some justification for sequencing construction from the center outward, there also is a reward for maintaining uniform spacing between improvements in all rings of the Study Area.

These are the most general precepts for sequencing expressway segments. There should be deviations where growth has an unusual rate and/or where there already is a significant deficiency in the area's traffic carrying ability. The traffic relief and upgrading of service resulting from the introduction of a new expressway will be much greater where existing conditions are below average.

In sum, the guide to the preferred building sequence is to keep the improvements as evenly distributed as possible over the period of construction. This would mean that with half of the total system completed, the network would consist of every other expressway. So, at the

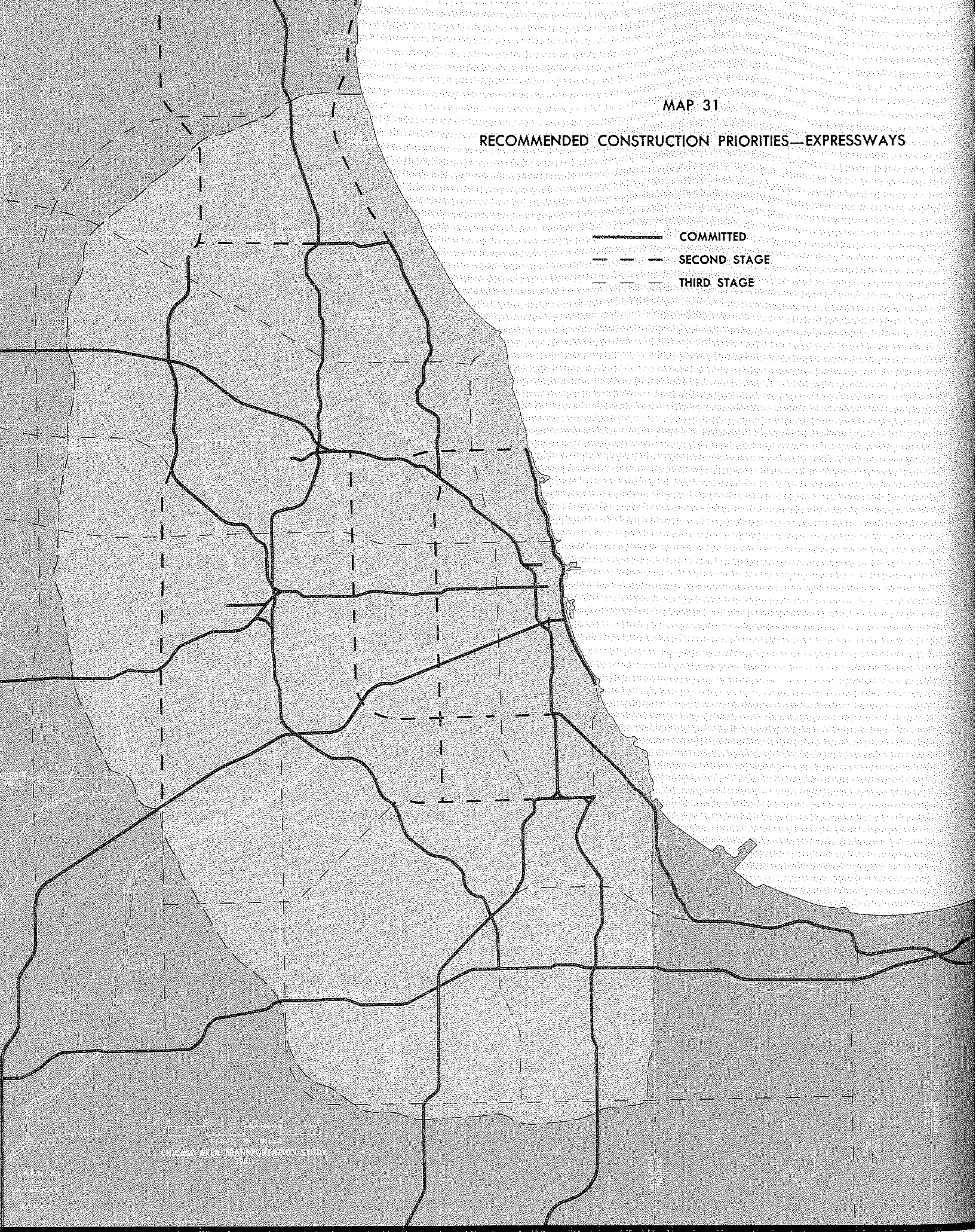


halfway point, the system would, under a ring and radial scheme, look much like the picture presented in the diagram above. Here the solid lines represent completed segments, the dashed lines those remaining.

To obtain a program, these general rules must be adjusted further to the specifics of the Chicago region. This requires some recognition of the effect of governmental policies and recognition of the system at its present stage of completion.

Perhaps the dominant governmental policy at present is the pressure to complete the federal interstate highway network. With ninety per cent of the cost of these facilities paid for from federal grants, work on those segments of the plan that have an interstate designation have been those most accelerated. At the end of 1961, the interstate segments were all complete or under design, excepting for one north-south connection, Interstate Route 494. This will probably be designated and programmed next. At this point, the interstate highways of the Chicago region will be complete, but those planned for the remainder of the state and nation will still carry a completion date of 1972-1975.

One reason the Chicago region's work on interstate routes will be finished ahead of the national completion date is the substantial mileage completed by the Illinois Tollway Commission. Another reason lies in the borrowing by Cook County to speed up the work. Yet the truth remains that the flow of federal aid for interstate construction in the Chicago region will dry up towards the late sixties



The three stage priorities illustrate what is being done under current funds and contracts, what is recommended for the early 1970's and what can be delayed until after 1975 for execution.

because the allotted highway mileage on the interstate system will have been completed. This discloses two priority problems: one, the fact that the interstate highways are built first; the other, that there is a potential slowdown in available federal aid funds after the last segment of interstate mileage is complete.

The priority program proposed reflects these considerations. The first stage of work takes committed construction projects plus the interstate mileage through to completion. This is called the committed system and is stage one in priority. The remaining construction is divided into two parts: the first group of routes s that needed to arrive at a complete, yet more widely spaced network; the second group ncludes all remaining work needed to complete the highway plan. These three stages re illustrated on Map 31, showing the yet-o-be-completed interstate routes; the routes eeded to complete the second stage; and those egments falling in the final construction phase.

These are broad priorities, as they must be, or no one is sufficiently well informed to lay ut the annual work program for a particular ear in the 1970's. The three major phases are easured by costs and expressway mileage to ive some better scale to this rough priority roposal. Table 22 illustrates the mileage, the osts and the approximate completion date of ach stage.

TABLE 22
COST ESTIMATES AND MILEAGE OF THE THREE
RIORITY STAGES OF EXPRESSWAY CONSTRUCTION
(As of December 31, 1960)

Stage	Route Miles	Total Cost (Millions)	Construction Period	Completion Time
isting	181	$ 970	1950-1960	11 years
mmitted (First Stage)	92	458	1961-1967	6 years
cond Stage	109	576	1967-1975	8 years
rd Stage	142	714	1975-1981-3	7 years
Total	524	$2,718	1950-1981-3	32 years

The total expenditure through 1960, on ex-essways, was $970 million. An additional 50 million is required to complete the com-tted system. At that time, work probably ll slow down because of the completion of e interstate highways in the area. However, ere will be a gradual gain as revenue from motor vehicle user taxes increases, so that the second stage of development, costing $576 million, should be completed in 1975. The final stage—involving $714 million and 142 miles of routes should be started in 1975 and could be finished by 1981 or 1982.

SUMMARY

In this chapter, a quick view of the timing and cost of the plans has been presented. Substantial community effort is needed to meet the enlarged needs of a growing and extending metropolis. The plans are designed not only to enlarge the transport system, but also to improve it.

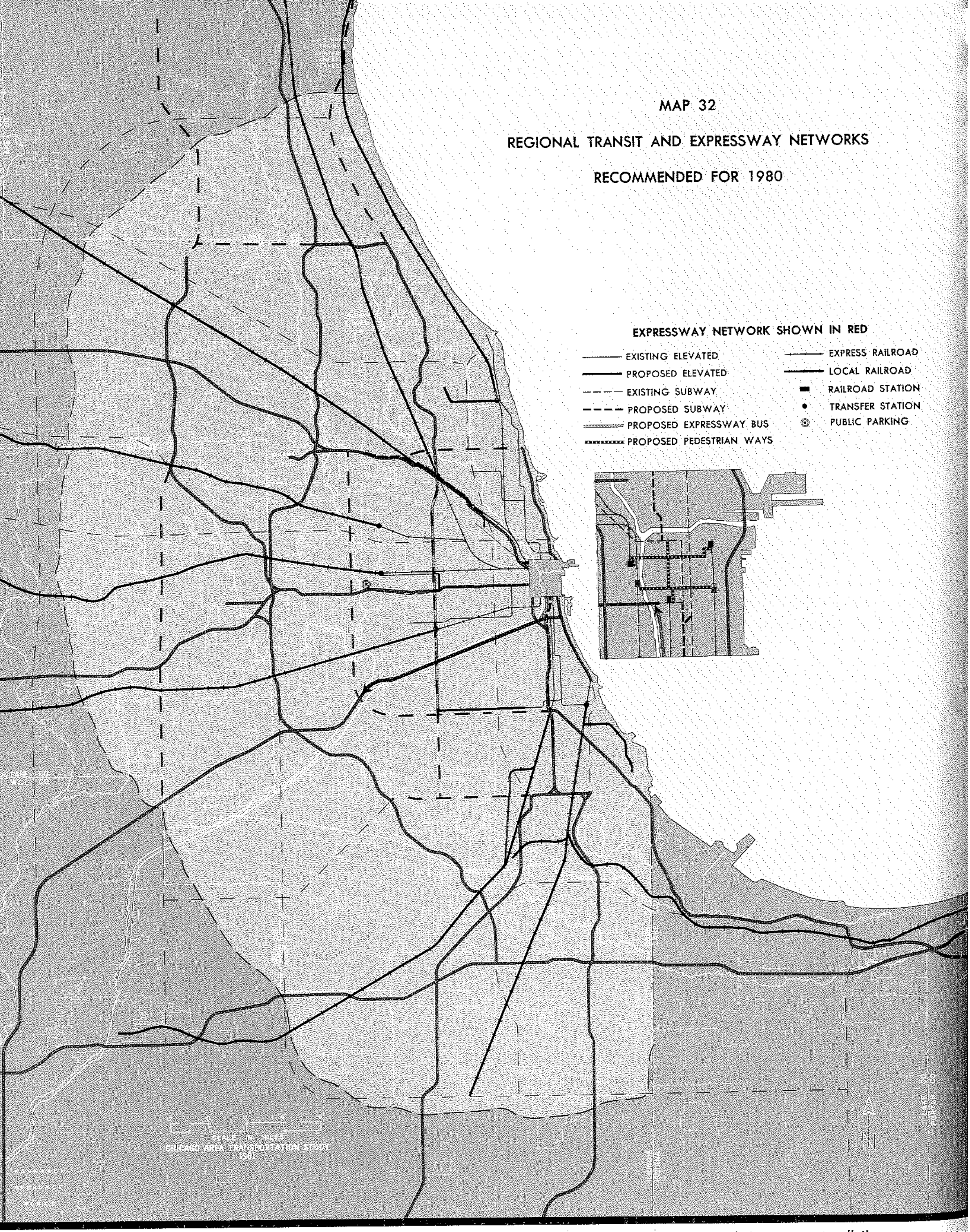
Transit improvements are not so large, but they should be accomplished as quickly as possible. Highway improvements are of substantial magnitude and should be programmed steadily over the next twenty years.

Effective advance planning requires that laws be modified to permit communities to make firm plans for the locations of new highways. First, they should be able to designate general alignments. Second, they should be permitted to buy rights-of-way as far in advance of construction as the public interest dictates. Finally, revolving funds should be authorized for this purpose.

Highway plans can be sequenced in a fashion best calculated to benefit the vehicle driving public. Proposals for a three stage set of priorities have been recorded and mapped.

Financing is in sight for highways. User revenues for highway purposes are growing, but so are needs. Each year there are more vehicles and more miles are driven. A projection of revenues suggests that there will be enough money available to finance the highway proposals provided: 1) that construction proportions spent in the Study Area remain the same as at present; 2) that costs of construction don't rise; 3) that the Chicago region maintains its current share of State collected highway moneys.

The financial tests of the plans show them to be within the scale of community capability. They represent a realistically set and achievable target for combined governmental action.



The rail facilities are generally designed to serve radial travelers, whereas the expressway network interconnects all the noncentral parts of the region. This basic system should serve thru the 1980's and beyond, for it is scaled to a thoroughly

Chapter VII

CONCLUSION

This report has been concerned with planning for the future. The investments in roads and in other transportation facilities for the metropolitan region must, as year upon year of work is completed, gradually approach a goal. What is the goal? What will the region become after a generation of building? This has been the subject matter of this volume.

No government, business, or family can best organize its efforts so as to build progressively towards a desired result unless they plan. The same truth applies to the construction of transportation facilities in a huge metropolitan region.

But in a metropolitan region, plans must be widely known and accepted. If one man starts to build, he may carry the plans in his head. Building in a metropolitan region, by contrast, is accomplished by many different groups. The cities, the counties, public authorities, private companies—each and all can build and maintain transportation facilities. To realize the most from these separate efforts, each builder must know what the total plan is and how his work will best fit. It is through comprehensive plans that these many forms of investment can be compiled and interlocked to produce integrated and complete systems.

There are many transportation agencies in the Chicago metropolitan region. Moreover, each agency—public and private—has its particular goals. For railroads, the objective may be, among other things, profits; for the city, to serve local taxpayers; or, for the federal government, to aid state and local governments in achieving an interstate network. How will each of these particular goals affect the growth and health of the greater metropolitan community? Without a community plan—the work of each, in seeking its particular objective, might not fit with the work of others. It has been amply demonstrated that the metropolitan community functions as a single, large, social system. Daily, the residents of one city travel to work in others. Sales and service activities are not neatly circumscribed by political boundaries. The processes of buying, selling, trading and communicating cannot be so contained. Chicago, for example, may provide an airport or lakeport designed to serve not only Chicago, but the entire metropolitan hinterland. So, in terms of transportation facilities, it becomes clear that plans must be aimed at the goals best calculated to serve the greater metropolitan community. Within this framework, the preferences of the individual political jurisdictions and the other private and public agencies must be recognized.

It is the object of this report to set forth the regional designs for highway and for rail transportation facilities. This regional scale has been adhered to. In a geographic sense, the scale has been regional—avoiding the specific problems of route locations. In a jurisdictional sense—the scale has been broad, avoiding details of specific responsibility and cost allocation. These more specific questions are undeniably among the most difficult problems that will have to be faced by public and private officials. Yet it is clear, too, that such specific questions are in the province of particular decision makers. This report, in centering on larger scale problems, emphasizes the interests of the larger community so the over-all regional needs can be understood. This establishes a frame for the metropolitan system and provides the boundary conditions within which the more specific and local decisions can be made.

To make plans, it is important to have a solid understanding of the present and a careful estimate of the future. These foundation blocks were provided by detailed studies of present conditions as reported in Volume I, and by measured estimates of community growth and change reported in Volume II. These were studies of the metropolitan anatomy, particularly of its circulation system. The travelers, the sources of travel, and the channels for travel—all were examined. Projections were made as to how each of these elements would look by 1980. These projected new dimensions were developed by considering the economic and population forces, together with the official plans and goals of the several governments of the region.

Greater metropolitan Chicago will continue to grow. The combination of steady national increase of births over deaths and the national tendency to migrate into metropolitan areas from rural places should conspire to increase the population within the Study Area to 7.8 million by 1980.

Not only will there be more people but there is every evidence that average family income will be higher. Rising family income in all income classes brings about shifts in the patterns of living and traveling. More growth will enlarge the community and the land area devoted to urban uses. Greater wealth is expected to magnify this tendency by producing greater quantities of land used per urban person. Living and working at lower densities have been traditional by-products of greater real income. While consumer preferences could suddenly vary from the pattern of past choices, it is most reasonable to expect greater purchasing power to continue to be expressed in home ownership and, therefore, more single family houses.

More people, naturally, mean greater travel requirements. But once again many aspects of these greater travel demands change as incomes rise. Home ownership and low density dwelling are characteristically found at the outer perimeter of urban growth where new housing and other building are reflecting the current dwelling preferences of the growing community. Lower density development means both more difficulty in supplying transit services because of the more sparsely populated trade area and a correspondingly greater tendency to own and drive private cars. So the growth in people produces growth in travel, but with greatest increases in usage of private passenger cars.

The projected shift of emphasis towards private rather than public transport is associated with the shifts to privately owned homes and towards more extensive suburban growth. These expected shifts in consumer demand provide one of the basic problems for transportation planning—how can this huge metropolitan region best adjust to these changing requirements? For a healthy, competitive region, adjustments must be planned so as to accommodate these new patterns of demand. And this is the key policy underlying the plan that is recommended; i.e., to bring about changes in the supply and character of regional transportation facilities so as to be in better balance with emerging future requirements.

The philosophy of plan-making is to accept the new growth as a challenging opportunity to enlarge and modernize the metropolitan transport system. Without the driving force of growth, metropolitan regions can lapse into slow aging—but with the challenge of growth it is possible to improve the environment by adding more efficient facilities. In this way the existing supply of facilities becomes more modern as the older parts that are wearing out are replaced with newer, safer, and more efficient elements.

The strategic elements of plan-making have consisted of (1) enlarging the capacity to serve the automotive vehicles—cars, buses, trucks, and taxis; (2) devising ways to improve the specialized rail transit services to the central business district; and (3) finding how best to interlock and coordinate a more specialized set of facilities so that each is working with the other and needless duplication is omitted.

The transit facilities of the region are largely an inheritance from past eras of building. The more mature and stable passenger estimates of the future call for consolidation and coordination. In accordance with the emphasis of Chicago on growth and on improvement of its Central Area, the railroads and rapid transit facilities must be geared to do the bulk job of delivering the people to man the offices and purchase the goods and services in this large Central Area. Their emphasis must be radial—aiming at the center.

In contrast, the bulk job of serving local trips (those with neither terminal in the Central Area) will continue to befall the private passenger car. Bus lines must make constant readjustment to the advantages provided by improved highways. The highway network is designed to interconnect the fast growing suburbs with all parts of Chicago and also with one another. The dominance of vehicular travel outside of the Central Business District is being met by selective investment in new expressways. These new facilities relieve the fast congesting arterial streets and step up the speed of interchange. Such specialization of highway types increases safety and economy as well as speed. Of particular importance, the traffic relief accorded to surface streets helps to keep non-local vehicles out of neighborhood areas. Through traffic can be handled on the fewer main surface arterials and this assists in the development and redevelopment of healthy neighborhoods. Elimination of unnecessary through traffic also can assist in the upgrading of commercial and shopping areas.

By emphasizing rail service to the center and by providing completely grade-separated networks of expressways to interconnect all noncentral parts of the region, the plan encourages a readjustment of transportation facilities towards a new and different set of regional travel demands. Long journeys are separated from short ones and more efficient specialization of types is encouraged.

The demands of travelers and the public works needed to stay abreast of these demands will be expensive. The full program is estimated to cost almost $2.2 billion in 1960 dollars. Yet, it has always been characteristic of the Chicago region that each generation has solved larger problems than its predecessors. The size of the program seen through the eyes of the 1980 resident will naturally seem to be more nearly at the right scale than it does to today's citizen. And when it is recognized that the program will take 20-25 years to complete, the task once more becomes manageable.

As was stated, the plan calls for much work and public investment. Perhaps the most delicate aspect of plan evaluation is to try to assess how much should be planned and spent. Too little in the way of improvements and the traveler pays directly through accidents or indirectly in lost time and convenience. Too big a program and there are more facilities than the people can afford—i.e., the system becomes a luxurious one. This problem was balanced back and forth. Larger plans were tried and evaluated and so were lesser ones. The recommended one, in terms of measurable criteria, is best. If less were done, the costs of congestion, accidents and time would be greater. If more were done, some of the investments would be idle or too lightly used to justify the investment.

As different plans have been drawn and tested, many methods, never before available to transportation planners, have been employed. This has been possible because of the very great capacity of today's high speed computer and because of new knowledge about the behavior of people in large urban complexes. Moreover, the reasoning that has, step by step, culminated in a particular recommendation has been disclosed in the three volume report. The four steps of sound planning—i.e., to observe, to analyze, to project and to test—have been followed.

This is a technical report. It represents what seems reasonably called for in light of existing conditions and of expected future growth. Yet, it also is clear that the measurements of costs, of benefits, and of future travel are all subject to variation. Moreover, a technical report must concern itself with visible and measurable phenomena. It cannot, for example, reflect all of the human and political considerations which must be fitted into the decisions of the responsible governmental leaders. So, this is a staff report—that is, it is prepared as a technical recommendation to the governmental officials of the region.

Continuing Review

Recognizing that much review and evaluation will be undertaken by the administrative and legislative leaders of the governments concerned, steps have been taken to maintain the data inventory and the technical means to assist in this process of review. The wealth of information obtained in surveys can be kept current through periodic review, special sampling, use of new aerial photos, or official census data. Such continuing measurements will insure that the true growth and the projected growth are not in different directions. In addition, steps have been taken to retain sufficient technical staff to provide such further research and testing as may be wanted by reviewing agencies. So this is not just a proposed plan but rather evidence of a living document —subject to change as more information becomes available and as public decisions gradually translate recommendations into specific public policy.

As this great metropolitan region prepares for the next generation of growth, the forethought of plans and the improved supply of information provide the means for solid building. With common information and objectives, the several governments will coordinate their capital improvements programs. Such coordination consists of working together as between jurisdictions and, also, working in a coordinated fashion within each jurisdiction. Certainly the fashioning of transportation plans and renewal plans will allow close cooperation of both programs in space and in time. In this way, the tax dollar is made to go further and the continuing task of creating a more satisfactory environment is bound to be more effectively carried out.

Appendix

DERIVATION OF FORMULA FOR OPTIMUM EXPRESSWAY SPACING

An optimum set of expressways may be stated to be that system which yields the greatest benefits. A particularly simple definition of the maximum benefit system follows from the point of view that travel is always an expense both to perform and to construct facilities for, but that this expense is fundamentally inescapable: the maximum benefit system, then, is just that system which minimizes the total cost due to traveling. If costs are restricted to economic costs—to items that can be priced (that is, made commensurable and additive)—the total cost of constructing and using a street system can, in principle, be written as a function of street performance and location, and the minimizing conditions determined.

Of course, this problem cannot be solved with real exactness or generality. However, an approximate solution can be rather easily developed for the simplified situation of an unlimited region of uniform properties. The region contains a regular grid of local streets and a regular grid of arterial streets, both networks fixed and not subject to change. If an overlaid grid of expressways is being considered, the critical parameter is the grid interval, or spacing, of expressways that will minimize the sum of the construction and travel costs. The total cost, C, can immediately be set down in the form

$$C = C_1 + C_2, \qquad [1]$$

where C_1 is the cost of constructing the expressway system and C_2 is the cost of travel in the entire street system. If C_1 and C_2 can be expressed as functions of the expressway spacing, the problem is the straightforward one of solving for that spacing at which the derivative of C goes to zero.

Since the region is uniform—the density of trip origins and the behavior of trips is everywhere the same—there is no reason for one piece of expressway to be different from another, so construction costs are simply proportional to the lineal miles constructed, while the number of miles is determined by the spacing. Visualizing a grid within a square and adding up the length of all grid lines gives

$$C_1 = 2c\frac{L^2}{Z}; \qquad [2]$$

c is the construction cost per mile
L is the side of the region
Z is the expressway spacing
(the border line is negligible when the region is large).

The travel costs, C_2, are more complicated. Consider first only those trips which are too short to use any but local streets. Their total travel cost will be the sum of their lengths times the cost per mile of traveling on local streets:

$$\rho L^2 \int_O^A K_a r F dr; \qquad [3]$$

ρ is the density of trip origins in the region.
K_a is the cost per vehicle mile on local streets —it may include fuel consumption, vehicle depreciation, accident expectancy, and so on, but its major component is in the value of time to the driver and passengers.
F is the distribution of trips with respect to length: $F = \frac{dn}{dr}$; it must be assumed that the expressway system will not appreciably deform this distribution.

The limit of integration, A, is the longest distance for which it is not worthwhile to use any street higher than local. This really depends on the exact placement of a trip's origin and destination, and properly there should be another integration over the distribution of trip end locations. But treating all trips as though they had some average end points does little violence, within the precision of the whole technique.

The travel cost of trips longer than A, but still not long enough to use expressways, is similar, except that part of their distance will be spent on local streets and only the remainder will lie on arterials:

$$\rho L^2 \int_A^B [K_a A + K_b (r - A)] F dr. \qquad [4]$$

The remaining trips are those long enough to use expressways; that is, longer than B. Their cost is quite analogous, so the total travel cost in the region is

$$C_2 = \rho L^2 \left[\int_O^A K_a r F dr + \int_A^B [K_a A + K_b (r - A)] F dr + \int_B^{\infty} [K_a A + K_b (B - A) + K_c (r - B)] F dr \right]. \quad [5]$$

C_2 is now a function of the limits of integration. But of these, only B—the average distance used for access to and from the expressway system—depends on the expressway spacing. Since C is to be differentiated with respect to spacing, all terms not containing B may be neglected. Adopting the definitions

$$\int rFdr = R \quad \text{and} \quad \int Fdr = G, \quad [6]$$

and dropping terms extraneous to the differentiation, C_2 may be notationally transformed for clarity to

$$\rho L^2 \big[K_a AG(B) + K_b R(B) - K_b AG(B) - K_a AG(B) + K_b BG(\infty) - K_b BG(B) + K_b AG(B) - K_c R(B) - K_c BG(\infty) + K_c BG(B) \big]; \quad [7]$$

or, collecting terms,

$$\rho L^2 (K_b - K_c) [R(B) + BG(\infty) - BG(B)]. \quad [8]$$

Differentiating this is just a matter of referring to definitions [6]:

$$\frac{dC_2}{dZ} = \frac{dC_2}{dB} \frac{dB}{dZ}$$

$$= \rho L^2 \frac{dB}{dZ} (K_b - K_c) \left[BF(B) + G(\infty) - G(B) - BF(B) \right]$$

$$= \rho L^2 \frac{dB}{dZ} (K_b - K_c) \left[G(\infty) - G(B) \right]. \quad [9]$$

The quantity $[G(\infty) - G(B)]$ is the proportion of trips that are longer than B, and might as well be called $P(B)$. Adding in the derivative of C_1 gives

$$\frac{dC}{dZ} = \rho L^2 \frac{dB}{dZ} (K_b - K_c) P(B) - 2L^2 \frac{c}{Z^2}. \quad [10]$$

Setting this equal to zero and solving for Z results, finally, in the minimum cost spacing:

$$Z = \sqrt{\frac{2c}{\rho (K_b - K_c) \frac{dB}{dZ} P(B)}}. \quad [11]$$

At this point, the value of B becomes an issue. B can be estimated by examining access patterns to the expressway system from randomly located trip ends. An approximation is[1]

$$B = \frac{2.4}{6} (2Y + Z), \quad [12]$$

where Y is the spacing of ramps. The value of $\frac{dB}{dZ}$ may be taken, then, to be 4/10. On the matter of precision of this and the other quantities in the calculation, there is some comfort in the spacing's being sensitive only to the square root of these parameters.

Withdrawing the stable constants leaves

$$Z = 2.24 \sqrt{\frac{c}{\rho (K_b - K_c) P(B)}}. \quad [13]$$

This is not a perfect solution, since $P(B)$ is itself a function of Z. However, for any particular trip length distribution Z can be fixed by algebraic solution or, if that is impossible, by iteration. One realistic distribution function, for example, is

$$F = \frac{1}{7} e^{-r/7}. \quad [14]$$

For this distribution,

$$P(B) = e^{-B/7}, \quad [15]$$

or, referring to [12] and adopting a ramp spacing of one mile,

$$P(B) = e^{-(.8 + .4Z)/7} = .89e^{-.057Z}. \quad [16]$$

To fill in the other constants, assume that a vehicle mile of travel on arterial streets costs \$.06 more than on expressways, that the trip origin density is 20,000 per day per square mile, and that expressway construction cost is \$6 million per mile; the travel and construction costs, of course, must be put in the same units—either the daily travel cost must be capitalized to a fixed investment or the construction cost must be reduced to the daily charge on a \$6 million bond. When all the calculations are made (using an interest rate of ten per cent and neglecting depreciation), [13] becomes

$$Z = 2.78e^{.0285Z}, \quad [17]$$

[1]See Creighton, *et al.*, *op.cit.*, pp. 6-13. The symbol B, here, corresponds to $2(A + B)$ in that text.

which must be solved by some numerical method. In this case, a set of intuitive trials is about as convenient as anything else—in fact, the obvious first trial, $Z = 3$, turns out to be quite close enough. Even if the trip length distribution exists only as a graphed curve or a frequency table, relation [13] holds and can be solved numerically.

Although [13] is solvable in principle, it is entirely possible that no real and positive value of Z will satisfy it. In the above example, for instance, if expressways were a hundred times more expensive to build, they would not be worth building at all because [17] would then be

$$Z = 27.8e^{.0285Z}, \qquad [18]$$

and no value of Z can satisfy that. Also, there is no guarantee that [13] will yield a minimum. The root of the equation might be at a maximum, or there might be more than one root. Indeed, equation [17] in the example is satisfied at another value of Z, i.e., 137 miles. The test is to insert the extremal value of Z into this expression:

$$\frac{2P(B)}{Z} - \frac{dB}{dZ}F(B); \qquad [19]$$

if the resulting quantity is positive the extremum is a minimum, if negative, a maximum. (Expression [19] is the result of differentiating [10] assuming $\frac{dB}{dZ}$ to be constant, and separating out coefficient terms that are always positive by definition.) Unsurprisingly, the test shows, for the example, that $Z = 3$ gives a minimum and $Z = 137$ a maximum.

Because the travel costs on the three street types (K_a, K_b, and K_c) are regarded as constant, and because the estimate of B disregards fine considerations of performance, this analysis ignores effects of congestion and street capacity. Or, rather, it may be said to assume that all streets are designed to handle without much strain the volumes falling on them under an optimum spacing of expressways. As the calculations turn out, this is quite a reasonable assumption, consistent with conventional design standards. Attempts to correct [13] for congestion tend to decrease the spacing somewhat, but not enough to have any real planning significance.

The tendencies of equation [11] are interesting because they are so intuitively correct. As the construction cost grows large, or trip density small, or the travel cost advantage of expressways small, or the trip distribution poor in long trips, the optimum spacing grows large or fails to exist at all—fewer and fewer expressways can be economically justified. But if expressways become cheap to build, or if their cost advantage is great, or so forth, the spacing decreases—i.e., more expressways become profitable.

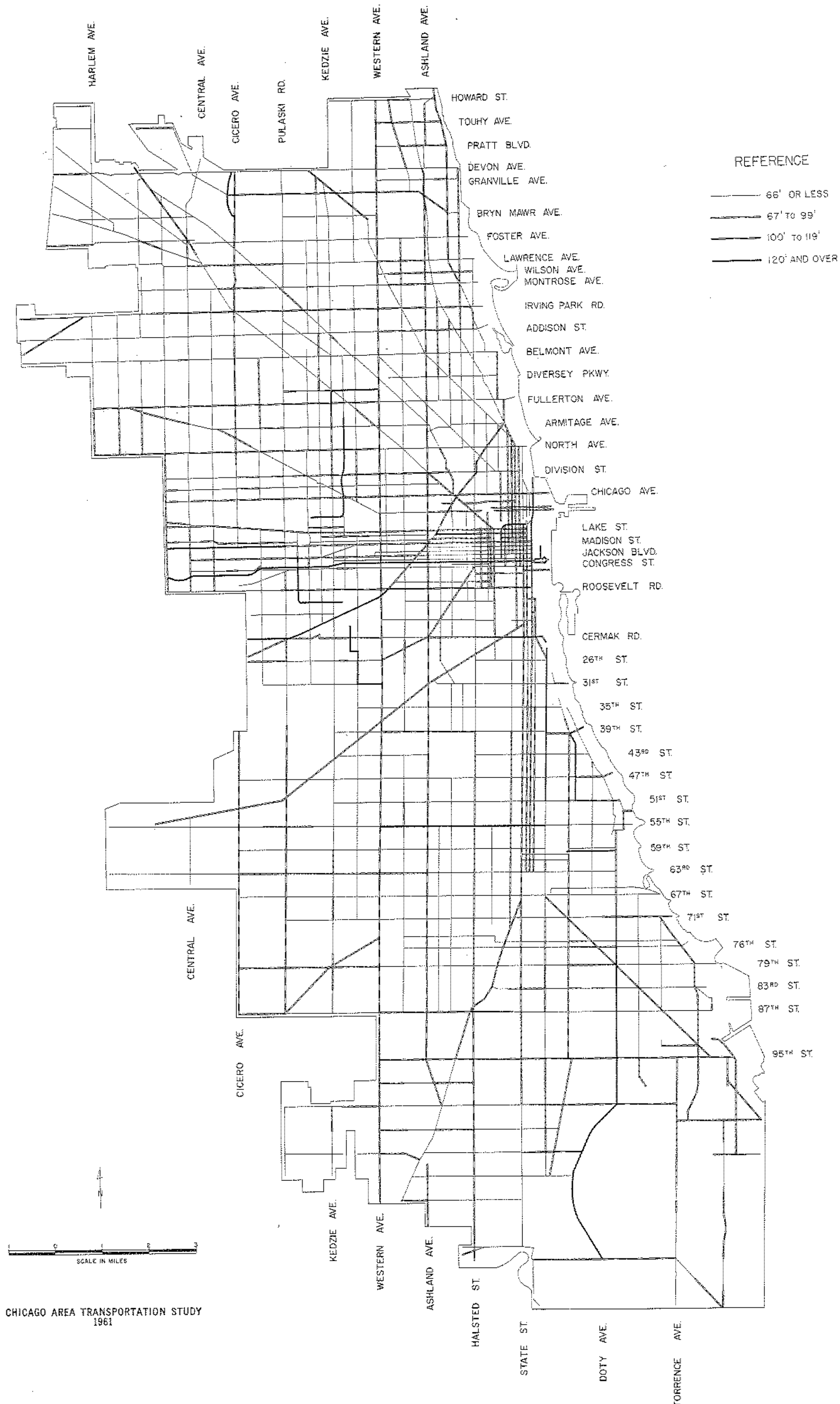
These tendencies may be delimited a bit more by observing that construction and travel costs are generally related to the trip origin density in the region. In the Chicago area, construction costs (in dollars) roughly follow the relation

$$c = 520\rho + 1{,}120{,}000. \qquad [20]$$

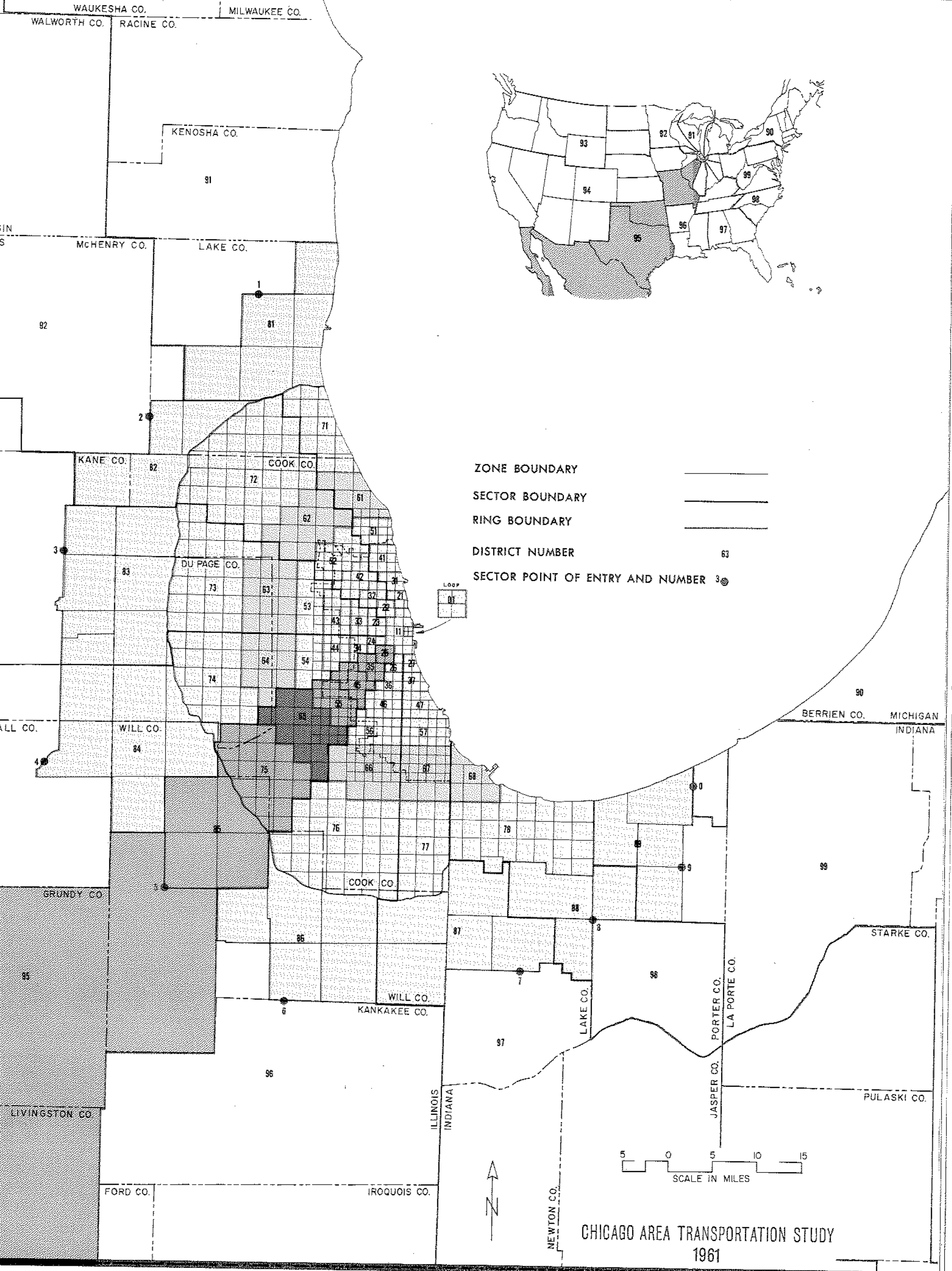
Putting this into [13] gives

$$Z = 2.24\sqrt{\frac{520}{(K_b - K_c)\,P(B)} + \frac{1{,}120{,}000}{\rho(K_b - K_c)\,P(B)}}. \qquad [21]$$

Although the second term under the radical disappears as the density grows very large, the first term does not—the spacing does not go to zero at infinite density but takes as a limit the value given by the first term. As the density increases, the travel cost difference between expressways and arterials goes up to a high in the neighborhood of twelve cents a vehicle mile or more. This implies a least spacing, no matter how great the density, of something like three miles.



MAP 33—RIGHT-OF-WAY STREET WIDTHS FOR MAJOR ARTERIALS IN CHICAGO



MAP 34—ANALYSIS ZONES, RINGS, SECTORS AND DISTRICTS

TABLE 23
VALUES OF PASSENGER CAR AND TRUCK TIMES AS REPORTED IN VARIOUS STUDIES

Study of Travel Time	Value of Time in Dollars/Hour	
	Per Automobile	Per Truck
Maine Turnpike	$2.45	
Pennsylvania Turnpike as reported in G. P. St. Clair and Nathan Liederer, "Evaluation of Unit Cost of Time and Strain-and-Discomfort Cost of Non-Uniform Driving," Highway Research Board Special Report 56, Washington, D.C.: 1960.	1.14	
Paul J. Claffey, "Characteristics of Passenger Car Travel on Toll Roads and Comparable Free Roads for Highway User Benefit Studies," Highway Research Board, Washington, D.C.: January, 1961.	1.42	
American Association of State Highway Officials, "Report on Road User Benefit Analyses for Highway Improvements," Washington, D.C.: 1960.	1.55	
Lawrence Lawton, "Evaluating Highway Improvements on Mileage-and-Time-Cost Basis," Eno Foundation, *Traffic Quarterly*, Saugatuck, Conn.: January, 1950.	1.10	Light 1.89 Medium 3.24 Heavy 5.43

TABLE 24
ACCIDENTS RELATED TO TRAFFIC VOLUME BY TIME OF DAY FOR NINE ARTERIAL STREETS IN CHICAGO,* 1958

Time	Mean Number Of Accidents	Mean Hourly Volume
Morning Hours		
4 AM— 5 AM	18	169
5 AM— 6 AM	18	341
6 AM— 7 AM	35	1,053
7 AM— 8 AM	82	1,736
8 AM— 9 AM	69	1,479
9 AM—10 AM	58	1,156
10 AM—11 AM	63	1,089
11 AM—12 N	81	1,096
Afternoon And Evening Hours		
12 N — 1 PM	73	1,087
1 PM— 2 PM	77	1,098
2 PM— 3 PM	88	1,243
3 PM— 4 PM	106	1,404
4 PM— 5 PM	128	1,701
5 PM— 6 PM	123	1,688
6 PM— 7 PM	92	1,332
7 PM— 8 PM	80	1,147
8 PM— 9 PM	72	964
9 PM—10 PM	61	885
10 PM—11 PM	53	719
11 PM—12 M	48	618
12 AM— 1 AM	44	472
1 AM— 2 AM	36	287
2 AM— 3 AM	31	190
3 AM— 4 AM	24	143

*Ashland, Belmont, Cicero, Irving Park, Kostner, Laramie, 63rd, Stony Island, Western.
Source: Chicago Police Department accident card file for 1958, and City of Chicago and State of Illinois traffic counts.

TABLE 25
AUTOMOBILE OPERATING COSTS AT VARIOUS SPEEDS
(In cents per vehicle mile)

Average Speed	Operating
05	4.80
06	4.52
07	4.29
08	4.08
09	3.88
10	3.69
11	3.53
12	3.39
13	3.29
14	3.19
15	3.10
16	3.01
17	2.93
18	2.88
19	2.83
20	2.78
21	2.73
22	2.69
23	2.65
24	2.61
25	2.57
26	2.53
27	2.50
28	2.47
29	2.44
30	2.41
31	2.40
32	2.39
33	2.38
34	2.37
35	2.36
36	2.35
37	2.34
38	2.33
39	2.33
40	2.32
41	2.37
42	2.42
43	2.47
44	2.52
45	2.57
46	2.62
47	2.67
48	2.72
49	2.77
50	2.82
51	2.87
52	2.92
53	2.97
54	3.02
55	3.08
56	3.13
57	3.18
58	3.23
59	3.29
60	3.35
61	3.41
62	3.47
63	3.53
64	3.59
65	3.65

Source: Haikalis, George and Hyman Joseph, "Economic Evaluation of Traffic Networks," a paper presented before the 40th Annual Meeting of the Highway Research Board, Washington, D.C., January, 1961.

TABLE 26
COST OF TRAVEL RELATED TO VOLUME, BY TYPE OF STREET
(Volume in 2-way average daily travel vehicle equivalents and cost in cents per equivalent vehicle mile)

Volume	Average Travel Cost	Average Total Cost
Local Street		
0—5,000	13.94	13.94
Arterial Street		
9,800	10.08	10.08
13,400	10.55	10.55
16,100	10.99	10.99
17,600	11.47	11.47
18,900	11.98	11.98
20,000	12.48	12.48
Improved Arterial Street		
5,000	9.00	12.08
10,000	9.00	10.54
12,300	9.00	10.25
16,800	9.40	10.32
20,100	9.81	10.58
22,100	10.44	11.14
23,600	10.88	11.53
25,000	11.37	11.99
27,500	12.17	12.73
29,100	13.17	13.70
mproved Arterial With hrough-Lane Overpasses		
15,000	8.56	14.24
17,200	8.56	13.51
23,600	9.00	12.61
28,300	9.34	12.35
31,000	9.69	12.42
33,200	10.09	12.66
35,200	10.50	12.92
38,600	11.31	13.52
40,800	11.99	14.08
43,100	12.67	14.65
ut-Back Expressway		
30,000	6.31	16.32
40,000	6.32	13.83
50,000	6.35	12.35
60,000	6.39	11.39
70,000	6.43	10.72
80,000	6.58	10.33
90,000	6.80	10.14
00,000	7.07	10.07
10,000	7.51	10.24
-Lane Expressway		
40,000	6.06	15.80
60,000	6.07	12.58
80,000	6.08	10.93
00,000	6.11	10.00
20,000	6.13	9.38
40,000	6.14	8.92
60,000	6.18	8.61
80,000	6.27	8.43
00,000	6.38	8.33
20,000	6.64	8.41

sed on: Haikalis, George, and E. Wilson Campbell, "Quality of Traffic Service—Basis for Highway Design Selection," a paper presented before the 41st Annual eeting of the Highway Research Board, Washington, D.C., January, 1962.

TABLE 27
DISTRIBUTION OF TRIPS AND VEHICLE MILES OF TRAVEL BY RIGHT ANGLE TRIP LENGTH, TRUCKS WEIGHTED, CHICAGO AREA, 1956

Right Angle Trip Length	Percentage of All Vehicle Trips	Percentage of All Vehicle Miles of Travel
0	15.2	1.4
1	20.2	5.5
2	14.0	6.4
3	9.3	6.0
4	6.3	5.2
5	5.4	5.5
6	4.9	5.9
7	4.1	5.6
8	3.0	4.7
9	2.6	4.6
10	2.1	4.1
11	1.9	3.9
12	1.6	3.6
13	1.3	3.2
14	.9	2.4
15	.7	2.1
16	.7	2.2
17	.6	2.0
18	.6	2.1
19	.6	2.1
20+	4.0	21.5
Total	100.0	100.0

Note: Right angle trip length is the length each trip would have to travel if it could proceed only by way of a gridiron street system.

TABLE 28
COMPARISON OF THE NUMBER OF REPORTED MOTOR VEHICLE TRAFFIC ACCIDENTS ON SELECTED ARTERIALS BEFORE AND AFTER THE CONGRESS STREET EXPRESSWAY WAS OPENED

Street	Total Accidents In 1955	Total Accidents In 1958	Per Cent Reduction In Accidents
Augusta	457	362	—20.8
Fullerton	162	170	+ 4.9
Jackson	955	652	—31.7
Roosevelt	79	59	—25.3
Warren	318	193	—39.3
Washington	925	578	—37.5
Oakley	279	160	—42.6
Hamlin	99	81	—19.2
Total	3,274	2,255	—31.1

Note: Figures for Roosevelt, Fullerton, Hamlin and Oakley represent only the portion of each of these streets under Park District jurisdiction.
Source: Park District Monthly Summaries of Accidents for 1955 and 1958.

TABLE 29

ECONOMIC EVALUATION OF SEVERAL PLANS

(for a typical weekday in 1980)

Plan	Miles Of Expressways	Daily Investment Cost	Daily Travel Cost[b]	Total Daily Cost
A	288	$ 294,336	$6,176,571	$6,470,907
B	327	413,421	5,837,186	6,250,607
K	466	583,137	5,490,484	6,073,621
L-3	520	651,125	5,377,430	6,028,555
I	681	797,313	5,259,538	6,056,851
J	968[a]	$1,031,929	$5,292,077	$6,324,006

[a]Includes 656 miles of intermediate facilities; see Chapter III for definition of intermediate facility.
[b]Estimated from various assignments. Includes operating, accident and time costs.
Note: The data in this table and in Tables 30 and 31 below were taken from Haikalis, George, *An Economic Evaluation of Roadway Improvements* (36,500), (Chicago: CATS, 1962).

TABLE 30

COMPARISON OF EXPRESSWAY USAGE UNDER SIX DIFFERENT PLANS

Plan[a]	Total Vehicle Trips	Expressway Users	Per Cent Users	Total Vehicle Miles	Expressway Vehicle Miles	Per Cent Vehicle Miles
A	10,909,480	2,376,400	21.8	67,913,600	22,877,600	33.7
B	10,908,856	2,683,016	24.6	67,054,200	25,191,000	37.6
K	10,864,232	3,664,600	33.7	67,700,400	33,320,200	49.2
L-3	10,894,184	3,854,856	35.4	67,563,500	34,414,300	50.9
I	10,883,232	4,027,000	37.0	66,592,800	35,061,400	52.7
J	10,882,728	4,788,000	44.0	65,819,000	41,573,700[b]	63.2

[a]Restrained assignment results.
[b]Includes intermediate type facilities (21,750,000).

TABLE 31

CHARACTERISTICS OF PLANS A, B, I, J, K AND L-3

Characteristics	Plan A	Plan B	Plan I	Plan J	Plan K	Plan L-3
Miles of Unimproved Arterials	1,117	1,117	963	669	1,117	1,110
Miles of Improved Arterials	1,713	1,713	1,626	1,578	1,713	1,713
Miles of Intermediate Facilities	...	...	...	656	...	...
Miles of Expressways	288	327	681	312	466	520
Total Miles of Non-Local Roads	3,118	3,157	3,270	3,215	3,296	3,343
Cost of Improving Arterials (In Millions)	$360	$360	$341	$331	$360	$360
Cost of Intermediate Facilities (In Millions)	...	...	...	$1,978	...	...
Cost of Expressways (In Millions)	$547	$914	$2,116	$871	$1,437	$1,647
Total Cost (cost to complete after 1960) (In Millions)	$907	$1,274	$2,457	$3,180	$1,797	$2,007
Daily Time Spent in Travel (Vehicle-Equiv. Hours) (In Thousands)	2,420	2,256	1,937	1,990	2,049	1,990
Annual Fatalities	781	698	606	638	638	626
Number of Daily Traffic Accidents	504	450	346	416	378	359
Daily Vehicle Miles of Travel (In Thousands): Arterials*	45,036	41,863	31,531	24,245	34,380	33,149
Intermediate Facilities	...	...	...	21,750	...	...
Expressways	22,878	25,191	35,061	19,824	33,320	34,414
Total Daily Vehicle Miles of Travel (In Thousands)	67,914	67,054	66,593	65,819	67,700	67,563
Travel Costs in Cents Per User Mile	9.10	8.71	7.90	8.04	8.11	7.96
Capital Cost in Cents Per User Mile	.19	.62	1.20	1.57	0.86	0.96
Total Cost in Cents Per User Mile	9.29	9.33	9.10	9.61	8.97	8.92

*Includes travel on expressway ramps—a coding technicality.

TABLE 32

SOME HISTORICAL TRENDS OF TRANSIT USAGE AND AUTOMOBILE OWNERSHIP IN THE CITY OF CHICAGO, 1901-1960

	A	B	C		
Year	Passenger Vehicles Registered	Population	Annual Revenue Riders On CTA Or Predecessor Companies* (In Millions)	Annual Riding Habit (C/B)	Annual Commuter Passengers On Suburban Railroads (In Millions)
1901	....	1,747,236	362.4	207	.....
1905	....	1,941,880	473.3	244	.....
1910	....	2,196,238	656.0	299	.....
1915	35,218	2,464,189	787.7	320	.....
1920	86,670	2,766,815	966.1	349	.....
1925	289,948	3,096,409	1,115.7	360	.....
1930	406,916	3,376,438	1,053.3	312	92.0
1935	397,023	3,386,623	835.4	247	62.6
1940	549,537	3,396,808	853.2	251	75.8
1945	427,779	3,508,884	1,080.6	308	120.3
1950	705,197	3,620,962	833.1	230	76.2
1955	831,418	3,585,684	624.5	174	68.5
1960	854,572	3,550,404	534.8	151	63.1

*Harrington, Kelker & De Leuw, *A Comprehensive Local Transportation Plan for the City of Chicago*, 1937, Table 16, p. 323, for years 1901-1930.
Chicago Transit Authority, for years 1935-1960.

TABLE 33

WEEKDAY INBOUND CENTRAL AREA TRAVELERS OF 1980 ASSIGNED TO RAIL FACILITIES FROM ONE SECTOR OF THE REGION*

Miles from CBD	On at Each Station	Cumulative
1	3,695	78,338
2	3,528	74,643
3	2,625	71,115
4	4,527	68,490
4.5	9,684	63,963
5	2,396	54,279
5.5	4,837	51,883
6	2,013	47,046
7	5,409	45,033
8	2,467	39,624
9	2,030	37,157
10	3,626	35,127
11	712	31,501
12	2,945	30,789
13	5,062	27,844
15	936	22,782
17	2,113	21,846
18	651	19,733
20	3,730	19,082
22	2,579	15,352
24	4,290	12,773
26	1,371	8,483
28	777	7,112
32 and over	6,335	6,335

*Approximates Sector 2, the Northwest Sector of the Study Area.
Derived from Black, Alan, "A Method for Determining the Optimal Division of Express and Local Rail Transit Service," a paper prepared for presentation before the Origin and Destination Surveys Committee at the annual meeting of the Highway Research Board, Washington, D.C., January 8, 1962.

TABLE 34

COMPUTATION OF ANNUAL COSTS FOR VARYING LOCATIONS OF BREAKPOINT BETWEEN LOCAL AND EXPRESS RAIL TRANSIT SERVICE IN ONE SECTOR OF THE REGION*
(in thousands of dollars)

Location of Breakpoint (Miles from CBD)	Construction Cost	Equipment Cost	Travel Cost	Total Costs
0	0	7,249	38,584	45,833
1	275	6,888	36,764	43,927
2	551	6,571	35,127	42,249
3	826	6,350	33,801	40,977
4	1,102	5,984	32,260	39,346
4.5	1,239	5,266	29,995	36,500
5	1,377	5,103	29,073	35,553
5.5	1,515	4,781	27,897	34,193
6	1,653	4,680	27,206	33,539
7	1,928	4,402	26,398	32,728
8	2,203	4,297	26,059	32,559
9	2,479	4,222	25,849	32,550
10	2,754	4,098	25,642	32,494
11	3,030	4,125	25,674	32,829
12	3,305	4,067	25,703	33,075
13	3,581	3,953	25,858	33,392
15	4,131	4,072	26,682	34,885
17	4,682	4,182	27,638	36,502
18	4,958	4,257	28,010	37,225
20	5,508	4,363	29,333	39,204
22	6,059	4,504	30,726	41,289
24	6,610	4,693	32,568	43,871
26	7,161	4,931	34,095	46,187
28	7,712	5,156	35,571	48,439
32	8,814	5,535	40,083	54,432

*Based on estimated 1980 rail transit travelers to the Central Area from the sector. The sector approximates Sector 2 of the Study Area.
Derived from Black, Alan, "A Method for Determining the Optimal Division of Express and Local Rail Transit Service," a paper prepared for presentation before the Origin and Destination Surveys Committee at the annual meeting of the Highway Research Board, Washington, D.C., January 8, 1962.

TABLE 35

TOTAL HIGHWAY, CONSTRUCTION AND EXPRESSWAY EXPENDITURES IN COOK AND DU PAGE COUNTIES BY ALL GOVERNMENTS, 1957-1959

Expenditure Purpose	1957	1958	1959	Three Year Average
Total Highway and Street Expenditures	$197,499,237	$253,388,052	$239,742,672	$230,209,987
Right-of-Way and Construction Expenditures	$112,240,688	$156,520,935	$141,858,476	$136,873,366
Expressway Right-of-Way and Construction Expenditures (Toll Facilities Not Included)	$ 78,498,133	$119,613,949	$105,108,074	$101,073,385

Source: Illinois Division of Highways, Bureau of Research and Planning, Local Finance Study and Status Report of Expenditures on Chicago Metropolitan Expressway System. Funds are assigned to the period of final expenditure.

TABLE 36

FUNDS EXPENDED FOR HIGHWAY PURPOSES IN THE CHICAGO AREA, 1959

Source	Expenditures By Government				
	Municipalities	Counties	Other Governments	Direct State Expenditures	Total
State Shared Moneys					
Motor Fuel Tax Allotments	$27,200,000	$16,000,000	$ 300,000	....	$ 43,500,000
Reimbursements for Construction	25,400,000	2,200,000	....	....	27,600,000
Debt Service	....	10,900,000	....	....	10,900,000
Division of Highways Expenditures	....	....	....	$49,900,000	49,900,000
Total Expenditures State Shared Moneys	$52,600,000	$29,100,000	$ 300,000	$49,900,000	$131,900,000
Local Revenues					
Vehicle Taxes	$25,100,000	....	....	....	$ 25,100,000
Property Tax and Other Revenue	9,000,000	$ 8,000,000	$13,500,000	....	30,500,000
Borrowings	13,000,000	39,200,000	....	....	52,200,000
Total Local Revenue Expenditures	$47,100,000	$47,200,000	$13,500,000	....	$107,800,000
Total Expenditures in Chicago Area	$99,700,000	$76,300,000	$13,800,000	$49,900,000	$239,700,000
Right-of-Way Construction Expenditures	$46,850,000	$49,000,000	$ 4,300,000	$41,650,000	$141,800,000

TABLE 37

HIGHWAY, STREET, AND RELATED EXPENDITURES IN COOK AND DU PAGE COUNTIES (1957-1959)
(Cost in Dollars)

	State	Counties	Townships	Cities	Chicago Skyway	Special Districts	Total
1957							
Right-of-Way	9,709,828	16,072,813	....	2,126,335	1,461,323	....	29,370,299
Construction	16,132,696	8,709,700	183,157	15,311,876	40,984,330	1,548,630	82,870,389
Maintenance	2,926,878	1,818,757	1,124,372	9,781,556	....	834,981	16,486,544
Equipment	....	188,071	131,932	936,468	....	335,504	1,591,975
Engineering	645,308	5,597,146	7,848	2,417,911	1,622,319	....	10,290,532
Administration	2,217,700	2,260,746	151,430	13,027,049	....	840,420	18,497,345
Debt Service	....	8,627,252	18,272	8,134,298	3,254,375	1,278,000	21,312,197
Transfers, Others[a]	....	....	1,847	15,110,206	....	1,967,903	17,079,956
Total[b]	31,632,410	43,274,485	1,618,858	66,845,699	47,322,347	6,805,438	197,499,237
1958							
Right-of-Way	22,008,038	15,855,508	....	6,706,377	792,472	....	45,362,395
Construction	38,718,154	22,393,477	272,246	24,900,209	23,866,581	1,007,873	111,158,540
Maintenance	3,079,567	1,852,770	1,334,198	10,855,315	33,952	636,084	17,791,886
Equipment	....	313,208	146,994	828,368	....	277,500	1,566,070
Engineering	1,548,726	6,980,969	14,239	3,527,530	915,829	....	12,987,293
Administration	2,638,000	2,411,719	157,583	14,332,544	463,026	3,062,589	23,065,461
Debt Service	....	9,363,654	19,944	8,216,445	3,538,750	1,467,000	22,605,793
Transfers, Others[a]	....	....	....	14,045,680	....	4,804,934	18,850,614
Total[b]	67,992,485	59,171,305	1,945,204	83,412,468	29,610,610	11,255,980	253,388,052
1959							
Right-of-Way	14,862,249	9,402,435	....	7,957,767	....	....	32,222,451
Construction	54,193,189	37,627,179	442,012	13,498,967	3,220,433	654,245	109,636,025
Maintenance	3,255,261	2,505,249	1,206,661	11,524,071	520,989	290,137	19,302,368
Equipment	....	376,191	256,143	1,043,825	....	70,548	1,746,707
Engineering	2,167,728	7,518,788	8,067	3,359,073	97,766	....	13,151,422
Administration	3,039,800	2,258,560	188,241	14,897,182	196,009	74,759	20,654,551
Debt Service	....	14,415,911	92,603	9,387,377	3,538,750	1,771,048	29,205,689
Transfers, Others[a]	....	....	....	12,645,531	....	1,177,928	13,823,459
Total[b]	77,518,227	74,104,313	2,193,727	74,313,793	7,573,947	4,038,665	239,742,672

Source: Illinois Division of Highways, Bureau of Research and Planning.

[a] Transfers are those amounts which have transferred to general city funds, others contain tree trimming, snow removal and other miscellaneous activities.

[b] In addition, municipalities expended $27,086,252 in 1957, $36,131,895 in 1958, and $33,501,957 in 1959 for allied street functions which included parking facilities, street cleaning, lighting, etc.

TABLE 38

HISTORICAL AND PROJECTED STATE REVENUES FROM HIGHWAY USERS, BY MAJOR CLASSIFICATION, 1940-1980

Year	Motor Fuel Tax (000)	Registrations, Licenses, and Misc. (000)	Federal Aid (000)	Total (000)
Historical				
1940	$ 42,285	$ 24,068	$ 9,330	$ 75,683
1941	45,725	25,921	5,587	77,233
1942	40,668	26,474	3,970	71,112
1943	29,786	23,388	7,183	60,357
1944	29,491	22,613	2,718	54,822
1945	32,520	24,011	1,406	57,937
1946	43,779	26,058	2,754	72,591
1947	47,077	29,562	6,228	82,867
1948	52,659	33,618	14,828	101,105
1949	54,393	37,069	15,527	106,989
1950	61,182	40,984	14,685	116,851
1951	72,388	46,036	19,612	138,036
1952	87,942	64,779	27,656	180,377
1953	114,268	63,493	26,011	203,772
1954	116,492	67,735	27,030	211,257
1955	127,339	73,445	35,141	235,925
1956	130,321	79,397	32,446	242,164
1957	135,863	88,130	32,900	256,893
1958	139,159	93,724	107,089	339,972
1959	143,439	96,951	183,086	423,476
1960	145,928	99,998	186,893	432,819
Projected				
1961	$ 149,948	$ 101,407	$ 128,950	$ 380,305
1962	154,094	104,444	147,694	406,232
1963	158,366	107,616	165,432	431,414
1964	162,763	110,888	176,168	449,819
1965	167,287	114,257	181,236	462,780
1966	171,820	117,663	186,504	475,987
1967	176,361	121,092	191,772	489,225
1968	180,951	124,569	197,040	502,560
1969	185,589	128,097	197,040	510,726
1970	190,237	131,647	197,040	518,924
1971	195,012	135,316	190,982	521,310
1972	199,954	139,110	159,963	499,027
1973	205,104	143,063	164,083	512,250
1974	210,501	147,198	168,401	526,100
1975	216,187	151,544	172,950	540,681
1976	221,566	155,706	177,253	554,525
1977	226,955	159,895	181,564	568,414
1978	231,758	163,712	185,406	580,876
1979	234,779	166,348	187,823	588,950
1980	237,845	169,025	190,276	597,146
1961-1980	$3,877,077	$2,692,597	$3,547,577	$10,117,251

Source: Illinois Division of Highways, Bureau of Research and Planning, estimated receipts from motor fuel taxes, motor vehicle registration fees, miscellaneous sources and operators' and chauffeurs' fees to 1975. Study estimate 1976-1980.

Federal Aid estimates through 1971 were taken from Illinois Division of Highways, Bureau of Research and Planning, Manual of Highway Finance and Legislation Table L-4 Federal Aid Appropriations under the 1956, 1958, 1959, and 1960 Acts. 1972-1980 Federal Aid is assumed to be at the rate of four cents per gallon purchased.