HIGHWAY RESEARCH RECORD

Number 229

Transportation System Planning and Current Census Techniques for Planning

7 Reports

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Foreword

The papers in this RECORD are concerned with a wide range of component elements of the transportation planning process that range from a discussion of urban growth and travel patterns to measurement of community value factors, to data techniques and requirements of the transportation planning process, and further, to a special focus on the New Haven Census Use Study. As the topics are quite broad, covering many aspects of the transportation planning process, this RECORD should be of interest to a wide range of professionals engaged in transportation planning as well as administrators specifically charged with implementation of plans.

Creighton discusses what measurements are needed to develop a regional accounting model defined as a multi-dimensional operational description, in mathematical terms, of the economic, soical, governmental, physical, and spatial activities of a region or state, organized for use within a high-speed computer, and capable of being extended forward in time so as to test probable effects of any proposed government action of any discernible trend in other sections of a region's life.

Morison and Hansen discuss the development of the techniques and procedures developed from transportation study methodology to provide an array of planning tools to compare the performance of eight plans for Canberra, Australia.

Ganz discusses the fundamental changes in urban growth patterns and travel patterns over the next 20 years and the resultant transportation requirements based on the anticipated patterns of urban growth and development.

Three papers focus on the broad subject of community values and citizens' attitudes toward transportation and community development. Falk discusses the pilot study conducted in Spokane which was aimed at a better definition of the community value factors, both intangible and tangible, that must be considered in developing specific transportation project proposals. Ellis proposes a strategy for quantitatively estimating the community or social consequences of transportation projects which he defines as the "residential linkage." Wachs discusses a home interview technique used to obtain information regarding citizens' opinions of the effectiveness, needs and techniques of urban transportation planning in order to relate opinions expressed to the socioeconomic and travel characteristics of the respondents and their implications.

Leyland concludes this RECORD with a description of the New Haven Census Study. The study was set up to demonstrate how Census techniques can be employed to display information about the use of land and the distribution of people within cities. Conclusions and results of the tests are presented. Also, comments and reactions are presented by a group of knowledgeable experts.

Contents

Measurements and the Regional Planning Process

ROGER L. CREIGHTON, Creighton, Hamburg, Inc., Delmar, N.Y.

•TO lead into the subject of measurements and the regional planning process, it is appropriate to recall some of the progress made in past years in transportation planning.

Although the early history of highway transportation planning was spotted with a few massive programs of measurement such as the Los Angeles and Detroit studies of 1923 and 1927, most traffic data collection in the 1930's was quite small in scale and was used for the planning of single new facilities. The roadside origin-destination study is the most familiar example of this kind of work.

However, when the attention of the country was turned to the growing problems of urban traffic congestion, it was found that planning needed a new data base. So the home-interview survey was born during 1944-45. In subsequent years, many large cities obtained these kinds of data. In addition to the travel surveys, complete inventories were taken of transportation facilities, and starting in 1956, of land use.

From this data base, knowledge was gained of certain urban phenomena of great importance to the transportation planning process. These phenomena include the generation of trips, the distribution of trips by length, the choice of route, and choice of mode of travel.

At about the same time, it was realized that transportation facilities for urban areas should be planned as complete networks, and not as individual facilities added one to another, year by year. Transportation facilities had to be planned as systems because each link is dependent on nearby links, out to a considerable distance.

Such network planning required a complex planning process to be created, in which scores of different activities had to be meshed together. A PERT diagram for such a planning process might include over 150 different steps, each requiring several man-months to complete. But this planning process can be generalized into a core process consisting of five or six elements, such as shown in Figure 1.

Perhaps the most important element in the planning process was the testing of alternative transportation plans. With the knowledge gained from the survey data, it became possible to test very complex transportation networks in their entireties. Simulation techniques were employed to test these networks since the phenomena being dealt with could not be represented by analytic mathematics. Computers were used to simulate the flows of persons and vehicles through networks of transit and highway facilities. Feedback procedures simulated the effect of highway traffic congestion.

These techniques allowed the consequences of alternative transportation plans to be foreseen. The costs of making improvements could be related to people's goals. In the case of highways, improvement in goal-related performance could be measured in the reduction of accidents, vehicle operating costs, and time losses. Through these relationships better decisions could be made about the amount, configuration, mode, and timing of transportation improvements.

Of course, transportation planning was not the only process employing these kinds of techniques. The planning of water resource systems is a similar kind of undertaking (1). It is interesting to note that while urban transportation planning deals with a very regular phenomenon—that is, weekday travel—water resource planning deals with rainfall, which is a random phenomenon. Yet both employ the same kind of overall process, and both develop plans for physical improvements.

Paper sponsored by Committee on Urban Information Systems and Measurements and presented at the 47th Annual Meeting.

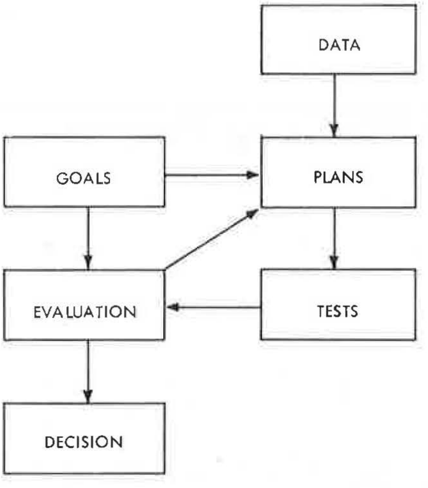


Figure 1. Diagram of basic planning process.

A number of people then began to ask why these kinds of processes could not be employed in much larger and more comprehensive planning operations. Why should not the use of land, the transportation of goods, and actions of government in the housing field be tested with the same rigor as in planning urban expressway and transit systems? Ultimately, should not governmental programs in education, health, welfare, and crime prevention be examined in the same fashion?

It would seem extremely desirable to give administrators as clear an idea as possible, in advance, of the effects of their proposed actions. Instead of planning and building single projects, as was the case in most urban transportation programs in the 1930's (and as still seems to be the case in a number of governmental programs), we should be considering total systems. And this should be based upon a sure understanding of the major urban phenomena.

These questions seemed to be good ones, and so about a year ago, in a limited and hesitant sort of way, we began to think about a regional planning process. As originally conceived, the term "regional accounting model" was used because extensive, numeric accounts would have to be kept of land use, population, housing supply, travel, income, and many other items. Unfortunately, we found that economists had preempted the term and "regional accounting" was widely interpreted as meaning only economic accounting. We found also that we had to drop the term "model" because as our thinking developed we found we were talking about a process which contained at least five models, and in the present state of the art these cannot readily be rolled into one single computer program. So, we have finally emerged with the term "regional planning process." In some ways this seemed to be like starting out in 1945 to diagram the transportation planning process as we know it today. However, certain clues were present which helped us.

1. The basic planning steps of (a) obtaining data, (b) setting goals, (c) preparing alternative proposals, (d) testing by simulation, and (e) evaluation would all have to be included.

2. The tangible urban phenomena, at least, would have to be identified, and then made the targets of research so that they could be simulated. These tangible phenomena include population growth, the production of goods and services, the daily movements of people and goods, modifications to the supply of buildings, and movements of people within the housing supply.

3. Certain established processes, such as transportation planning and economic forecasting, could be included in toto.

4. Although at first glance the comprehensive regional planning process seems to open a view of endless relationships and feedbacks, the more one thinks about it, the fewer of these exist which are significant. The problem is to identify the significant ones.

Given these ideas, then, we developed a preliminary PERT diagram of a regional planning process in three-dimensional form (Fig. 2). The regional planning process consists of three major elements: transportation and land use taken together, housing and social condition, and economic and population forecasting. The goods movement transportation planning process has been illustrated only by single block in the diagram but if expanded proportionally it would add a fourth component of the same magnitude as the preceding three. Of course, the way in which the process is organized could be different. Later work will undoubtedly produce a much better and more nearly complete description.

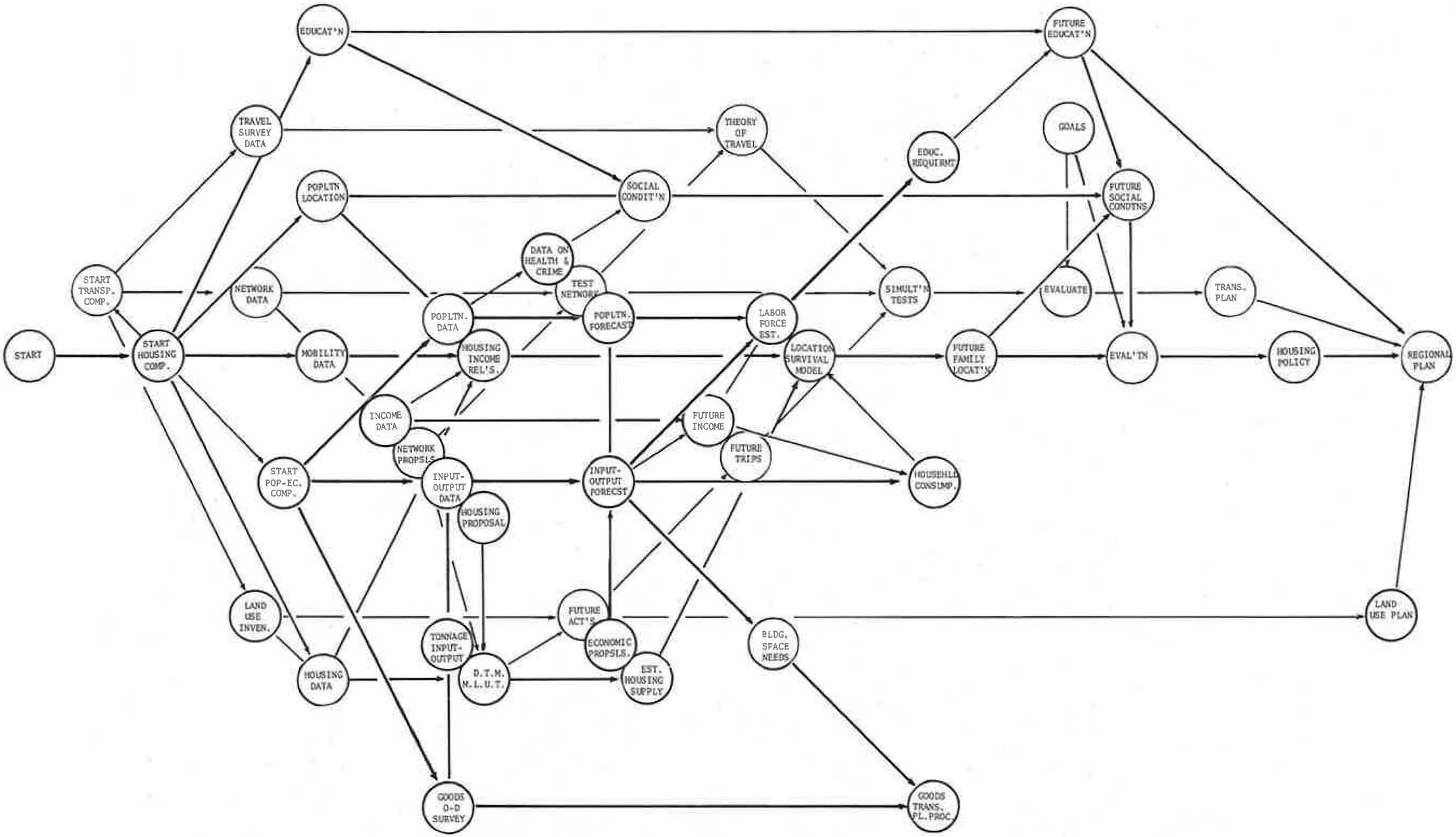


Figure 2. A diagram of a regional planning process.

The regional planning process contains five computer simulation models. These simulate (a) the growth of the population, (b) the growth of the economy, (c) the addition of housing and building to the present supply, (d) the migration of population within the stock of present and future buildings, and (e) the daily movements of people throughout the metropolitan area.

We must reiterate, of course, that this is only a very preliminary view of the regional planning process and that a great deal of work remains to be done.

Within this planning process, the major gaps in our understanding are in the fields of housing, in goods movement transportation, and in an understanding of the noneconomic relationships between people. These last, of course, are extremely important because they are presumably affected by governmental programs such as education, police protection, and health and welfare. It would be extremely desirable for these things to be included within the regional planning process.

The progression of the advancement of the regional planning process is probably, however, indicated by past advances. These have been in the fields where measurement of tangible things has been easy, and where plans are for physical changes which are under the direct control of a few governments. Water resources and transportation are the foremost examples, and the state of the art is most advanced here.

Two fields therefore suggest themselves as areas where advances may next be made. One of these is the process by which new buildings are added to the existing supply in a metropolitan region. Several models have been proposed or developed which simulate this city-growth phenomenon. Hamburg and Lathrop's is one case in point. Another is Schneider's work on land development and transportation for the United States Department of Transportation.

Another phenomenon of importance is the migration of population within the metropolitan housing supply. While some work has been done in this area, it is probably fair to say that an immense amount of systematic work remains before we can forecast future locations of population groups with different social and economic characteristics within the metropolitan housing supply.

Having now given a preliminary picture of the regional planning process, we turn to the measurements which would be needed for such a process. This is where the preceding ideas begin to bear upon the work of the Urban Information Systems Committee which sponsored this paper. Defining what information is needed for an urban information system or for a data bank is always a difficult and trying process. One way to help define data needs is by considering the requirements of a regional planning process. At present, of course, this is only speculative, but in part common sense and previous experience suggest what will be needed.

I would suggest, therefore, that the data needs for regional planning will consist of eight main files, seven of which measure tangibles. The eighth measures the economic relationships. Five of the files contain data which are at present gathered (although not always on a regular basis) for metropolitan areas, but not necessarily for regions. Three of the files are new or would require so much new information as to be substantially new.

The first three files on the following list have traditionally been obtained by urban transportation studies, files 5, 6, and 7 would be substantially new ones.

1. Land Use. All parcels (or small groups of parcels) in a region should be measured and identified as to use. In addition there should be cross referencing between parcels and buildings. Data on value of a regular sample of parcels should be obtained so as to be able to deal systematically with changes in land values and total land values for a region.

2. Transportation Facilities. All transportation facilities in the region should be measured in the fashion typically employed by modern transportation studies. This should include transportation facilities not only for the movement of people in vehicles but for the movement of goods.

3. Daily Travel. A sample of daily travel by persons and vehicles in the region should be obtained, with additional data on weekend and holiday travel.

4. Population Data. This file would be obtained from the Census, but might have to be updated on a sample basis.

5. Building Survey. Measurement of a sample of all buildings in a region, obtaining data on such things as floor area, number of rooms, age, condition, and value.

6. Migratory Travel. A sample of five years of migratory travel of families and unrelated individuals within the metropolitan region should be obtained, with auxiliary data on before and after housing, income, education, family composition, and the like. Although some mobility surveys have been made within metropolitan areas, only two (Chicago and New York) have obtained metropolitan-wide data.

7. Daily Movement of Goods. Measurement of a sample of freight movements within the region under study, obtaining data on origin, destination, type of commodity, weight, value, and mode of travel.

8. The Economy. These are economic data such as would be required for input-output forecasting and for estimating income and consumption patterns. Probably considerable additional detail on income and consumption would be needed in order to link this file with the file of buildings and migration.

Data needs do not stop, of course, with the possession of the regional measurement of just these preceding, and mainly tangible, items. Ultimately, some kind of measurements will probably have to be made of the noneconomic human interrelationships. These would include the processes by which information and understanding are transferred (such as by education) and the processes of social restraints (such as law and crime prevention). It cannot even be suggested here how this could be done, or whether it would be appropriately included in a simulation-oriented planning process.

However, there is a temporary way out of this dilemma which is suggested by past experience in transportation studies. This is to obtain data that measure the condition of the population (before and after planning proposals are put into effect) as defined by the population's goals. For example, in the transportation planning process, we found that in addition to our main data files, we had to get data on accidents, time lost in congestion, and vehicle operating costs, since reduction of these things was a major goal. The trick, of course, is not only to measure certain conditions which are goal-related, but also to measure the relationship between these conditions and the improvements which are being planned—in some cases there may be no relationship at all.

In the regional planning process, we suggested some of the things which, at least as a beginning, might define the condition of a population, and which are, in effect, goals of population. These are given in Table 1, together with some of the data which might be obtained to measure them.

Regional measurements will probably be obtained only to satisfy demonstrable needs. An important need is to develop a systematic regional planning process. A regional planning process provides a way in which the long-range consequences of certain governmental programs or lack of programs can be evaluated. By understanding better how the important urban phenomena occur, they can be simulated. Government actions or constraints affecting these occurrences can then be studied, as in a laboratory.

Having gone through the labor of preparing a preliminary picture of a regional planning process, it has become clear that the best way of defining exactly what information should be obtained, and how the regional planning process will be structured, is by plunging in and doing it. This is the way in which

TABLE 1

GOALS DEFINING CONDITION OF POPULATION AND POSSIBLE MEASURES OF GOAL PERFORMANCE OR CONDITION

Goals	Measures of Goal Performance
Health	Numbers of persons in hospitals; visits to doctors; medical payments.
Mental health	Numbers of persons in institutions or under treatment for mental illness.
Personal income	Census income statistics; tax payments.
Housing quality	Space available for housing per family; age and condition of structure; neighborhood characteristics and services.
Freedom from crime	Crime statistics.
Education	Education statistics.

transportation planning and water resource planning processes were developed. Further, the lesson of past experience is that a large organization, adequately staffed and supported, is far more productive than a series of short, small projects undertaken by different people.

The voids in our understanding of urban phenomena are tremendous. We do not yet know well enough how cities grow, how buildings are added to the stock, how modifications are made to the building stock, how people move about within the supply of structures which are available to them, and how efficiently goods are moved within regions. At present, most actions in these fields are being taken on a project by project approach which is analogous to that of the highway building era of the 1930's. In the light of the tremendous funds which are being spent by private persons and governments in developing metropolitan areas and regions, it would certainly be worthwhile for an adequate data base to be obtained, from which greater understanding and greater ability to plan could be obtained.

REFERENCE

1. Hufschmidt, Maas, et al. Design of Water Resource Systems. Harvard University Press, 1962.

Canberra: Toward a Scheme for Continuous Growth

IAN W. MORISON, National Capital Development Commission, Canberra, Australia, and
WALTER G. HANSEN, Alan M. Voorhees and Associates, Inc.

This is a pragmatic examination of the physical planning issues facing a city expanding rapidly toward metropolitan status under a program of comprehensive development. A number of simple procedures are developed from existing transportation study techniques to provide an array of planning tools to compare the performance of eight plans for one million population. These are all on the theme of a constellation of subregional units about a metropolitan center, but radically different in their degrees of subcentralization, urban form, distribution of activities, and transport networks. Diagnosis of the problems produced in retailing and travel patterns, along with those of congestion, limited capacity to grow, insecure demand for major facilities, leads to the identification of a set of practical planning principles. These are in terms of the urban form, degree of centeralization, structural balance, configuration of the transport system, and growth strategies, which when taken together form a general conceptual plan.

•CANBERRA, Australia's national capital, was founded in 1913, twelve years after federation. It lies in a rift in the Great Australian Alps, 200 miles from Sydney and 400 miles from Melbourne, which forms part of the 911 square miles of the Australian Capital Territory, ceded to the Commonwealth Government by New South Wales in 1911. Some 300 square miles of rural land in the northeast part of this area was acquired by the Commonwealth for the development of the capital (Fig. 1).

The bare outline of the city, designed for a population of 75,000 by Walter Burley Griffin of Chicago in an international competition, was established by the late 1920's. It grew slowly, to a population of only 22,000 by 1950. After a decade of planned transfers of federal departments from state capitals and rapid institutional and commercial growth, the population has passed 100,000 and Canberra is clearly recognizable as the national center of the Commonwealth.

Growing at its present rate, Canberra will have 590,000 people at the end of the century and could have one million early in the next. Situated in circumstances where the comprehensive control of land can be practiced through public ownership, the proper direction of national capital growth poses a special challenge to the city's developers. The advantages of comprehensive and integrated development must be understood and exploited so that the forces of growth and change can be channelized to meet the immediate needs of an affluent society, within an effective long-range framework.

This paper originates from a study conducted in 1966 by the authors for the National Capital Development Commission which is responsible for the planning and development

Paper sponsored by Department of Urban Transportation Planning and presented at the 47th Annual Meeting.

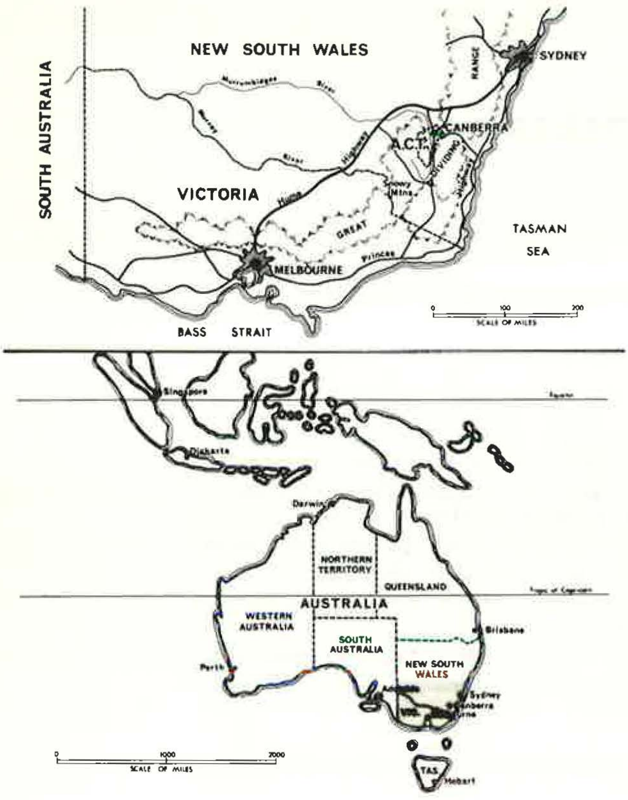


Figure 1. Location map.

of Canberra. It describes this study with the object of finding ways of directing future growth into an acceptable urban form and structure: one capable of accommodating increasing physical expansion and higher levels of activity without developing the chronic transportation bottlenecks symptomatic of large cities around the world.

However, this study was not an academic investigation of regional forms, constructed on the basis of satisfying a single transportation objective. Instead, the problems of transportation were examined within the context of several wider terms of reference. These were the growth of the national capital as a dignified setting for the seat of government; the need for an urban structure within which development can proceed on a rational basis but leave room for future social and technological change; and the need to maintain a choice of residential environments and work opportunities. Finally, the problems involved in the growth process itself had to be recognized and a practical programming strategy developed.

ESTABLISHED BASIS OF LAND DEVELOPMENT

Before this study, some important policies had already been well established as controlling factors in the growth of the city; notably the accommodation of residental expansion in suburban districts planned to have the character of self-contained complete towns. Two such towns, which will ultimately house about 100,000 people each, are being developed in areas to the south and northwest of the present city in areas having distinct topographic identities, and separated from the city by well-defined hills and ridges up to a mile or so in width, in which natural forest and open country will be retained.

The nodal points of these subregional units or towns are to be more than residential service centers. Local retail and service functions will be strengthened by commercial and government office employment and town-center activities. This will give the town centers greater scale and variety, and will also be a means of safeguarding against pressure for excessive building, leading to excessive traffic concentrations around the center of the capital.

THE TEST PLANS

The spatial arrangement of these towns and the transport networks to serve them were the prime subjects of this study. Three mean variables were considered (Fig. 2):

1. The arrangement of towns (metropolitan form),
2. The location and size of centers (activity-structure), and
3. The network of transport facilities (transport structure).

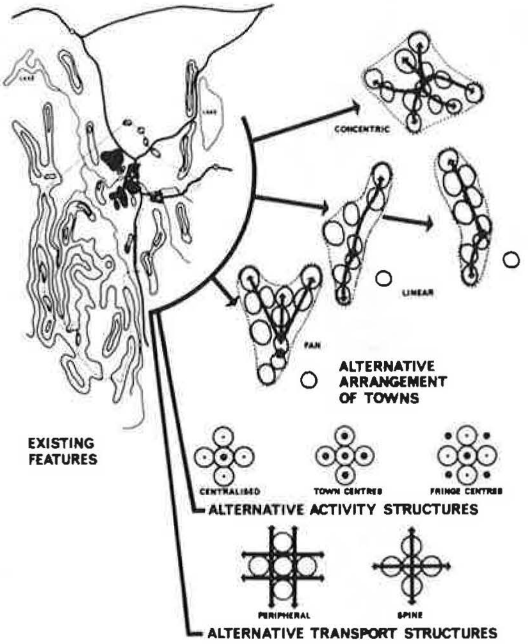


Figure 2. Major components of test plans.

Among the manifold advantages that flow from a comprehensive control of land is that of being able to formulate, as potentially practical plans, alternatives that are radically different from one another. Urban forms, as well as activity and transport structures that might be thought suitable only for theoretical study in regions without such control, were included in this project in order to explore every possibility.

Nine plans were constructed, using towns of 50 to 150,000 population as building blocks, to demonstrate, through independent variations in total urban shape (form), subcentralization, and highway structures, to uncover the physical characteristics of a conceptual plan having:

1. Efficient organization at metropolitan scale,
2. A measure of self-containment in subregions (towns),
3. Acceptable degrees of centralization at town and metropolitan levels, and
4. Efficient arterial, freeway and public transport systems.

The main characteristics of six test plans for one million people are shown in Figure 3. Plans A, A1, and A2 arranged towns concentrically around the existing city. Plans B and C each involved substantial growth along two corridors in opposite directions and Plan D assumed substantial northerly growth in a V-shape.

Plan F was built up using criteria developed from analysis of the preceding plans. It made use of more clearly defined and structured corridors in a Y-shape. Plan G was a stage development of Plan F to accommodate 500,000 people.

DETAILED PLAN ASSEMBLY

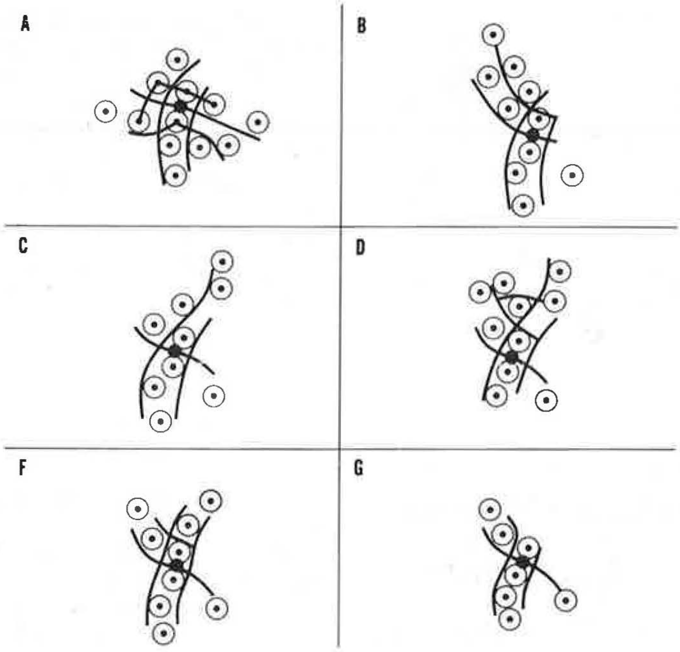
For ease of manipulation and to be consistent with the broad planning aims of the study, plans were constructed from land-use units having more or less standard dimensions and character.

For each plan the same projected requirements for one million people (Table 1) were distributed in different ways over the triangular area (measuring 50 miles north to south and up to 25 miles east to west) capable of large-scale urban development. This area was divided into 300 subareas for computer input.

The basic network of arterials designed to serve these 300 areas was common to all plans. This network recognized topographic limits and major traffic generators and was physically integrated in most cases with the pattern formed by separate land areas. Freeways were added by upgrading arterial links where necessary. Later handling of traffic feedback on a manual basis enabled two separate computer networks of freeways to analyze the nine plans effectively.

TRAFFIC MODELS

The examination of an urban structures performance in the remote future demands the formulation of models based on a few simple and, hopefully, predictable parameters: resident population, retail employment and total employment. Vehicle trip-production rates were based on 1961 data adjusted for the likely consequences of having 0.4 cars per person in the future. Public transport was assumed to maintain its present level of 15 percent of work trips but a subjective "transit factor" allowed for



% OF JOBS IN CENTRAL AREA			
A	17.5 HIGHER-DENSITY HOUSING	C	17.5
A-1	17.5	D	17.5
A-2	32	F	25
B	17.5	G	30-50 HALF-MILLION

Figure 3. Main features of test plans.

possible major variations in usage in local areas. Trip production and attraction equations were developed for home-based vehicle trips to work, shop and business, social and recreation, and nonhome-based trips for an average weekday. The overall level of trip making was assumed to be over 1.9 vehicle trips per person (all ages) per day, compared with the 1961 level of 1.6.

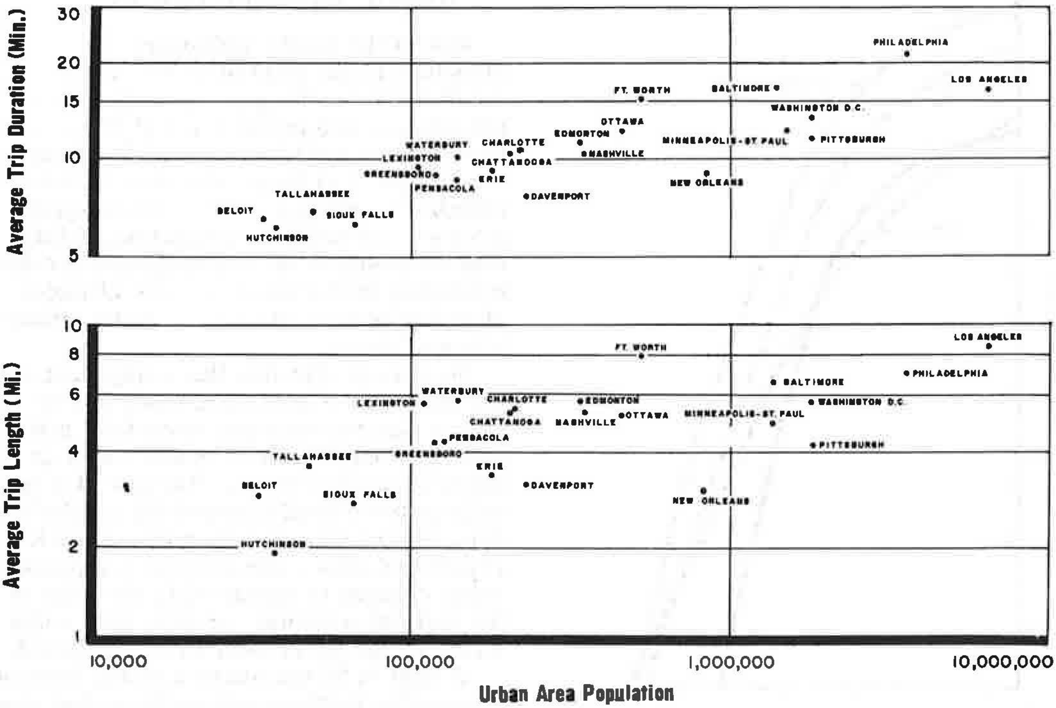
TABLE 1

LAND-USE AREAS FOR ONE MILLION PEOPLE

Dominant Character	No. of Units in Plans	Extent of Avg. Unit (acres)	Avg. Size of Unit	
			Residents	Jobs
Suburban	45	1,500	17,000	800
Higher density suburb	10	400	17,000	800
Extensive institutions	20	3,000	1,000	500
Light industrial	10	1,500	—	7,500
Government Office Centers	2-4[1]	200	—	12,000
Intensive inst.	20	200	2,000	3,000
Town Centers	8-11[1]	400	2,000	10-15,000[2]
City Center (CBD)	1	600	5,000	30-60,000[2]

[1]Range reflects change in urban forms.
[2]Range reflects degrees of centralization.

For trip distribution, the gravity model required assumptions to be made about the order of magnitude of future trip lengths for the four categories of trips produced, without having any reference points provided by the present city, except that it would be an open-textured, low-density metropolis with a high level of mobility by private transport. It was therefore necessary to



Auto driver average trip times and distance exclude terminal time effects.

Figure 4. Average auto driver work trip length, duration, and population (twenty-three cities).

refer to information on trip lengths by motor vehicle in other cities of the order of one million population.

Figure 4 shows the variation in average trip lengths from a research study conducted for the National Cooperative Highway Research Program (1). From this study, the average duration (in minutes) and length (in miles) of work trips could be estimated, given the average speed of trips, and the range of core density (high, medium, or low) for a city of given size. The expected work trip lengths for Canberra, using these relationships, were of the order of 15 to 16 minutes and 7 to 8 miles.

A trial-and-error process was used to develop a set of synthetic friction factors for work trips which achieved average trip lengths within this range for the first plan. These friction factors were then held constant for the subsequent comparative analysis with alternate plans. In real situations radical variations in the form of the city and in the allocation of work opportunities would lead to modified attitudes to travel (i.e., friction factors would change), but for the purpose of this study the introduction of this variable (whose effects would be difficult to disentangle from other factors) would have tended to blur rather than clarify differences between alternate plan characteristics.

The set of work trip friction factors finally adopted for the study are shown in Figure 5, along with sets of factors for shopping, other home-based trips and nonhome-based trips, which exhibit less variance with city character and therefore could be selected with relative ease. No assumptions were made about variations in socio-economic characteristics as these are expected to produce little differentiation in the travel characteristic of individual zones.

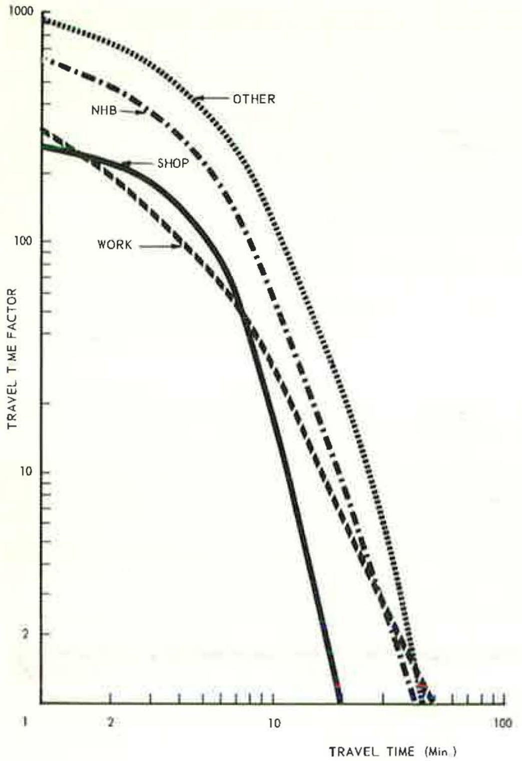


Figure 5. Final friction factors.

RETAIL EXPENDITURE MODEL

One of the major influences on city structure is the pattern formed by major retail centers. They are sensitive to market changes and pressures and form the key areas of activity in any plan. From the viewpoint of future stability in merchandising, as well as that of transport planning and traffic management, a full understanding of the requirements for determining the location and size of major shopping centers is critical to the formulation of plans.

To gain insight into this component of the plans, forecasts were made of consumer expenditures per household and average comparison of goods sales at major shopping center. The use of a retail market potential model (2) enabled the sales linkages from consumers in each residential zone, attracted by competing retail centers to operate (via the links of the highway network), and the total sales attracted by each center to be estimated.

A total of 22 subroutines in the form of alternative location-size patterns for shopping centers were tested. These enabled balanced retailing systems to be devised for each plan, where all centers attracted sufficient sales in relation to their assumed size to be profitable to the entrepreneur, without being so profitable as to suggest an unsatisfied demand for further growth.

COMPARISON OF PLAN PERFORMANCE

The output of gravity model analysis, first for annual retail expenditures, and then for daily vehicle trips, followed by traffic assignments, enabled plan performances to be compared. The objective of comparative analysis was not the selection of the most

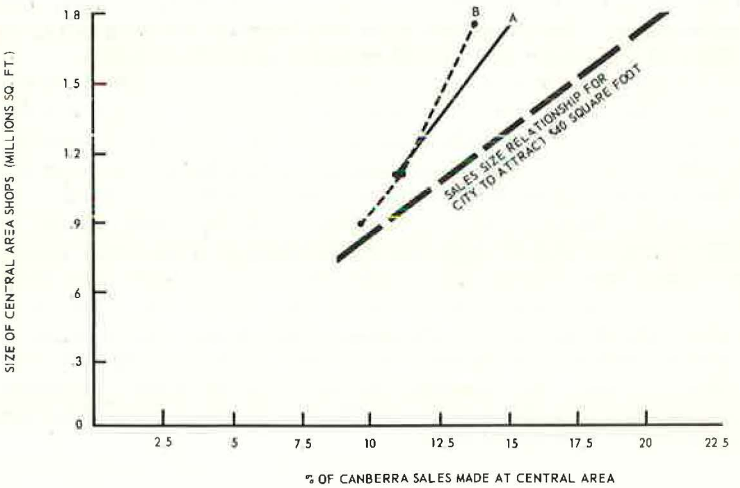


Figure 6. Influence of plan-form on proportion of local sales made in CBD.

TABLE 2

RETAIL PERFORMANCE BY LOCATION OF SITE

Plan Form	Location of Site		
	Access via Freeways	Focal Point of Town Arterial System	Elsewhere in Towns
A	$38	$57	$48
B	$33	$63	$45
C	$34	$63	$48
Average for Plans A, B, C	$35 (15 sites)	$61 (29 sites)	$47 (30 sites)
Range of individual performance	$25-$50	$43-$100	$34-$68

efficient plan in terms of transportation however, as the plans were designed to uncover the transportation implications of a full range of urban forms. In particular, the analysis set out to uncover those transportation situations and travel characteristics which suggested:

1. Limits in capacity for further urban expansion;
2. A configuration of assigned travel demands which could weaken the development of freeways and rapid transit facilities needed to support, and in turn create, metropolitan structure; and
3. Avoidable conflict between traffic concentrations attracted to freeways and those attracted to subregional centers of activity.

To find these points of weakness in alternative urban forms and structures, a number of specific questions were asked:

1. What is the most efficient system of retail centers?
2. What are the transportation implications of alternate population and employment and activity patterns?
3. Where do traffic bottlenecks occur?
4. What is the potential for freeways and rapid transit under alternate regional forms?

THE SYSTEM OF RETAIL CENTERS

Analysis of sales potential showed that the CBD would attract 10 percent to 12 percent of the local market. Tests of plans which assume a much larger attraction to the CBD showed that it might indeed attract a greater share, but average sales might drop to an unhealthy level (Fig. 6).

In none of the plans was there a definite potential for the establishment of major shopping centers on freeways running between residential towns, unless the development of centers inside the towns was placed under some restraint. In fact those shopping sites which were dependent on freeways for their accessibility generally had the least attractive power. Freeway sites, in open competition with other locations, were only able to attract an average of $35 sales per square foot, compared with $47 inside the town areas, and $61 at the focal point of the town arterial system (Table 2).

This conclusion, which is the opposite of much practical experience in the United States, may be explained by the well developed pattern of towns proposed for Canberra and the avoidance of freeways running through residential areas. The physical and spatial definition of the towns, with an internal focus, appears to more than compensate for the influence of the fast speeds on freeways in creating accessible locations.

Due to a high level of self-containment of consumer expenditures within each residential area, radical changes in the spatial arrangement of towns throughout the metropolitan area had little effect on the efficiency of town-centered shopping systems. This evidence, plus the lower average trip lengths (for consumer expenditures) produced in plans using a shopping pattern based on town centers, led to the conclusion that they produce the most efficient and stable system.

EVALUATION OF TRAVEL DEMANDS

Assessment of travel demands between alternative plans is commonly done by comparing total vehicle-miles traveled. This was not the best measure for a region made up of clearly separated residential areas having a measure of self-containment. Total vehicle-miles were therefore broken down by freeway, arterial and local roads and a

TABLE 3

SUMMARY OF TRAVEL DEMANDS—ALTERNATE PLANS

Travel Demand	Concentric Growth		Corridor Growth		
	A	A-2	B	C	F
Total vehicle-miles (000)	9750	9970	9930	9770	9570
Intertown travel (% of all vehicle-miles)	77	78	72	72	74
Intertown vehicle-miles (000)	7500	7800	7150	7000	7080

separate breakdown developed for intertown vehicle-miles, to see more precisely where any efficiences might be developed.

Intratown vehicle mileage was 22 to 28 percent of the total; this was the portion of the travel that must be carried by roads within the towns, constructed as part of the suburban development operation. Comparison of the remaining (intertown) travel, therefore, provided a better measure of the demands for major metropolitan facilities: freeways and rapid transit. On this basis corridor-type Plans B, C, and F made lesser total demands for regional facilities than Plan A which was based on concentric expansion (Table 3). The most centralized plan (A-2) made the highest demands, and corridor-type plans were generally 10 percent better in this respect.

Trip Lengths

As might be expected, the average length of trips made for the purposes that tend to be locally oriented, such as shopping and social travel, varied little from plan to plan, despite the radically different spatial arrangements of towns.

The average length of vehicle trips to work varied between 15.2 minutes for Plan A-1 to 17.6 minutes for Plan C—a difference of 15 percent. The substantially greater length of work trips in all plans and their relatively wide variation from plan to plan indicate clearly the potential economies of an urban form and a distribution of work opportunities, which minimize the total miles of vehicle travel to work.

Table 4 gives the effect on vehicle-trip length (in Plans A and A-2) of increasing metropolitan centralization of employment from 17.5 to 32.5 percent. It is recognized that increased centralization would also increase the potential for public transport usage and could result in reduced car use for longer trips. The practical result of the tendency for vehicle trips to be lengthened by centralization would therefore be dependent on related changes in public transport service.

The results for Plan A-1 illustrate the effect of increasing residential densities from 12 to 30 persons per gross acre around the town centers. The average length of locally oriented trips, as well as work trips, was reduced. Additional reductions in work trip by auto could be derived by rapid transit designed to exploit accessibility to residences, if this kind of compaction of development occurred on a large scale.

Plans B and C illustrated the effect of a significant lack of balance in employment-location in relation to the major directions of growth. Approximately 20,000 jobs were located in the southeast area of the region, whereas growth was substantially to the north. This lack of balance countered the localizing effect on work trips of a more linear form of growth. Compared to A plans, the more linear form had a lower accessibility to work, so that the resident work force of each town would tend to place more value

TABLE 4

AVERAGE TRIP LENGTH VS PLAN FORM AND CENTRALIZATION

Trip	Urban Form					
	Concentric Growth			Corridor Growth		Articulated Corridors
	A	A-1	A-2	B	C	F
Home based						
Work	15.8	15.2	16.8	17.1	17.6	16.0
Shop	8.5	8.3	8.4	8.5	8.5	8.4
Other	11.2	10.7	11.3	11.1	10.7	11.3
NHB	10.9	10.7	10.7	10.8	10.5	10.2
Centralized employment, %	17.5	17.5	32.5	17.5	17.5	24.6

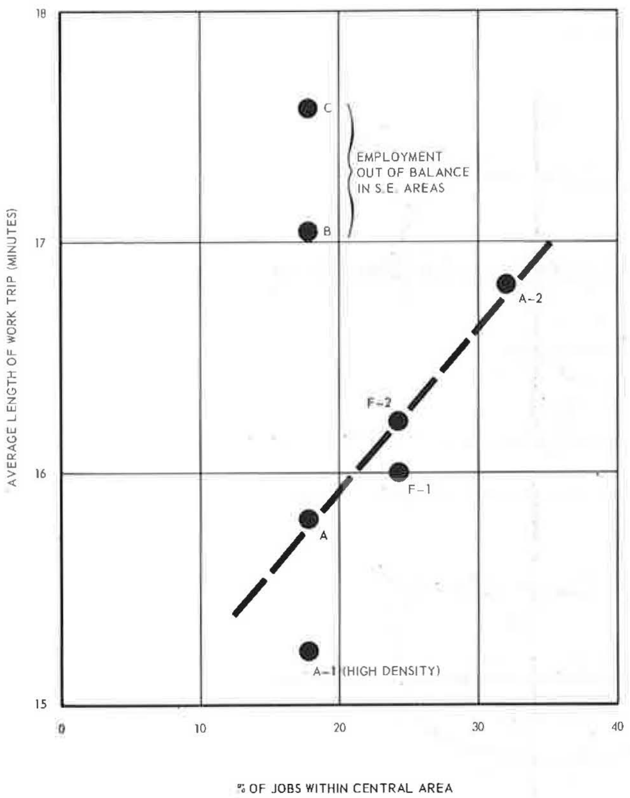


Figure 7. Variation of work trip lengths in test plans.

on local opportunities. This conclusion is supported by a 5 percent increase in intratown trips in these plans. Despite this increased tendency to self-containment, the imbalance between residences and jobs in B and C plans increased the average length of work trips, above those of the A plans.

This imbalance was corrected in linear Plan F, so that, despite its more centralized employment pattern (24.5 percent compared to the 17.5 percent of B and C) the average work trip length was lowered sufficiently to make it comparable to the average trip length for the concentric growth of A plans (Fig. 7).

Growth Strategy

Road traffic bottlenecks on a scale defying satisfactory or permanent solution are normally due to an over-concentration of activities at major urban centers. Thus an important objective was to find the general upper limit of concentration that could be tolerated in the central area (a lower limit of 17.5 percent central employment at the one million population stage was based on the national minimum required to establish a central area transport structure and to maintain an activity-node of metropolitan status and dimensions). The upper level of centralized employment tested (32 percent) appeared more likely to overload the secondary system of distribution in the central area than its approach freeways. This indicated the probability of the detailed distribution of central area activities (rather than transportation) as the prime determinant of limits to centralization. Subject to the changing role played by public transport, the centralization of 24 percent of jobs at the stage when one million people live in the metropolitan region, appeared to provide one of the many reference points needed to design for growth at the heart of the capital.

To develop similar reference points for the central area as the region expands to one million population, an analysis was made of a plan containing 500,000 persons. In test Plan G, it was first assumed that growth of employment at the central area of Canberra would maintain its present 50 percent share of total jobs. Traffic analysis showed that travel demands on numerous roads leading to the central area by the half million population stage would exceed those generated at the one million stage if the central area grew at this rate. (Traffic conditions could of course be a great deal worse in practice, because traffic corridors would be less highly developed to carry the load at this stage.)

To avoid developing higher traffic demands along certain corridors than are forecast at later stages (a condition not easily rectified once it has appeared), it is clear that a balance needs to be struck between the growth of towns with subcentralized employment, and increases in jobs in a central area that absorbs a decreasing proportion of total activity. To achieve this, the activity in the central area should be kept in

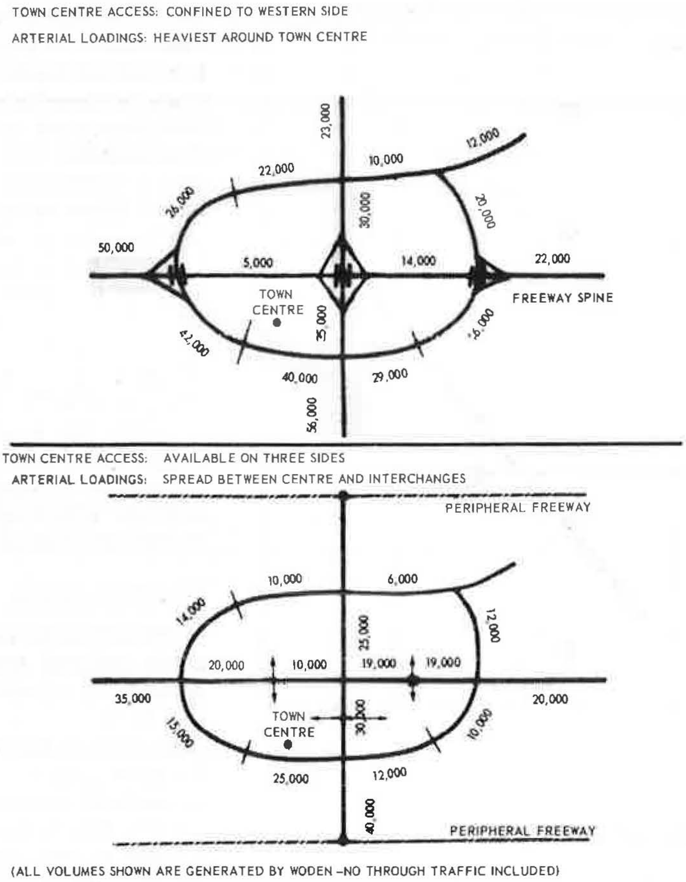


Figure 8. Impact of freeway location on town traffic conditions at the center of Woden.

approximate balance with the ultimate contribution made by the labor force of each town to central area employment. This ultimate balance between town and central area could be achieved if each town and its work center were established together and as early as possible, to promote attractive alternatives to central area work locations. On the other hand the central area would need to grow slowly as a work place, reaching at a half million population level only two-thirds of its size at the million level.

Traffic Bottlenecks

The pattern of traffic loads assigned to arterial-freeway networks provided valuable clues to the capacity of the total land use and transport network to accommodate outward growth without the development of major bottlenecks. An important finding of the tests of Plans A to D was the potential congestion around town centers when located on urban expressways penetrating the towns and functioning as major intertown routes. Figure 8 shows the effect of penetrating a town of 90,000 people with a limited-access expressway facility designed to serve both the town center and regional intertown traffic compared to a plan which separates these transportation functions by the provision of peripheral freeways.

In each case, the traffic volumes are only those associated with the town. If through traffic were also shown, the results would be even more striking. It is quite clear that a central transportation spine creates a few points through which the majority of traffic must move irrespective of its ultimate origins and destinations. In addition, the expressway facility drastically reduces the access-egress perimeter of the town center, thereby concentrating the generated traffic even further.

The resolution of these localized difficulties points to the separation of intensive local traffic generators and high-type traffic facilities. A plan that looks beyond a static horizon to the requirements of continuing growth (growth of either the nodal activity centers or of long-distance metropolitan traffic demands) must look to an articulated highway system composed of arterials inside the urban growth corridors, to give access to activity-nodes, and transport-nodes (interchanges) on peripheral freeways linking towns to one another, and to the metropolitan core.

FREEWAYS AND RAPID TRANSIT

The objective was to evaluate the geographic pattern of travel demands, particularly those long intertown movements which should be accommodated on a freeway system. Information on daily two-way vehicle trips assigned to each link of the highway system was supplemented by the assignment of intertown trips to a spider network in which each centroid represented a town. The longer trips were identified on each spider diagram link as the difference between total intertown trips and adjacent intertown trips. These trips were considered to represent the basic demand for freeway-type travel.

Intertown vehicle travel demands for Plan A exhibited a dispersed pattern compared to the more centralized Plan A-2, whose freeway demands were substantially greater. The clearly structured demands of Plan B could be served easily by an efficient system of freeways, but the development in Plan D of a heavy cross-metropolitan demand between its extensive northern towns, accompanied by reduced radial demands, produced a pattern of longer trips that would be difficult to translate into a freeway network.

Corridor Plan F developed freeway demands of 50,000 trips or more per day in three directions from the city center, clearly enabling a radial network to be defined. (The addition of adjacent intertown trips raised the total assigned load on the network of peripheral freeways to between 30,000 and 60,000 trips per link.)

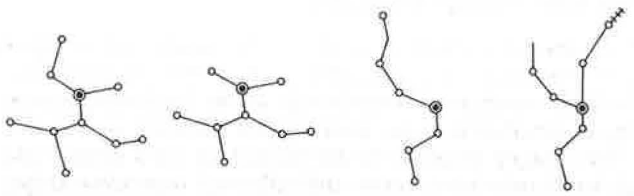
Potential for Public Transport

Of particular concern was the assessment of possibilities for providing Canberra with a high level of public transport service. This objective did not stem from notions of favoring public over private transport but from the recognition of its importance to large segments of the population in urban areas of the size being considered: Their requirements are neither more nor less important than others, and the ability to utilize fully the transport characteristics of public transport modes will increase the opportunities of opening up the range of land development intensities that can be provided in the future.

No attempt was made to forecast modal splits for alternative plans, but a basic 15 percent level of patronage was assumed to exist for work trips. However, the information available from spider diagrams in intertown travel provided a general guide to the potential for providing a regional or intertown public transport system. Intertown trips were factored to represent total person movements which might be attracted to a form of public transport providing high levels of service.

The factoring procedure involved examining the purpose-composition of vehicle trips of 12 minutes' duration or more and assuming that up to 5 percent of their person trips in the shopping, social, recreation categories and 10 percent in the work category could be attracted to a good transit system. The resulting 17 percent factor was applied to total intertown vehicle trips to produce a diagram of potential public transportation usage for each plan (Fig. 9). The trunkline demands that were produced by Plan A showed that a system requiring high capital investment (fixed track vehicle, or bus on separate right-of-way) would not be justified. This was after allowing that prior reservation of a right-of-way at no cost would require a daily patronage (including intratown) of around 25,000 passengers to offset operational costs. Plan A-2 showed a more clearly structured potential, with three intertown links approaching the required level. However,

		Concentric Growth		Corridor Growth	
		A	A-2	B	F
Intertown links with potential as rapid transit or express bus route	Number of links	9	8	6	7
	Sum of link loads	129,000	124,000	112,000	131,000
	Number of lines & branches formed	5	5	2	3



Configuration of potential network for rapid transit

	A	A-2	B	F
Potential rapid transit link-loads as % total intertown link-loads	67%	67%	65%	75%
Average load per R-T link	14,400	15,500	18,600	18,800
Miles of route involved	35	30	25	30

Figure 9. Comparison of public transport potentials.

as shown in Figure 9, the directional diversity of the potential in both plans and the resulting branch lines was an additional barrier to a practical design that would exploit the potential demand.

Plan B indicated clearly the value of a linear plan form as a means of providing higher levels of public transport. With carefully located employment centers and residential development at the local as well as the metropolitan level, this plan could possibly support 25 miles of a high-type public transport route.

The articulated land-use pattern and corridors of Plan F show clear support for a high level of transit service in three directions from the central area. Figure 9 shows that Plan F was able to attract 75 percent of the assumed potential intertown patronage, whereas the other plans could attract only 65 to 67 percent. The average potential patronage over the 30-mile system involved was 18,800 persons per day: intratown usage, with suitably designed towns, could provide the additional support required to justify a system on its own right-of-way. From examination of Plan G, it appeared that a high-level transit service might be begun at about the half million population stage.

In considering how operations in a separate rapid transit reservation might be commenced, it should not be assumed that justification in terms of daily load can be a guarantee in itself. The feasibility of initiating such a system could very likely lie in the ability to make a series of improvements in the service given by existing bus systems, by putting successive sections of the reserved alignment into operation over a period.

The conclusion was that public transport on separate rights-of-way is a realistic objective, providing that future land development at the regional, town, and local level is developed to exploit the full potential of this mode of travel. This involves the channeling of growth into several radial corridors to increase the density of point-to-point movements, the growth of the central area to be as large as its design and function will allow, and town centers and other out-of-town employment areas with a high level of activity (such as universities) to be sited and designed in relation to a reserved public transport spine as an integral element.

Work Trips, Urban Form and Structure

The conclusions to be drawn on the relationships of form, structure and travel confirm in the main what has been established in earlier work (4); namely, that efficient land-use distribution is the major source of reductions in travel demands and is a potential source of transport economies. Analysis of variations in work trip length under corridor-type and concentric-type plans with varying degrees of subcentralization provided further specific conclusions on this general theme.

First, as demonstrated by Plans B and C, an imbalance of seemingly minor proportions in the distribution of jobs over the whole metropolitan region can increase the mileage of travel to an extent that nullifies the effect of organizing the rest of the urban structure into self-contained areas having a high measure (60 percent) of internal work opportunities. In practice of course any significant imbalance in employment that is not a centralized one will, in addition to increasing the amount of travel, have a weakening effect on the development of efficient transport facilities through the introduction of more competing and conflicting desire lines.

Second, linear forms which are reasonably balanced in respect of work locations can have work trip lengths similar to those of the circular plan that, under superficial inspection, seems to require shorter trips because it looks more compact. Figure 7 illustrates a relationship between average work trip lengths and centralization of employment for circular and linear plan forms. For plans having some claim to structural organization, and without serious imbalance in employment distribution, the form (or shape) of urban growth alone should have little influence on average trip length. On the other hand, regional centralization in the context of the loosely knit low-density metropolis seems to have a dominant role in the production of longer trips to work.

If plan form, as a result of this conclusion, can be regarded a relatively neutral factor in the production of inefficient work trip patterns, it becomes even more important to look at the question of structural balance, particularly the capacity of different plan forms to grow in a way that retains a balance between population and employment locations.

Concentric and lineal or corridor-growth patterns may have different capacities to maintain a near optimum trip length for any given degree of imbalance in employment distribution. With limited possibilities for clearly articulated growth, a city undergoing concentric expansion will have less potential for developing efficient patterns and modes of travel. But as a part compensation for these limitations, badly distributed employment could increase trip lengths less in a circular city form than in one assuming an articulated form.

In the all to normal context of limited or nonexistent control over land development, it is obvious that a city articulated into corridors, each with a balanced employment structure, represents a higher order of organization than one based on peripheral growth around a single dominant core. Yet it is the ability to progress, in land-use terms, toward such higher order structures that appears to provide cities with the capability of sustaining continued growth in an efficient manner.

SUMMARY AND CONCLUSIONS

This examination has shown how much the performance of alternate plans, all of them genuine attempts at metropolitan organization on the common theme of subcentralization, can vary in their capacity to cope with the problems caused by growth. The necessary adoption of the multi-nucleated approach to urban development has been shown to require the strict application of many checks and balances if in the future, cities are to develop the firm and efficient structural elements to a large degree self-reinforcing, that characterized those of the past. A constellation of centers is capable of growing and generating demands in so many ways that its major hazard is the loss of this organization at the metropolitan level.

The concentration of land development into corridors in conjunction with a structured arterial freeway system will allow metropolitan growth to occur with a minimum of points or areas of congestion. This concept will also give maximum support to a good public transport system in low-density and low-patronage conditions.

Finally, and perhaps most importantly, the general concept of directional growth in the motor age appears to entail careful attention to the detailed timing, location, detailed arrangement, and growth of the important centers of activity and of the transport network, if it is to actually achieve the structural strength and stability that will avoid chronic congestion being a concomitant of continuing growth.

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Emerging Patterns of Urban Growth and Travel

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•FUTURE changes in urban travel patterns and growth in urban travel demand, within 20 years' time, will require substantial innovation and broad expansion in our urban transportation system. These basic new transport needs will develop in response to growth and changes in the structure of employment and its intra-metropolitan area location, as well as the relative shift of metropolitan area population to the outside central city portions of metropolitan areas.

URBAN TRANSPORT NEEDS

Urban Travel Patterns

In the period of one generation, to 1985, urban travel patterns will experience a fundamental shift from a central city funneling orientation to that of a dispersed outside central city network. In the present scheme, travel patterns are dominated by workers living and working in central city, supplemented each day by a flow of workers living outside and commuting into central city. Less than one-third of all workers live and work outside of central city. By 1985, travel patterns will be reversed. One-half of all workers will live and work outside central city, supplemented each day by a margin of workers living in central city and working outside central city. Workers living and working in central city will make up only one-fifth of the work force. Workers commuting into central city will be equally matched by workers flowing out of central city. The typical urban travel pattern will be from one outside central city origin to an outside central city destination, over a longer travel route, without an increase in travel time. The line-haul trip to the central business district, hardly respresentative even of present travel patterns, will be an even smaller share in the coming generation.

Urban Travel Demand

Urban travel demand will increase notably in response to population growth, shifts in employment and residence location, the rise in household income levels and a related augmented preference for auto use, and changes in urban travel patterns. Daily metropolitan area person trips will double as a 50 percent rise in metropolitan area population is combined with a 50 percent increase in autos per household. Vehicle-miles of urban travel will much more than double in line with the increase in auto ownership, the changes in urban travel patterns, a one-third expansion in the urbanized land area, and an increase in average trip length. Auto-driver trips per person will rise by one-third in accordance with the increase in autos per household. Average trip lengths will be extended by one-third as a consequence of the modification of urban travel patterns. The overwhelming share of vehicle-miles will be in the outside central city portion of metropolitan areas. In effect, metropolitan area population 50 percent larger will double the present number of trips, whose length will be one-third longer, in line with the suburbanization of employment and residence locations, the up-grading of income levels and auto ownership, and the inversion of urban travel patterns.

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Auto Ownership

Autos in use will more than double and will be even more predominant as the preferred mode of urban transport. A greater share of households will use a larger number of automobiles. Auto ownership is closely associated with the distribution of households by income levels, the age of household heads, the regional location of the population, and the intra-metropolitan area location of residences. Households with incomes of $15,000 and over have more than twice as many autos as households with incomes of less than $4,000. Households living outside of central city have a 50 percent higher level of autos per household than is the case for those living in central city. Households living in the West have a one-fourth higher level of autos per household than households in the Northeast. In line with the projected rise in household income levels, the growth and shift of metropolitan area population to the outside central city portion of metropolitan areas, and the greater growth rate of metropolitan area households in the West, autos per household in metropolitan areas will rise by 50 percent, and metropolitan area auto use will expand by one and one-half times. The outside central city portion of metropolitan areas will raise their share of autos from 38 percent, in 1964, to 53 percent, in 1985.

Travel Mode Preference

Virtually all of the increment in travel demand will be by auto. Public transit trips will gain only marginally, because of the changing urban travel pattern and the preference for auto use. The share of intra-metropolitan area daily person trips by auto, presently over 80 percent of the total, will rise to over 90 percent by 1985, with less than one-tenth of all trips made by public transit. In large central cities with a metropolitan area population of 1 million and over, nevertheless, public transit will continue to account for more than one-third of journey-to-work trips.

Rapid Transit

Rapid transit will be substantially improved in the 5 cities with such systems, and some 6 or 10 new rapid-transit systems may be developed in other large cities, but this will hardly change urban travel demand and travel patterns. Rapid-transit person trips will increase only fractionally even with the operation of new systems. Nevertheless, where rapid-transit systems are in operation, they will be an important element of improved travel into central cities and central business districts. With travel into central city increasing only marginally, it will be easier to combine a range of transport measures to alleviate congestion and improve the ease of travel.

Consumer Expenditures on Urban Transport

Consumer expenditures on transport are third in importance after food and housing. The share of the consumer dollar spent on auto use will rise, while that for public transportation will decline.

Households Without Automobiles

All will not be rosy, however. While the share of households with no automobiles will be reduced by more than half, from the present one-fourth of all metropolitan area households, almost one-fourth of large central city households may still own no automobile in 1985. This prospect, together with the decentralization of jobs in metropolitan areas and the dispersion of housing and schools, will make for a continued hardship for low-income minority groups, as well as the young, the old, and the infirm, unless the evolving urban transport system includes features for effectively increasing their mobility.

Demand for Urban Freeways

In the context of the prospective nature of urban travel patterns, travel demand, and travel mode preferences, the demand for urban freeway-type travel facilities will dominate the expansion of the urban transport system. Nonlimited-access urban arterials, streets, public transit, rapid transit, and commuter railroads will continue to be an important part of the overall urban travel picture, but the configuration of future urban travel patterns, the doubling of trips, the expanded trip length, and the preferences for the auto travel mode, signify a prospect for a more than doubling of freeway route miles needed by 1985, after the completion of the urban portion of the Interstate System scheduled for 1972. In comparison with a present estimated need for some 12,000 route-miles of urban freeways, the requirement for 1985 may be 27,000 route-miles. This estimate of route-miles of urban freeway needed is based on the relationship of autos in use with freeway needs by metropolitan area size class, and central city-outside central city composition. Most of the addition would be for outside central city route-miles of freeways. Needed expansion of nonlimited-access arterials, in contrast, will be only some 50 percent plus above present levels. Urban freeways would account for the greater share of urban arterial and freeway vehicle-miles of urban travel.

Role of Urban Passenger Transport in the Economy

The urban passenger travel system is a major part of the whole economy, in terms of current expenditures on services and capital expenditures on facilities. Its share in the overall economy will increase over the next 20 years, in line with the expanding consumer preference for spending more of each additional dollar of income on urban transport and the increasing demand for more and better urban transport facilities and services. The aspect of the urban passenger transport system which bulks largest is that of automobiles and freeways. Of an estimated need for outlays of $88 billion for all types of transport rolling stock and facilities, in the year 1975, to meet transport goals, for example, more than half would be required for autos and urban highways. The estimated transport expenditure need of $88 billion for the year 1975 includes $39 billion for autos, $7 billion for urban streets and highways, $19 billion for rural highways, $7 billion for trucks, buses, and trailers, and $6 billion for highway maintenance, rapid transit, and new urban transportation methods; the remaining $10 billion is accounted for by the whole range of expenditures for railroads, ships and inland waterways, oil pipelines and air carriers, general aviation, airports, air navigation, hydrofoils, and air cushion vehicles. If these expanding expenditures signify a better supply of transport services, and an improved solution to urban transport needs, as well as a more efficient use of capital and manpower, thus contributing to the overall improvement in the productiveness of the economy, the role may be positive from all points of view. An improved, expanded and innovative urban highway system must be a major part of the evolving urban transport system, and will contribute to achieving these goals.

THE URBAN GROWTH CONTEXT

These prognoses for travel patterns, travel demand, and urban freeway needs flow from the perspective for urban growth in the context of the outlook for expansion of the national economy, and change in the structure of employment and its intra-metropolitan area location.

Future Urban Growth Patterns

In the generation to 1985, and in the framework of a larger but younger population, with higher income levels, living in an expanded urbanized area, there will be a substantial growth and shift of employment and residence location from central cities to the outside central city portion of metropolitan areas. There will also be a continued relative shift of economic activity, employment, and population to the Far West, though the North-East-Central megalopolis will continue to be the dominant center of population, production, and employment.

The nation will be principally an urban non-central city population; the bulk of residence, employment, and urban travel activity will be in the urban areas outside of central cities. Population and employment levels in central cities will be hard put to hold to present levels. Virtually the whole increment in population and most of the increase in employment will go to the outside central city portions of metropolitan areas. New housing will be principally single-family units in metropolitan areas outside central city.

Central cities, nevertheless, will continue to be viable as growth in service activities—government, business, and personal services—offsets, in part, declines in central city manufacturing and trade. This prospect, together with the respite provided by the relative shift of employment and residence to outside central city, will facilitate the revitalization of the central business district and the rehabilitation and renewal of grey areas.

Expansion of the National Economy

In 20 years' time, the population will be one-third larger and household growth even greater. Beginning in the 1970's, the birth rate will rise, despite a decline in fertility rate, in view of the sharp increase expected in the number of women in the childbearing ages.

Production of goods and services is expected to much more than double, growing even more rapidly than in the post-1945 generation, though somewhat less than in the 1960-66 period, as a more rapid expansion of the labor force complements more advanced economic and fiscal policies to insure sustained growth. Production and employment structure will change. Services, in general, and state and local government activity, in particular, will be the growth industries of this coming generation. In manufacturing, machinery and chemicals will have the greatest growth. This prospect for expansion of the economy, and change in structure, has important implications for regional and urban growth, and the inter- and intra-metropolitan area location of economic activity.

Prospective economic growth and the broad expansion of per capita personal income will shift a large share of all households into higher income levels, and this, coupled with the younger age composition of the population, holds great significance for the related demand for housing, residence location, travel mode, and urban services.

Employment Growth, Structural Change, and Shift in Intra-Metropolitan Area Location

Employment in the economy as a whole will rise by some two-fifths, by 1985, somewhat more than the anticipated growth in population, in line with the increase in population 14 years old and over, and the greater participation of women in the labor force. This rise in employment will be made up of a lesser growth in manufacturing and trade, and a larger expansion of government and other service activities.

This prospective development has a fundamental implication for the intra-metropolitan area location of employment. In the period 1948-63, central city employment in metropolitan areas with a population of 1 million and over hardly grew at all, as declines in central city manufacturing and trade offset a rise in service activity. Outside central city employment almost doubled, with increases in manufacturing, trade, and services. In line with new manufacturing, trade and transport technology, and in their quest for more space and better communications, with easier access to both rail and highway networks, manufacturing and wholesale trade enterprises shifted to outside central city locations. Retail establishments followed the customers outside central city. Service activity employment expanded in both central city and outside central city.

Reports on industrial and commercial construction activity, by intra-metropolitan area location, over the last five years, an indicator of future employment location, suggest that these trends in employment location may be expected to continue.

These intra-metropolitan area location factors, combined with the inferences on change in structure, suggest that most of the increment in employment to 1985 will take place outside of central city. This will reverse the central city-outside central city employment location distribution from 65 percent-35 percent in 1960, to 45 percent-55 percent in 1985.

Regional Location of Economic Activity

The Far West will continue to experience a population growth rate larger than that of the nation as a whole, favored by change in the structure of the national economy and the growing size of the migrating age group. Metropolitan areas of the North-East-Central megalopolis, stretching from Boston to Washington to Chicago, will continue to make up at least half of the nation's metropolitan area population. There are significant regional differences in urban travel patterns, and relative changes in the location of economic activity by regions, therefore, have important implications for future changes in urban transport systems.

Metropolitan Area Growth and the Intra-Metropolitan Area Location of Economic Activity

Metropolitan areas will undergo fundamental changes in structure as a consequence of the larger but younger population, higher household income levels, the change in production and employment composition, related changes in the location of employment and residences, and expansion of the urbanized land area. Virtually all population growth will be in the outside central city portion of metropolitan areas. The net increment in households will establish residences principally outside central city in accordance with the preference for greater space related to the rise in income levels, the younger age of household heads, and the shift of employment location outside of central city.

Since 1945, the outside central city portion of metropolitan areas has more than doubled its population, and surpassed that of central cities. Measured by the central city boundaries of 1950, central city population has not increased at all since that year. Since 1960, central city population, including that accounted for by the expansion of city limits, has been increasing at the very low annual rate of less than one-half of one percent. Large central cities have lost population. This relative shift of metropolitan area population reflects the effects of postwar mortgage lending institutional practices, postwar highway construction and automobile ownership, as well as population growth, employment location, and the rise in income levels.

For the future, the expected 50 percent increase in metropolitan area population, by 1985, will accrue wholly to the outside central city portion of metropolitan areas, raising their share of metropolitan area population to two-thirds. This will occur in the context of an upward shift of metropolitan area household income levels which will reduce the share of households with incomes of $4,000 and less, from one-fourth, in 1965, to one-eighth in 1985, and raise the relative importance of the $15,000 and over group from one-tenth, to one-third in these same years. Metropolitan area households will not only be more affluent, with a related preference for lower residential density outside central city, but a larger share of them will be in the "first home buying" age group. The share of households with heads under 34 years of age will increase by one-third from 1965 to 1985, making up one-third of all households in the latter year. In contrast, the 45-and-over age group, whose life-phase might support a return to central city, will increase only marginally in this period. These characteristics of higher income and younger age are also associated with a preference for single-family housing. The combination of higher incomes, younger age, single-family housing preference, westward population shift, and intra-metropolitan area employment location, all add up to an anticipated continuation of the relative shift of metropolitan area population residence location to the outside central city portion of metropolitan areas.

Household Formation and Housing Demand

Prospective housing construction in the 1970's and 1980's, to accommodate new households, replacements for demolitions, and the upgrading of housing demand in line with income growth, will increase our stock of housing by one-third and significantly improve its quality and change its location. All of the net increment in the housing stock will be built in the outside central city portion of metropolitan areas; two-thirds will be single-family units and one-third in multi-family and other types of units. Substantial renewal and replacement will take place in central cities, without adding to the housing stock there. Housing structure type, value class, and location are closely associated with distinctive types of urban travel needs and preferences, and will be a principal determinant in shaping expansion and change in urban transportation systems.

Expansion of Urbanized Land Area

Over the next generation, urbanized land area will expand by one-third to accommodate an urban population growth of almost one-half. Transportation requirements for such an expansion in urbanized land area will be substantial and add a new dimension to the urban transportation system.

BOSTON REGIONAL AREA URBAN GROWTH AND CHANGES IN URBAN TRAVEL PATTERNS—A CASE STUDY

In-depth studies of urban growth and transportation needs for the Boston Regional Area, covering some 150 cities and towns in a 30-mile radius from downtown Boston, have recently been made by the Boston Metropolitan Area Planning Council and the Eastern Massachusetts Regional Planning Project, and throw significant light on the interrelation of prospective urban growth and changes in urban travel patterns. These studies, looking ahead to 1975 and 1990, envisage a Boston Regional Area one-third larger, in terms of population, with per capita income levels almost doubling by 1990, as the past decade's upgrading of industry structure and jobs continues over the next quarter century. In the past decade, though the Boston Regional Area population has grown at a lesser rate than that of the nation as a whole, per capita income levels have expanded at a faster rate than the national average. New, higher wage and higher productivity jobs in electrical machinery, instruments, transportation equipment, research and development, higher education, medical services, finance, insurance, and real estate, and tourism, have substituted for the decline in lower paying jobs in textiles, leather, and fishing.

Even with a slower prospective population growth than that of the nation as a whole, the Boston Regional Area is expected to experience very substantial growth and change in the structure of its economy, and in the intra-regional area location of employment, and population residence. The Core Area, comprising the City of Boston, Cambridge, Chelsea, and several other municipalities, is expected to continue to lose population and employment, with all and more of the increment in employment and population going to the outer rings of the regional area, in response to the changing structure and location patterns of industry, and rising incomes and residence location preferences of the population. Nevertheless, the Core Area is experiencing a revival, even with its declining population density, as the expansion of service activities spurs an ambitious renewal program, and this may be expected to continue.

In this context, intra-regional travel patterns are expected to undergo a fundamental change, and travel demand is expected to more than double by 1990, with outside core cities travel making up virtually all of the increment in travel needs, and accounting for the bulk of Boston Regional Area travel. As a consequence of change and growth in the characteristics of travel requirements, vehicle-miles of travel on limited-access urban freeways is expected to increase three-fold, whereas travel on nonlimited-access arterials would grow by only half. As a result, urban freeway travel in the Boston Regional Area, in 1990, would make up three-fifths of total arterial and freeway vehicle-miles, in contrast to their present two-fifths share. Rapid transit trips would increase by some 15 percent. Transportation plans, based on these types of prognoses, indicate the need for broad expansion of radial and circumferential urban freeways to meet travel demand and to enhance the accessibility and viability of the City of Boston.

The projected dominance of urban freeway-type travel in the Boston Regional Area, despite its slower population growth, its rapid transit system, and its more compact make-up, has great significance for the expanding role of urban freeway type travel in metropolitan area growth in the nation as a whole. In Boston, as in other large and medium-size metropolitan areas, an expanded, improved, innovative, interconnected urban highway system, including radials and circumferentials, will provide an important part of post-1972 urban transportation needs.

PERSPECTIVES FOR GROWTH OF THE NATIONAL ECONOMY AND THE INTRA-METROPOLITAN AREA LOCATION OF EMPLOYMENT

In the coming generation, the magnitude and directions of growth in our national economy will bring with it a fundamental change in the structure and intra-metropolitan area location of employment. By 1985, central cities will no longer be the principal place of employment—marking a new turning point in the evolution of the economy. Elements in this basic change include the prospective growth and younger age composition of the population, an upward shift of households to higher income levels, a change in the composition of demand, and a broad expansion and change in the structure of production. With this, there will be a basic change in the location of economic activity, in line with new technology in manufacturing, trade and transport, and new levels of government, business and personal service activity.

Population

In the time of one generation, 1965-85, the nation's population will grow by one-third, a net addition of some 70 million inhabitants, representing a rate of increase comparable to the high population growth phenomena of the postwar generation, 1945-65. A large increase in the number of women of child-bearing age may be expected to raise the birth rate, despite a continued decline in the fertility rate. The anticipated large increase in the number of women of child-bearing age reflects another notable phenomena, the younger age composition of the population.

In the coming generation, to 1985, the under-45 population age group will grow by some 59 million, or one-third more than the increase in this same age group in the entire 35-year period, 1930-65. Of particular note is the extraordinary prospective increment in the 20-44 year age group, which had experienced only a marginal increase in the 1950-65 period (Fig. 1).

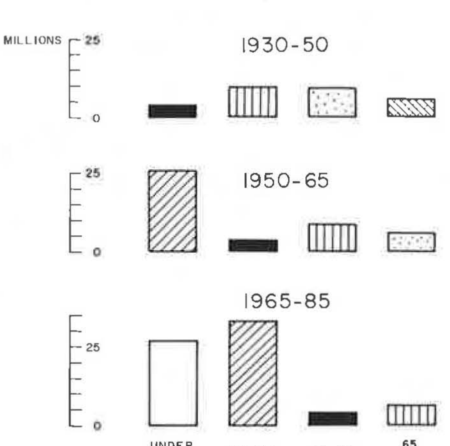

Figure 1. Population increase by age group.

Production

The larger but younger population growth will develop in the context of a more than doubling of the size of the economy in the next 20 years, in terms of the level of production of goods and services. With the new stage of sophistication of government and business fiscal and economic policy in the last decade, and a more rapid expansion of the labor force, future growth of the economy is expected to exceed that of the postwar period with its four minor recessions, though falling somewhat behind the extraordinary growth rate experienced in the 1960-66 period (Fig. 2).

Income Levels and Income Distribution

The order of magnitude of economic growth anticipated, will signify a broad upward shift of households to higher income levels. Even so, a small but still important share of households will still continue to live at poverty levels. Personal income, for the nation as a whole,

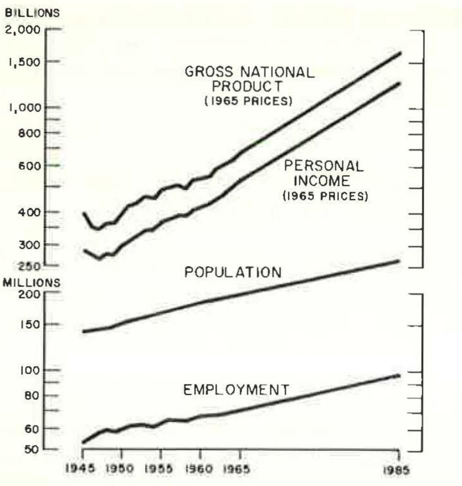

Figure 2. Growth in population, employment, production, and personal income.

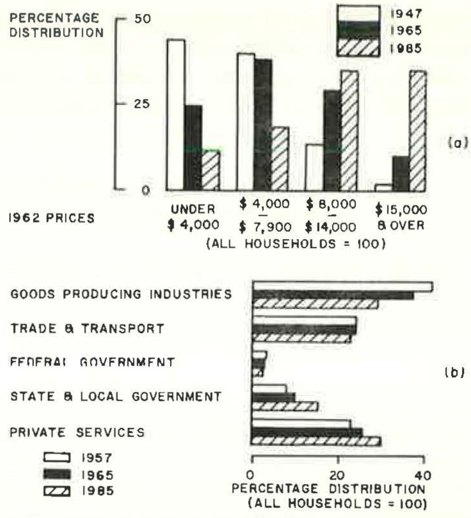

Figure 3. Distribution: (a) households by income level and (b) employment by industry.

doubled from 1947 to 1965, in constant prices, and is expected to more than double again by 1985, in accordance with the outlook for production growth. Personal income per household, which rose by one-third in the postwar generation, may experience an increase of more than 50 percent by 1985. Most significant of all, from the point of view of urban growth and travel patterns, is the postwar and prospective upward shift of households to higher income levels (Fig. 3).

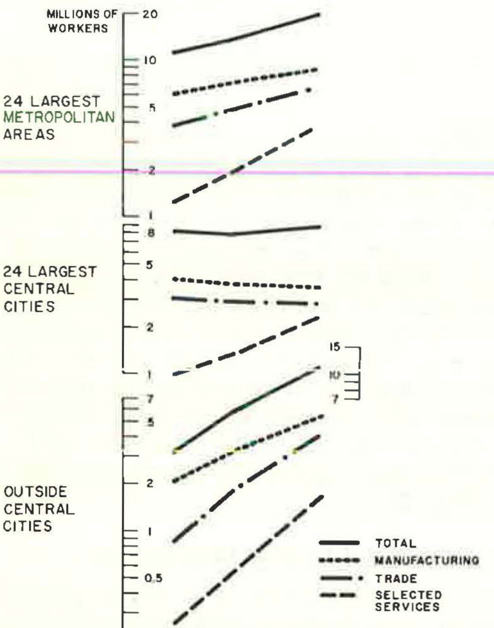

Figure 4. Employment in the 24 largest metropolitan areas in manufacturing, trade, and selected services.

Employment Structure

The prospective growth in population, labor force, and income levels will be accompanied by fundamental changes in the structure and intra-metropolitan area location of production and employment. For the economy as a whole, employment may be expected to grow by some two-fifths by 1985, a higher growth rate than that for population, in accordance with the larger share of 14 years old and over, and the expanding role of women in the labor force. More important, however, will be the anticipated change in the structure of production and employment, favoring the growth of government, business and personal service activities in comparison with agriculture, manufacturing and mining.

Intra-Metropolitan Area Employment Location

Growth and changing composition of metropolitan area employment have very basic implications for the intra-metropolitan area, central city-outside central city location of employment and related residence location and urban travel patterns. The postwar experience has been one of a basic dichotomy in the experience of central cities and the outside central city portion of metropolitan areas. Virtually all of the postwar growth in metropolitan area employment has gone to the outside central city portion of the metropolitan areas. For the 24 largest metropolitan areas, accounting for more than half of all metropolitan area employment, there has been no rise in employment levels in the postwar period, as a significant decline in manufacturing and trade employment in central cities offset a substantial rise in service activity employment (Fig. 4). In contrast, the outside central city portions of metropolitan areas virtually doubled their level of employment, absorbing all of the postwar increase in manufacturing and trade, and raising their share of total metropolitan area employment from one-fourth in 1948, to two-fifths in 1963.

For the future, suppositions on the central city-outside central city location of employment may be drawn from (a) information on recent metropolitan area nonresidential construction activity which is a precursor of future employment location, (b) future economic sector composition of employment with their specific location characteristics, and (c) the location preference, technology and institutional factors prevailing in the postwar period. These factors suggest that more than four-fifths of an expected 50 percent increase in metropolitan area employment, between 1965 and 1985, will take place in the outside central city portion of metropolitan areas. Employment levels in central cities are expected to increase marginally, nevertheless, with the large expansion in service activities under way and anticipated.

Future growth and change in the economic sector composition of metropolitan area employment suggests that, though the postwar and prospective outward shift of manufacturing and trade employment will continue to dominate the intra-metropolitan area employment location structure, the large expected future increase in central city oriented service activity will support the economic viability of central city. Factors of location preference and technology will continue to favor the outside central city areas for the expansion of manufacturing and trade, and these directions are not likely to be much influenced by heroic measures to bring them back to central city.

Economic Growth and Urban Development, A New Turning Point

The prospective emergence, in the coming generation, of the outside central city suburbanization of economic activity as the predominant location of production and employment suggests a fundamental turning point in the 200-yr trend of industrialization and urbanization in the United States. In broad terms, the whole long-term process of industrialization and urbanization of the economy can be described as a process of interaction of (a) rising levels of income and productivity; (b) related changes in the composition of demand, favoring, first, manufactures, and later services; (c) changing structure of production, in line with demand, productivity and technology, favoring urban oriented manufacturing and service activity location; and (d) the consequent urbanization of the population to accommodate the changing structure of demand and production. This process also involved the improvement of the quality and upgrading of the economy, in terms of levels of productivity, as the growth and relative shift of manpower and capital from one industry and location to another was associated with advances in technology, manpower education and the rising level of investment in plant and equipment per worker.

THE EMERGING METROPOLITAN AREA ECONOMY

Since the early 1960's, the outside central city portion of metropolitan areas has become the dominant locus of the nation's population. For the future, the outside central city portion of metropolitan areas may double by 1985, absorbing almost all of the increment in the national population. This expectation is associated with the anticipated upward shift in income levels, the younger age of household heads, the more rapid growth in the Far West, and the related preference for lower residential density and single-family houses in a suburban setting. The notable increase in household heads in the 20 to 44-year-age group combined with the upward shift in income levels will

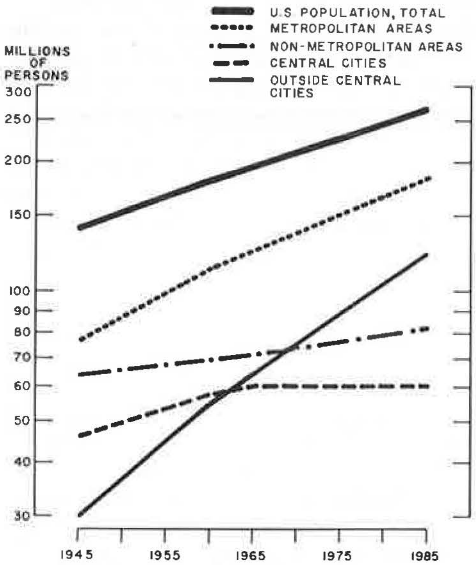

Figure 5. Urban population growth by central city-outside central city composition.

favor outside central city residence location. Conversely, the very limited growth in the over 45-year household head age group will limit the importance of the return to central city life phase in the 1965-85 period. Central cities whose overall population will not grow, despite a marginal increase in employment, will continue to have proportionately more of the very young, the old, and the poor, but the prospective change in central city employment structure will bring a new small flow of more affluent households to central city, while a share of lower income households will succeed in following manufacturing and trade jobs to the outside central city area. These developments will help revitalize central city economies, but special measures would be required, facilitating land-use changes, relocation of businesses and households, special financing, and redress for unrequited expenditures for central place functions benefiting the whole metropolitan area. Disadvantaged central city households will share less in the upward shift of income levels, and one-fifth of central city households may still be living below the poverty line in 1985 and have inadequate access to jobs and housing. While pressures toward Negro central city separatism are understandable, gains for the disadvantaged will come easier if access can be facilitated to outside central city jobs and housing. The magnitude of metropolitan area growth over the coming generation suggests the possibility for resolving many key urban problems in the context of this prospective growth.

Metropolitan Area Growth and Suburbanization of Population

In the generation 1945-65, metropolitan area population grew by 48 million, a rise of two-thirds, and accounted for all but 5 percent of the 50 percent population increase in the postwar period. As of 1965, metropolitan areas, defined as urban concentrations with central cities of 50,000 population and over, made up some 64 percent of the total population. The metropolitan area share had been 54 percent a generation earlier in 1945. Even more significant than this urban metropolitan area population growth, however, was the emergence of the outside central city area as the dominant locus of metropolitan area population (Fig. 5).

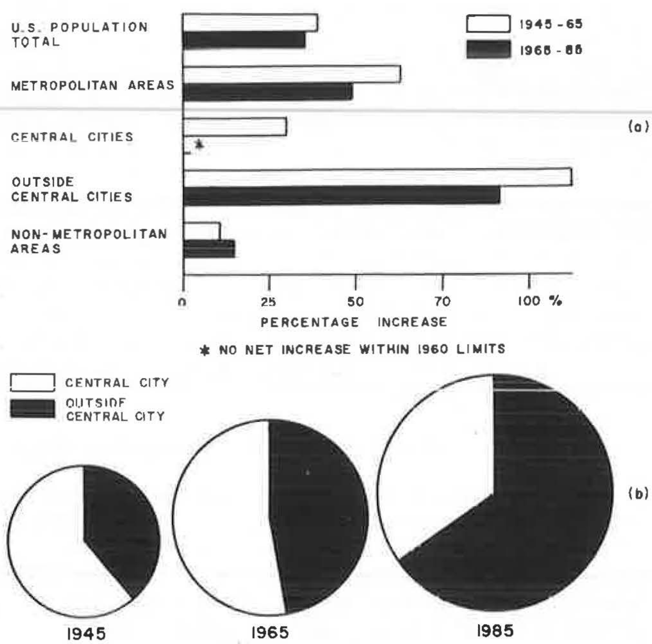

Figure 6. (a) Increase in urban population and (b) central city-outside central city composition of metropolitan area composition.

For the future, a population growth of 60 million in the outside central city area is expected to account for all of the anticipated 50 percent increase in metropolitan area population, and 85 percent of the projected 70 million rise in total U. S. population. While the metropolitan area share of total population would reach 70 percent by 1985, in comparison with 64 percent in 1965, the outside central city area population would make up two-thirds of that for metropolitan areas in 1985, in contrast to its one-half share in 1965 (Fig. 6). The population of the outside central city area, which more than doubled between 1945 and 1965, would almost double again by 1985. This pattern of outside central city population expansion would imply a continuation of the modest decline in the metropolitan area and outside central city area population growth rate experienced in the 1960-65 period in relation to the 1950-60 years. This overall pattern of no growth for central cities will be made up of continued marginal declines for central cities in the 24 metropolitan areas with a 1960 population of one million and over, offset by modest growth for central cities in metropolitan areas of less than one million.

Income Growth and Suburbanization

The broad upward shift of households to higher income levels in the postwar period was accompanied by an income growth related preference for lower residential density and outside central city living. By 1965, in line with the income growth related residence location preference, two-thirds of the affluent 46 percent of metropolitan area households having incomes of $8,000 and over were living in the outside central city portion of metropolitan areas. Conversely, in 1965, 78 percent of the disadvantaged one-fifth of metropolitan area households having incomes of less than $4,000 were living in central city. As a consequence of this pattern, households with incomes of less than $4,000 in 1965 made up 30 percent of all central city households and 9 percent of all outside central city households. With respect to the upper income scale households with incomes of $8,000 and over one-half of all outside central city households were in this category in 1965, in comparison with less than one-third of central city households.

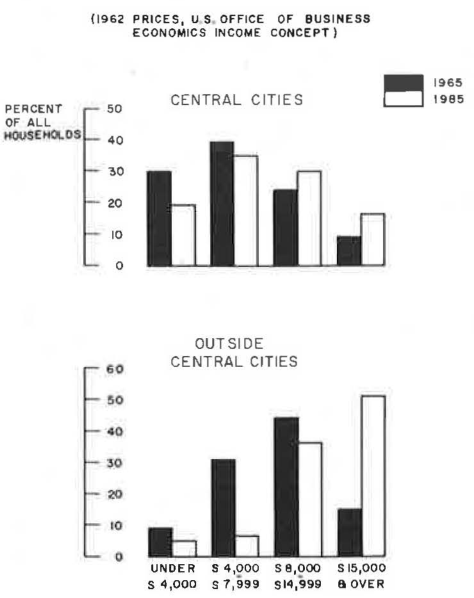

Figure 7. Central city-outside central city distribution of metropolitan area households by income level.

For the future, the anticipated growth and upward shift of households to higher income levels will also be accompanied by a further relative shift of households to outside central city residence location. In comparison with a one-third postwar growth in average household income, an expansion by more than half has been projected for the period 1965-85. In the context of the postwar experience, when central city population within 1950 boundaries showed no increase, the future expected upward shift in household income levels suggests that all of the 60 million increase in metropolitan area population, and more—some 18 million households, at least—will go to the outside central city portion of metropolitan areas. This prospect is complemented by the outlook for the growth in the number and share of household heads in the under-45-year age group with their related preference for single structures in a suburban setting. It is also supported by the perspective for continued relative shift of employment from central city (Fig. 7).

Viability of the Central City Economy

Despite the prospect for no growth in population and only marginal growth in employment, central city economies have a good potential for viability in view of the outlook for expansion of government, business and service activity in the context of an expanding national economy. Rising service activities in central city, offsetting an outflow of manufacturing and trade, will bring about a substantial change and upgrading of the central city labor force and the central city economy. The structure of households and their socioeconomic characteristics will change less, due to obstacles to mobility of disadvantaged central city population groups. Nevertheless, the potential for upgrading of jobs and income, and the change in economic function of central cities, together with the massive demolition and rehabilitation of structures that this would require, implies a possibility for substantial renovation of central city structure—in terms of public and private infrastructure facilities, as well as housing, including both slums and grey areas.

The achievement of this potential would require many things, including adaptation of land-use regulations to the changing needs of central cities, fiscal redress, and improved transport links with the expanding outside central city area.

NEW HORIZONS FOR URBAN TRAVEL PATTERNS AND URBAN TRAVEL DEMAND

A fundamental change in urban travel patterns, and an order of magnitude change in urban travel demand, may be expected in the coming generation. Urban travel patterns will shift from a central city funneling orientation to that of a dispersed outside central city network. Daily intra-metropolitan area person trips will double. These and other changes in the urban transport system will occur in the context of growth and structural change in the national economy, and related changes in the income, age and demand preferences of households, and the intra-metropolitan area location of employment and residence. Auto use in urban travel will become even more dominant, and the number of autos in use will double. Public transportation will be substantially improved with the introduction of many innovations and will continue to be an important part of the urban transportation system, even though public transit trips will increase only marginally. At least six new rapid-transit systems may be established, and existing systems will be sustantially improved and expanded, but the total number of daily passengers would increase only marginally. Growth in public transportation and rapid-transit travel will be limited by the dispersed location of employment and residence and the preference for auto use. At the same time, one-fifth of all households in large central cities may have no auto, even in 1985, and for this group, the urban transportation system may provide inadequate access to jobs. Auto expenditures will take an increasing share of the consumer dollar, while public transit outlays will absorb a declining portion. Urban auto and highway needs will account for more than half of all outlays required to meet total transportation goals, including needs for rural highways, trucks, buses, trailers, rapid transit, new urban transportation systems, waterways and ships, oil pipelines, railroads, airways and planes, and air cushion vehicles.

Workers' Residence and Employment Location

The relationship between workers' place of work and place of residence is one of the main determinants of urban travel patterns and urban travel demand. In this sense, with the suburbanization of population and economic activity, important changes in workers' residence and employment location have occurred in the postwar period, and fundamental changes are in prospect over the next generation.

In 1960, with the forces leading to the postwar decentralization of jobs and residences in operation for more than a decade, the outside central city portion of metropolitan areas was already approaching the relative importance of central cities as the place of residence, but central cities continued to dominate as the principal place of work. In that year, 53 percent of all metropolitan area workers lived in central city, while 65 percent worked there (Fig. 8).

For the future, looking ahead to 1985, the outside central city portion of metropolitan areas will be the dominant place of workers' residence location and work location. In the period 1965-85, the outside central city area is expected to absorb all of the 60

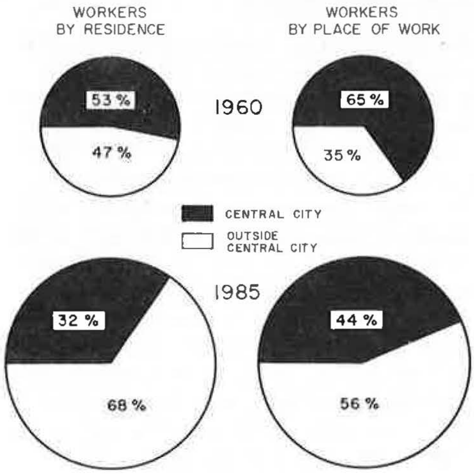

Figure 8. Workers' residence and place of work by metropolitan area.

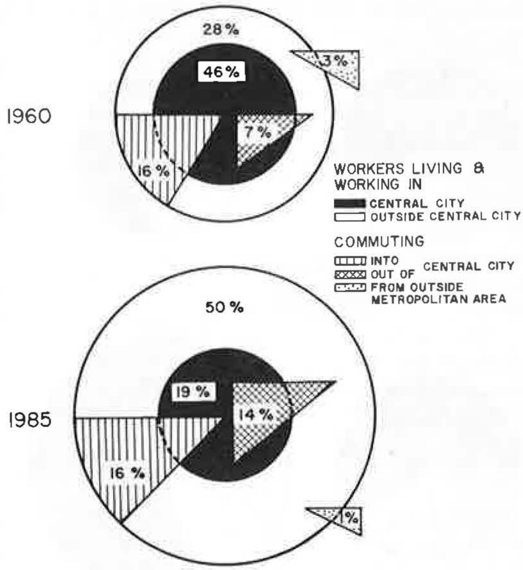

Figure 9. Urban travel patterns.

million increment in metropolitan area population, raising the share of workers residing in the outside central city area to more than two-thirds—twice that in central city. Central cities will fare somewhat better as a continuing center for workers' place of work, in view of the current and prospective expansion of government, business and personal service employment. Even so, with the continued outflow of manufacturing and trade, the outside central city area may be expected to be the place of work of more than half of all metropolitan manufacturing workers by 1985.

Workers' Commuting Patterns

The evolutionary change, postwar and prospective, in workers' residence and employment location signify the development of fundamentally new urban travel patterns. Based on these changes under way and in prospect, metropolitan area travel patterns may be expected to change from one in which the central city funneling function is dominant, to one in which dispersed travel from an outside central city residence to an outside central city place of work is the principal feature.

In 1960, most workers lived and worked in central city, and were supplemented each day by a margin of workers who commuted in from outside central city (Fig. 9). Only a small share of metropolitan area workers lived and worked outside of central city. In that year, 46 percent of all metropolitan workers lived and worked in central city, and were augmented each day by an additional 16 percent who commuted in from outside central city. Even then, however, some 28 percent of metropolitan area workers lived and worked outside of central city, and were complemented by some 7 percent of metropolitan area workers who commuted out daily from central city.

Looking ahead to 1985, the outside central city portion of metropolitan areas will be the principal place of metropolitan area residence and work, with new commuting patterns, from an outside central city residence to an outside central city work location, dominating, and obsolescing prevailing concepts. At least half of all metropolitan area workers will be living and working outside of central city. These outside central city workers will be supplemented by a daily flow of a margin of workers commuting out from central city, who will match the margin of workers flowing into central city. Only one-fifth of all metropolitan area workers will live and work in central city.

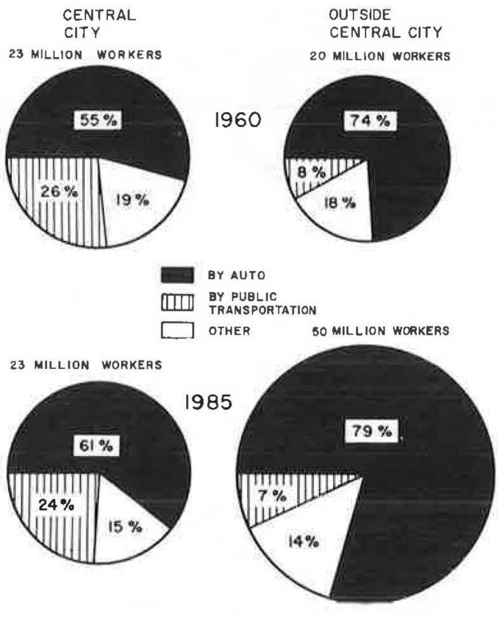

Figure 10. Workers' means of transportation.

Travel Mode Preference

These prospective fundamental changes in metropolitan area travel patterns are closely associated with travel mode preferences by central city-outside central city characteristics, as revealed in the 1960 census and in recent behavioral surveys. In effect, while the journey to work by auto is presently favored by more than half of all workers residing in central city and some three-fourths of all workers living outside of central city, the shift of population and jobs to the outside central city portion of metropolitan areas, with their associated higher levels of income, may be expected to increase the overall preference for autos as the dominant travel mode (Fig. 10).

Transport Needs of Disadvantaged Households

The prospective decentralization of jobs is likely to work hardship on those disadvantaged households living in central cities and having inadequate means of transportation to facilitate access to jobs. Even in the framework of a prospective broad upward shift of households to higher income levels, one-fifth of large central city households in 1985 are likely to have no automobile, and for this group, the problem of providing transportation access to take advantage of expanding job opportunities outside of central city is likely to be acute (Fig. 11).

Travel Demand

In the framework of expanding metropolitan area economies, expected to experience a two-thirds population increase between 1960 and 1985, urban transportation demand, in terms of intra-metropolitan daily vehicle-miles, is expected to much more than double by 1985. This anticipated burgeoning of urban transportation demand reflects a combination of (a) expected growth in the number of daily person trips as incomes rise and the labor force participation rate grows, (b) an enhanced auto travel mode preference, (c) a related increase in auto driver trips per person as the number of autos per household increases, (d) a rise in daily vehicle-miles per auto as urbanized land areas are extended and residence and employment locations are dispersed, and (e) an increase in the level of daily vehicle-miles per person arising from the foregoing factors (Fig. 12).

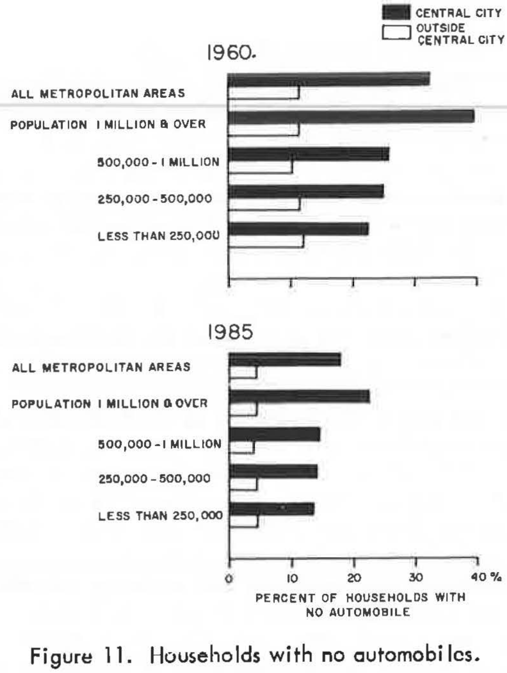

Figure 11. Households with no automobiles.

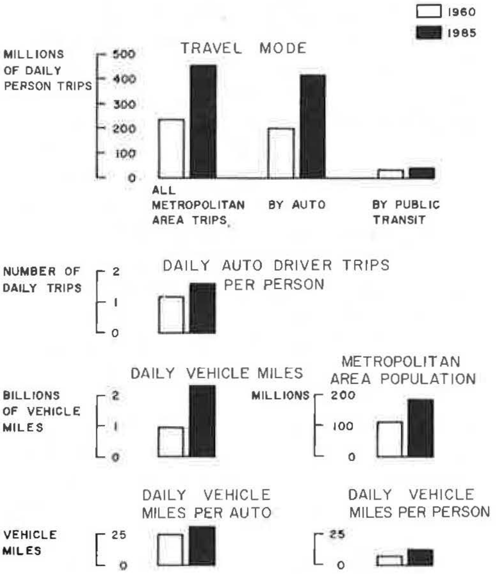

Figure 12. Intra-metropolitan area travel demand.

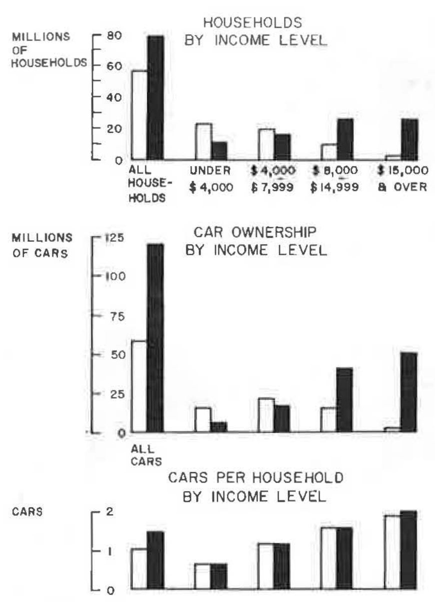

Figure 13. Car ownership and households.

Expanding Demand for Automobiles

In the perspective for urban travel demand, the outlook for expanded auto travel mode preference and the growth in the number of autos per household, by one-third in the course of one generation with a consequent doubling of the auto stock, has a key role. This outlook for expanded auto use is closely related to emerging urban growth patterns—growth and change in central city-outside central city residence location, rising household income levels, the younger age of household heads, and regional differences in growth perspectives.

In 1964, auto use varied radically by household income levels. Households in the nation as a whole had an average of 1.1 autos, but the 42 percent of households with incomes of less than $4,000 had 27 percent of the autos in use—an average of 0.7 autos per household. In contrast, households with incomes of $15,000 and over had an average of 1.9 autos per household (Fig. 13). The less than one-fifth of households in the $8,000 to $14,999 income class, and the more than two-fifths of households in the under $4,000 group, had the same share of autos, 27 percent.

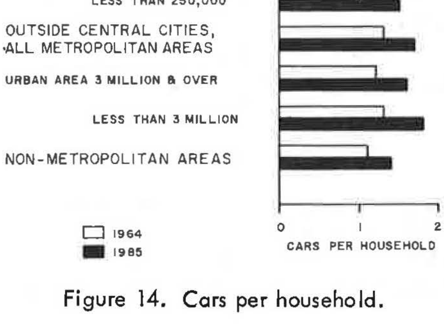

Figure 14. Cars per household.

Looking ahead to 1985, the growth in households and their upward shift to higher income levels will bring a doubling of autos in use. This will occur even if the 1964 rate of cars per household, by income levels, prevails in 1985. Households for the nation as a whole are expected to increase from 56 million in 1964, to 79 million in 1985, with a corresponding shift from one-fifth with incomes of $8,000 and more in 1964, to two-thirds in 1985. Assuming the same 1964 rate of autos per household, by specific income level, the number of autos per household would increase

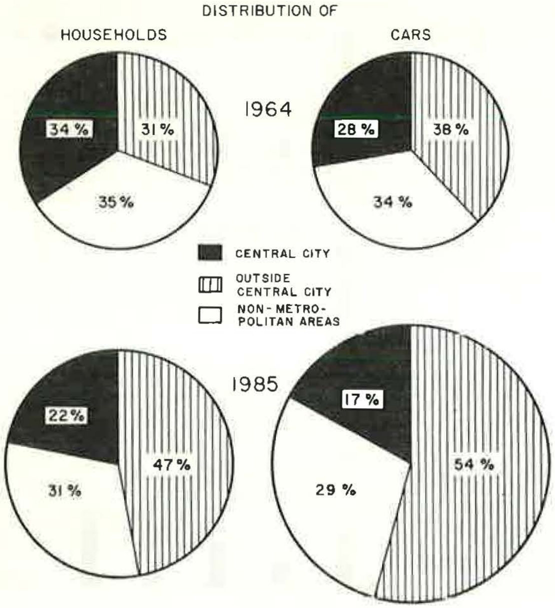

Figure 15. Cars and households.

from 1.1 in 1964, to 1.5 in 1985. The stock of autos in use would double. Households with incomes of $8,000 and over would increase their share of total autos in use from one-third in 1964, to three-fourths in 1985. This prognosis of a doubling of autos in use by 1985 is in line with other prognoses using other methods (Fig. 14).

Looking ahead to 1985, the growth and shift of households to the outside central city portion of metropolitan areas will bring about a substantial rise in auto use and a fundamental change in urban travel patterns and travel demand. The outside central city area may be expected to hold 47 percent of the households with 54 percent of the autos in use (Fig. 15). The corresponding central city share of households and autos would fall to 22 percent and 17 percent, respectively. Such a transformation will change basically the nature of urban travel patterns and travel demand.

Role of Public Transportation

Rapid transit and commuter railroad systems provided the means for the journey to work for 6 percent of all metropolitan area workers in 1960. The number of mass transit passengers has been falling since the end of World War II, as a consequence of the rise in household incomes, the suburbanization of the population, the expanding preference for auto use, the relative neglect of existing transit systems, and limited development of new ones. Nevertheless, for large central cities, those in metropolitan areas with a 1960 population of one million or more, rapid transit accommodated 16 percent of the workers in their journey to work and represented an important element of the urban transportation system.

Recent studies indicate a declining future relative role for rapid transit. The present study, with its indications of growth and change in residence and employment location, fundamental change in urban travel patterns, and basic expansion of travel demand, also suggests a limited though important future role for rapid transit systems. In the coming generation, potential travel densities, justifying the installation of new rapid transit systems, are likely to develop in only a handful of the largest cities.

URBAN TRANSPORT NEEDS

The demand for urban freeway-type travel facilities will dominate the expansion of the urban transport system, with a need for a more than doubling of route-miles of urban freeway by 1985, over and above that scheduled with the completion of the urban portion of the Interstate System by 1972. This need will flow from the new urban travel patterns, the enlarged travel demand, the increased auto travel mode preference, and a one-third increase in the urbanized land area.

The Need for Urban Freeways

Order of magnitude requirements for route-miles of urban freeway needed may be crudely estimated on the basis of the relationship of autos in use with freeway needs, as revealed in current urban transportation studies by metropolitan area size class and by central city-outside central city composition. A recent study suggests a need for

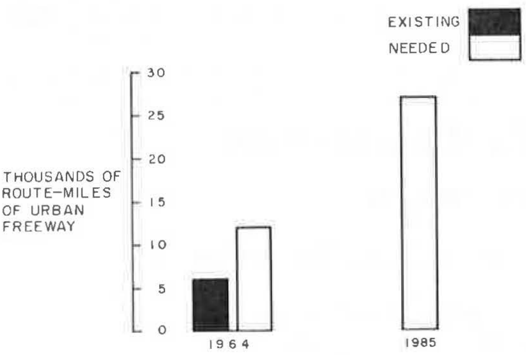

Figure 16. Urban Freeways.

2.5 to 3.5 route-miles of urban freeway per 10,000 autos, with the smaller requirements for large central cities, and the larger requirements for the smaller outside central city portion of metropolitan areas. Applying this criterion to autos in use in 1964 by metropolitan area central city-outside central city composition results in a hypothetical estimate of 12,000 miles of urban freeway presently needed—or roughly that called for by the time of the scheduled completion of the urban portion of the Interstate Highway System in 1972—about twice that existing in 1964, reflecting a substantial unmet present need (Fig. 16). Applying this same rule of thumb to the projected level of autos in use in 1985, by metropolitan area central city-outside central city size class, suggests a hypothetical need by 1985 for twice the route-miles of urban freeways scheduled for 1972.

Need for an Enlarged, Dispersed, Improved, Innovative Metropolitan Area Transportation System

While urban freeway type travel will be the dominant urban transportation mode of the future, more freeways alone would not resolve some of the key urgent transportation problems of the expanding metropolitan area economies. Trips would be substantially lengthened for the doubled population of the portion of metropolitan areas outside central cities. Multiple freeway lanes would pyramid. There would be a need to provide means to improve job accessibility, facilitate a wider choice in housing, and ease travel to education parks, while enhancing safety and paying due respect to aesthetics. The future transportation system must also aid the physical integration of the spreading metropolitan areas through improved spatial mobility. There is the important need to aid the viability of the central city through better freeway linkages.

All of these elements suggest the need for innovation in the expansion of the urban transport system. A key element must include devices for semi-automated travel over urban freeway type systems. Such an innovative urban transport system must be made up of radials and successive circumferentials to provide a flexible, multi-directional urban transport pattern. The system must provide speedier and more convenient travel over an expanded urbanized area.

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Toward Measurement of the Community Consequences of Urban Freeways

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The purpose of this paper is to propose a strategy for quantitatively estimating the community or social consequences of transportation projects. Specifically, a new measure—the residential linkage—is defined and its importance demonstrated through reference to the sociological literature. The application of this measure to the spatial definition of urban communities and the evaluation of alternative transportation plans is then illustrated.

•THE objective of this study is to explore quantitative strategies for incorporating consideration of community consequences into the urban transportation planning methodology. This purpose is value-free in that it does not imply that community impact should always be estimated when planning transportation projects. Rather, it is based on the assertion that public decision-makers may explicitly formulate community objectives, such as "improve the quality of the urban environment" and "increase the diversity and number of opportunities for residents," and ask the transportation engineer to estimate the relative contribution of alternative plans to the achievement of these goals.

There are several reasons to suggest that decision-makers will increasingly request transportation planners to evaluate the community impact of alternative plans. Numerous political controversies have developed throughout the country with regard to the location and design of major urban transportation facilities. Examination of these controversies demonstrates that the impact of the facility on the social and spatial environment through which it passes is usually the single largest cause of political opposition to a facility. Furthermore, this opposition has led to considerable delays in, and even curtailment of, elements of the transportation program (1).

Even a cursory reading of the newspapers suggests that individuals and groups are concerned about the consequences of transportation investments. Most frequently this has taken the form of protest concerning alteration of the environment in the immediate vicinity of the individual or group. A review of these controversies suggests that it is extremely difficult to identify much less measure or predict, the community consequences of transportation investment decisions. Community consequences identified in route location controversies are usually negative. Although progress is being made (2), a potentially large spectrum of positive consequences has been generally unexplored by both opponents and proponents of transportation projects. The neglect of these positive consequences has resulted in a strong emphasis on negative impacts and their amelioration. In addition, various authors have observed that other consequences, particularly impact on the social structure of an area, are important and neglected (3, 4, 5). It is apparent that the impact of a transportation facility on the community through which it passes is not sufficiently understood.

Merely predicting the aggregate consequences of transportation investment is insufficient since the distribution of these consequences is also relevant. Various individuals and groups (distributed in social, spatial, and temporal dimensions) are

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affected by transportation projects. It is clear that the impact of transportation investments on them is of considerable relevance to the decision-maker, if for no other reason than overlooking these impacts will result in citizens attempting to have their opinions considered through other channels. To summarize, the prediction of transportation impact on the urban community is an important and difficult task.

In the past decades, American society has become increasingly urbanized and wealthy. A national policy of concern with the "quality of life" implicitly places considerable import on the quality of the urban environment. In spite of the considerable wealth available, national resources are limited. It is imperative to analyze the contribution of each government program to the achievement of social, economic, developmental, and other goals. In view of the enormity of the problems of the American city and the major public and private expenditures devoted to urban transportation, it is particularly important that transportation programs be developed which maximize the derived social and economic benefits. Planners must view the transportation program as a versatile and powerful tool for shaping the macro and micro structure of the urban environment in accordance with prespecified political, social, and economic goals.

These observations are substantiated by the outcome of the Second National Conference on Highways and Urban Development (6) held in December 1965, at Williamsburg, Va. It concluded with an agreement on several basic principles, known as the "Williamsburg Resolves" which recognize that transportation is but one element in the total scheme of urban planning and, consequently, cannot be evaluated as a separate and individual function. As stated in the report:

> Planning agencies should emphasize the identification and evaluation of urban values and goals as an integral part of comprehensive transportation planning. There should be encouragement of research to develop more systematic techniques for rating all values and costs to be weighted in evaluating urban plans.
>
> The planning and development of facilities to move people and goods in urban areas must be directed toward raising urban standards and enhancing the aggregate of community values, both quantifiable and subjective; it should be recognized that transportation values (safety, comfort, beauty, convenience and economy in transportation) are a part of, and are to be given proper weight in, the total set of community values (6).

This research will concentrate on formulating a framework within which the transportation planner can structure his approach to estimating community impact and to measuring the contribution of alternative plans to the achievement of higher level societal goals. It will not provide a definitive methodology for evaluating community impact. Theoretical and empirical knowledge of the urban community is insufficient to permit such an approach. Furthermore, each transportation design problem is different and may require a unique analysis.

Mere estimation of community impact will not alleviate fears of urban freeways or quiet political controversies. It can provide an information base for comparing the effects of alternative locations and designs. If experiments can be devised to estimate the value implications of various levels of consequences, planners and decision-makers may have a firm quantitative foundation on which to base their decisions.

PERSPECTIVES FOR CONSIDERING COMMUNITY CONSEQUENCES

Many definitions of community have been presented in the literature (7, 8, 9, 10, 11, 12, 13). Two basic elements recur in most definitions: social interaction and spatial propinquity. Individuals and groups become involved in mutual activities through participation in organizations which have as their goal the satisfaction of physical, social, and psychological needs. A community is defined by the occurrence of this interaction within an appropriately limited spatial field.

Numerous approaches may be pursued for developing enhanced measures of community disruption. Each of the following strategies starts from a different perspective of the urban community. The first approach views the community as a distribution of power and is concerned with developing plans which will be approved and implemented. The particular analysis used depends on the perspective of the political decision process. If decisions are reached within the context of pyramidal power structure (14, 15), the analysis would concentrate on developing a plan which is acceptable to the leaders of the community. If decision-making is more diffuse and numerous groups, either alone or in conjunction, can defeat a plan (16, 17, 18), the analysis must be concerned with developing a plan which satisfies enough groups so that the plan is implemented. Dean (19) has proposed a model which specifies the minimum cost program for achieving this goal.

The advantage of evaluating community consequences in terms of the requirements for plan implementation is its intrinsic usefulness in getting facilities built. The approach shifts the burden of evaluating the consequences to the individuals and groups affected. Since these people have limited access to advanced technical information, they would tend to emphasize obvious factors such as aesthetics or level of sound. Further, some groups are more adept at exerting political influence than others, and their perception of the situation would be more intensively considered. Thus, important consequences might be ignored in the decision process and the differential effect distorted. It would appear desirable to develop an approach which allows for a more comprehensive and equitable application.

Another perspective views the community as an aggregate of people living in a specified geographic area. It hypothesizes that resistance to a facility is related to the existing organizational structure and defines this structure using various demographic indices (20). To the degree to which measures of community organization are a surrogate for potential disruption, these indices estimate community impact (21).

This approach focuses on the area traversed by a facility and defines the socioeconomic characteristics of the resident population. In this sense, it provides a better estimate of community impact than viewing the community as a distribution of power. On the other hand, the use of demographic indices to estimate community impact suggests that the consequences of a facility are independent of its characteristics. Thus, an eight-lane depressed facility would have the same consequences for the area traversed as an eight-lane elevated route. Further, the approach does not intrinsically allow for the empirical definition of community, and it would be stretching the point to suggest that the census tracts for which the indices are usually estimated correspond in any but the most general way to distinct communities. Viewing the community as an aggregate of people fails to define the community or to specify the impact process.

An alternative and more interesting perspective views the community as a system which has certain social and physical requirements for proper functioning. Within the framework of the community, a process of interaction takes place among the residents. The community consequences of a transportation project, then, are changes in the system as estimated by measuring perturbations in the process of interaction. Application of this approach is dependent on empirical measurement of the interaction process.

Emphasis on the interaction aspect of community is not original here. Sanders (11) places a heavy emphasis on the social importance of communication and the community as an arena of interaction. Meier (22) suggests that cities have developed out of the need for human communication and utilizes information theory to develop a framework for examining the communications process. Webber also emphasizes the importance of interaction as a concept for understanding the urban community: ". . . [It is] important that we also see the city as a culturally conditioned system of dynamic interrelationships among individuals and groups as these are modified by their locational distributions" (23). He suggests that "we can supplement our analyses by viewing the distribution of human activities as spatially structured processes of human interaction" (23). These citations emphasize the importance of interaction as a vehicle for examining the concept of community.

Bernard (7) discusses interaction in the context of the community's institutional structures and not from the perspective of the individual. Thus, he concentrates on aspects of the community subsystems, particularly their role in maintaining group norms and the processes of competition and conflict which develop among them. The role of the individual is emphasized in the literature of small group research (24) and interpersonal relations (25). Sociograms, aspatial plots of the pattern of social contacts among individuals living within a limited area, are used to study relations and their influence on the communications process (26). In their present form, sociograms are of limited usefulness for examining the consequences of transportation projects. Other contacts, such as relations with churches, stores, and schools, may also be of importance to households. Further, it is important to examine these contacts in a broad spatial context.

TRANSPORTATION IMPACT AND THE INTERACTION PERSPECTIVE OF COMMUNITY

Previous efforts to identify the community consequences of transportation projects have generally considered: (a) impact on various actors, including the individuals involved and the local government of the taking of property for the right-of-way; and (b) impact on the community, frequently referred to as "community disruption."

The delineation of these consequences is only as useful as the operational measures which are employed to define each impact. The effect of taking property is generally measured by the number of households or people and firms or employees who must be relocated. Consideration is sometimes given to the physical condition of the properties to be demolished and to the availability and location of new sites for the relocated people and firms. There is considerably less consensus on appropriate measures of community disruption, and serious methodological and conceptual difficulties have been encounterd in simply defining communities on the map (27, 28, 29). Impacts on the levels of public services, such as police and fire protection and accessibility to schools, have been used as measures of community effects (27, 30).

Two criteria appear important for evaluating measures of the community consequences of transportation projects: (a) How well does the measure spatially and socially define the community involved? (b) How well does the measure define the impact on the community of a proposed transportation facility?

One strategy for minimizing community disruption would locate the transportation facility so that it does not traverse the community. Such an approach requires that communities be spatially defined through either empirical or theoretical procedures. Examination of an aerial photograph or map of a metropolitan area shows that residential areas sprawl in all directions and these materials offer little assistance in defining communities. Urban areas are undergoing rapid social and physical changes, and procedures which define communities on the basis of a homogeneity of socioeconomic variables fail because of the considerable heterogeneity which is empirically observed (31, 32).

Researchers attribute spatial and social properties to a community; therefore, it is important to establish empirically the social interaction taking place. Complete definition of a community implies measurement of both the boundaries and the internal organization. Human interaction takes place within a physical and social framework which may be necessary for the proper functioning of the community. Physical elements such as a park, a bar, or a school may be critical points in the physical structure within which the life of a community takes place. In the West End of Boston, Gans found that commercial establishments served as important communication centers for the people of the community, but that the settlement houses were comparatively irrelevant to their daily lives (8). Similarly, certain individuals or social institutions may play important roles in the community. Thus, the specification of the community is not complete without the identification of the framework within which interaction takes place.

The second criterion is concerned with the quality of an index as a measure of the effect which a transportation or other facility has on the community. The community operates in a social and physical framework which has developed over time. The development of a new facility, such as a freeway, may shock this framework in a variety of ways. The important meeting locations, such as schools, churches, parks, or stores, may be removed. People playing key roles in the community may be relocated. Individuals may find it more difficult to communicate because of the barrier effect of a facility. Alterations to the framework affect the functioning of the community and this is the "community impact" which it is desired to measure. Since this functioning is essentially a process of interaction, the community consequences of a transportation facility may be viewed as perturbations in the communications process. Measures of community effects must, therefore, be concerned with estimating alterations to this process of interaction.

In the light of these criteria, it is apparent that current measures of community impact are deficient in several respects. Although schools may play an important role in a community, they are not the only important institution and their boundaries may be quite arbitrary. Since individuals are required to attend school and are administratively assigned to a specific location, changes in school service would appear to be a poor measure of community effect. Police and fire service districts are essentially administrative constructs, and there is little reason to believe that they correspond to communities as they have been defined.

Clearly, the number of people or employees who must be relocated is an important measure of community effect. Through consideration of the quality of the buildings removed and the availability of nearby alternative sites, an estimate is obtained of the effect of this forced relocation on the individuals involved. These measures do not, however, estimate the importance to the individuals of being located at the given site. Further, they do not consider the effects for those remaining in the area of removing some sample of the total population. Thus, the existing measures are deficient in that they do not permit a meaningful definition of community or a good estimate of the differential effects for individuals and communities.

DEFINITION OF RESIDENTIAL LINKAGES

By viewing the community as a process of interaction, considerable insight may be achieved into the impact of a transportation facility on the region through which it passes. It is suggested that the concept of a "residential linkage" be used as the basic tool for operationally implementing the theoretical view of the community as an interaction of its inhabitants.

Residential linkages may be defined as "ties between the housing site of the household and other spatially distinct points which are of importance to the individuals involved." The specification that a linkage exists implies that communication, but not necessarily a movement of people or goods, will take place between the housing and activity site. In the vocabulary of the transportation engineer, the residential linkage is a "desire line" for communication. The aggregation of the desire lines for all of the individuals in the community represents the process of interaction from the viewpoint of the individuals involved.

Any type of activity may take place at the nonhomesite end of the activity linkage. Certain types of linkages, to workplaces, stores, and friends or relatives, are probably close to universal, while others, to schools and churches are quite common. Still less frequent would be linkages to recreation or entertainment sites. Since the linkages are spatially defined, some methodological difficulty may be created by the occurrence of an activity, such as a social club, which does not have a consistent geographic location. Such activites should be included in the analysis, and the problem may be overcome by considering the most frequent locations for the activity or by defining a locus of locations and determining the centroid of this locus.

Existence of a linkage implies that some form of communication takes place. The impact of a new transportation facility on the linkage would appear to be a function of the mode of communications being used. Clearly, the impact of a new freeway on mail or telephone service is comparatively minor, as compared to its potential impact on the pedestrian and public and private transportation subsystems. Thus, it could be argued that the empirical determination of linkages should be confined to determining those linkages in which a physical transfer of people or goods takes place between activity sites. Whereas data on vehicle trips have been obtained for metropolitan areas throughout the United States, walking trip data are comparatively rare.

Determination of the importance of the linkage to the individual is particularly difficult since it involves measurement of levels of satisfaction. At least two aspects of importance can be distinguished: linkage substitutability and frequency of communication. The importance of a linkage would appear to be inversely related to the facility with which an alternate linkage could be developed. Unless a store serves other than commercial functions, it is comparatively simple to stop shopping at one store and begin shopping at another. Establishing a new linkage at a church or school or with an individual involves considerably more cost. It is hypothesized that the latter linkages are less substitutable and, therefore, more important to the individual.

A taxonomy of linkage types, perhaps based on ease of substitutability, would appear important. Within each linkage type, importance would appear to be a function of the frequency of communication. The linkage to the food store which is visited three times a week is considerably more important than the linkage to a furniture store which is visited once a year. Similarly, frequency of interaction provides an interesting, if not totally satisfactory, measure of the importance of friendship linkages.

STRUCTURING THE TRANSPORTATION IMPACT PROCESS

The transportation impact process may be defined as the set of events which transforms transportation system outputs, such as altered accessibility and environmental quality, into a final set of consequences, such as changes in land value and mobility. The residential linkage construct may be utilized as a vehicle for structuring a perspective of this impact process. Such an impact framework is shown in Figure 1.

A change in the transportation system, such as the opening of a new freeway or rapid transit line or the introduction of a change in service, may have a number of effects. If the individual's linkage pattern and frequency of interaction remains constant and he uses the changed facility, his communications costs would change. Thus, the introduction of a new freeway would cause a cost reduction, whereas the termination of service on a bus line would have the opposite effect. This alteration to the transportation system might also result in a change in the communications cost of nonusers of the altered facility or service. The barrier effect of a new freeway may considerably increase the cost of traverse movement, particularly for interactions using a walking or public transportation mode. If everything else remained constant, introduction of bus service on an arterial would tend to increase the travel time for other vehicles.

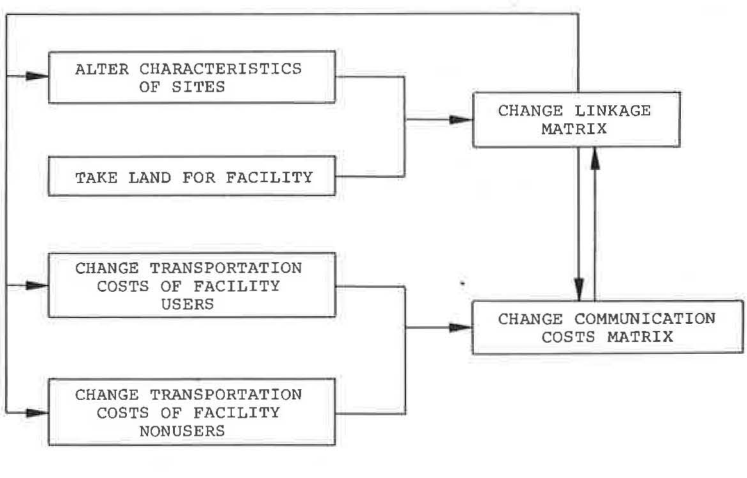

Figure 1. A framework for viewing the transportation impact process.

The net effect of these two changes is a transformation in the matrix of communications costs which, in turn, may cause the termination of some linkages and the initiation of others. Another store may be substituted for the one which is now on the other side of a freeway. A park, which previously took a 30-min drive to reach, is now visited because the travel time has been reduced to 10 min. The temporal aspect of mutations in the linkage matrix should be recognized. It might take months or even years for the individual to alter his linkage matrix in response to changes in the transportation system.

Linkages may also be altered because of the taking of land for a new facility. The individual or activity at either end of the linkage may be forced to relocate. To maintain consistency with the view that linkages are geographic specific, the maintenance of a tie to a relocated activity is viewed as the termination of an old linkage and the initiation of a new one. In some circumstances, the activity may cease to function. Parks may be taken for the right-of-way and not replaced and stores or institutions may cease operation.

Changes in the transportation system may also alter the characteristics of the linkage ends. The relationship between the construction of transportation facilities and the quality of the physical environment has been repeatedly emphasized. Changes in sound level, aesthetics, quality of the atmosphere, drainage, and safety may cause individuals to terminate linkages and to initiate others. Linkages may be altered by changes at the nonresidential or the residential end. A playground built on an excess portion of land purchased for an expressway may be used instead of the street. People may choose to terminate all of their existing linkages by moving to another residential site.

Individuals may also initiate linkages as the result of changes in communications costs and characteristics of the linkage ends. This possibility enters a feedback element into the flow model. Additional demand would alter the characteristics of most nonresidential linkage ends. A store might become more crowded and thus a less desirable place to shop. Since the cost of transportation is related to the demand (33, 34), the increased use of transportation facilities implicit in the initiation of linkages would alter the communications costs for users and nonusers of the facility. The impact process is, therefore, iterative although it is hypothesized that the process has internal equilibrating tendencies which result in the establishment of new, reasonably stable residential linkage and communications cost matrices.

This impact model could also be applied to the urban environment served but not traversed by a new transportation facility, although the relative importance of certain elements would be diminished. The impact of the facility on the termination and initiation of linkages because of alterations to the physical environment and relocation would be considerably reduced. This would lead to a greater emphasis on changes in the communications cost matrices and the resultant mutations of the pattern of residential linkages. Transportation and other communications modes can be substituted for spatial proximity as a means for allowing interaction.

RESIDENTIAL LINKAGES AS A MEASURE OF COMMUNITY

If communities can be spatially defined within a metropolitan area, the possibility exists of constructing expressways in corridors which bound rather than traverse communities. The route chosen through such an analysis should be the one which minimizes community disruption. Numerous approaches, perceptual (35, 36, 37, 38), ecological (29, 39), and empirical (28), have been investigated for use in spatially defining communities. In view of the mixed results of these previous efforts, the use of residential linkages as a measure of community appears to offer some promise. Through the application of an appropriate survey instrument, the residential linkages of the population in the study area would be defined. The essence of the procedure is to define communities through the delineation of concentrations of linkages. If loci of linkages were not observed, considerable doubt must be cast on the concept of urban communities as anything but historical constructs having a potential symbolic importance.

The precise operationalization of the procedure is, of course, dependent on the objective of the analysis and the resources available. One extremely simple but interesting algorithm for defining communities is the following:

1. Through survey methods, linkage data are obtained for households living within the study area. Since the purpose of the analysis is to define communities within this area, all linkages to regions outside the study area are discarded.
2. A zonal system is defined for the area. The size of the zone might vary from a block face or block to the dimensions of a census tract or travel anslysis zone, depending on data available and the size of the study area. The linkage data are appropriately adjusted and coded to the zonal grid.
3. Interzonal linkage data are tabulated and adjusted for the population of the origin zone to obtain an interzonal linkage rate. If the totals for the interzonal linkages were employed, differences in the levels of resident populations might distort the results.
4. Since the algorithm in its present version associates adjacent zones, it is necessary to map the matrix of interzonal linkage rates into a matrix showing adjusted linkage rates for adjacent zones. This may be done by considering the transportation routes as indicated in the survey data and summing rates at zonal boundaries. Alternatively, a set of routing rules could be developed and the rates summed. Finally, the rate from I to J and J to I is summed to yield an interchange rate between I and J for each pair of adjacent zones.
5. The zonal pair with the highest adjusted linkage rate is associated, the cell removed from the matrix, and the process is repeated. It is hypothesized that if communities do exist, clusters of zones (i.e., a community) should become evident. The analysis would terminate when each zone is associated with a cluster.

Aside from the somewhat tedious linkage rate adjustment procedure, this algorithm is extremely simple in both conception and execution. Two improvements would appear particularly desirable: the elimination of the adjustment procedure and consideration of the relative importance of different linkages. The former objective could be achieved by using an algorithm which ignored geographic proximity and associated zones in order of decreasing total interzonal linkage rates. The difficulty with such an algorithm is, of course, that there is no guarantee that geographically contiguous communities would be defined. These results would, in themselves, be of considerable interest.

The difficulty of evaluating the importance of various linkages has already been noted. Two dimensions of importance: substitutability, as approximated by linkage type, and frequency have been suggested. One method would apply the previous algorithm to each linkage type using linkage rates which are weighted by frequency of interaction. Different zonal aggregates, or communities, might result from the applications of the algorithm and some sort of adjustment procedure would be needed to develop the final set of community boundaries.

Other extensions of the procedure include the use of more sophisticated zonal grids and consideration of the ratio of the internal to study area over external to study area linkage rates. The use of a more complex geometrical arrangement of zones, as for example a hexagonal pattern, is suggested as a means for alleviating the previously noted adjustment problem. Of course, the boundaries of the zones must be adjusted to the circumstances existing in the study area. Considerable attention has recently been devoted to the wide range of contacts of urban residents (40, 41, 42). The ratio of the linkages within some specified geographic area over the linkages outside the area would provide an interesting measure of the importance of spatial propinquity. It seems clear that the importance of the local community, as measured by this ratio, is a function of the nature of the activity and the socioeconomic characteristics of the resident population.

The question of whether a community exists could be viewed as a simple hypothesis testing problem. The null hypothesis, that a community does not exist, implies that linkage rates are the same in all directions, although subject to some random variation. The test hypothesis, that a community does exist, implies that the linkages would tend to focalize. A measure of the spatial orientation of linkages could be derived and the parameters of its frequency distribution for the no-community case established. It would then be reasonably simple to test the null hypothesis that a given estimate for a study area is the result of random variation.

EVALUATION OF THE COMMUNITY CONSEQUENCES OF TRANSPORTATION PROJECTS

For many, if not most, transportation projects it would be impossible to locate the facility so that it bounds rather than traverses all of the communities in its path. Further, in many situations, it will not be possible to establish empirically precisely defined communities. This discussion will consider a methodology for defining the community consequences of transportation projects for the traversed urban environment. Its objective is to define an information package on community effects which, when combined with information on other consequences, outputs, and costs, will allow decision-makers to choose among alternative transportation investment programs. It is suggested that some of the material, particularly the discussion of the relocation of people and facilities, may have application when the same issue arises in connection with other urban programs.

The thrust of this discussion is that changes in the matrix of residential linkages may be used to evaluate and compare the community consequences of alternative transportation facilities and locations. Through this approach, a useful beginning is made on defining a measure for the previously incommensurable impact of "community disruption" and on providing an information base for considering the implications of relocation. The proposed information packages should be viewed as prototypes subject to modifications resulting from the needs of decision-makers, problems encountered in operationalization, and the conclusions of further research.

Before presenting this material, the danger of attributing solely negative value to alterations in the linkage matrix should be emphasized. In the case in which linkages are added as the consequence of a facility and no linkages are removed, there would appear to be a positive value associated with change. Similarly, the opposite situation of only removing linkages would appear to be of negative value. The intermediate situation in which new linkages are substituted for old ones is the most likely situation and the one to which it is most difficult to ascribe a normative judgment. Individuals and organizations are constantly changing their pattern of linkages when this is perceived as being in their own interest. The opening of a new supermarket may cause people to change an existing linkage with the neighborhood market. Certainly the proprietors of the local store suffer, but from the societal point of view, it would be difficult to place a negative value on this linkage change. The same view should hold if such a change occurs because the supermarket has been made more accessible because of the construction of a new transportation facility.

For most situations, therefore, it would appear difficult to place a priori negative or positive values on changes in the linkage matrix. A community's perception and reaction to these alterations is one measure of their importance. Attitude studies and examination of transportation related political controversies are potentially useful approaches for studying community response. Another measure of the import of altering the linkage matrix might be derived from careful longitudinal studies associating change with variables having a normative content, for example health and pathological behavior. Studies of this type have been conducted to investigate the consequences of relocating and rehousing families in Boston (43, 44) and Baltimore (45, 46). For the purposes of this study, it is assumed that there are costs associated with altering, and in particular terminating, a linkage. These costs would appear to be strongly related to the linkage's "importance" which was noted above as being a function of the linkage's substitutability and the frequency of interaction. This study approaches the problem of value by using these factors as dimensions of the proposed information structure.

A PROTOTYPICAL INFORMATION PACKAGE FOR COMMUNITY CONSEQUENCES

Transportation impacts include changes in the cost of maintaining linkages and changes in the matrix of linkages. These items are the basic types of information

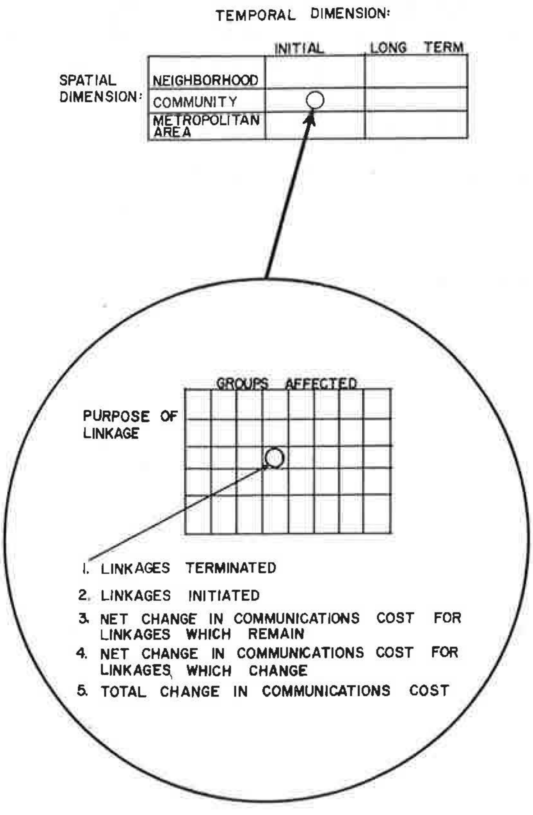

Figure 2. An information package for describing the community consequences of alterations to the transportation system.

which are presented in the cells of the matrices defining the community consequences of alterations to the transportation system (Fig. 2). Specifically, it is suggested that the following information be specified for each situation: (a) the number of linkages terminated; (b) the number of linkages initiated; (c) the net change in the communications cost for the linkages which remain, broken down by mode of communication; (d) the net change in communications cost for the linkages which change; and (e) the total change in communications costs.

Although the discussion has been couched in terms of the individual, it is clear that aggregate impact measures must be used for planning purposes and the measures proposed are designed to appreciate this fact.

Frequency of interaction for the linkages terminated and initiated has not been included for two reasons. Since the concept of linkage implies a minimal intensity of communication, frequency information is in some sense redundant. It is hypothesized that the relative importance of the changes is a function of the purpose of the linkage and the group impacted upon. The relationship between the type of linkage and the costs involved in establishing a substitute has already been noted. The following prototypical set of linkage types is proposed in the belief that the substitutability of linkages within a type is roughly similar but that it varies considerably among types: (a) work; (b) shopping; (c) educational; (d) recreational; (e) religious; (f) social (e.g., individual friends, neighborhood clubs); (g) community groups (e.g., civic groups, fraternal organizations, political groups); and (h) restaurants. The criteria which are used to define empirically a linkage are, of course, a function of the linkage type in question.

Under some circumstances, it may be important to distinguish the differential impact of a facility. The groups affected may be defined spatially, for example, by presenting the results for each community. This approach would appear particularly important when a substantial facility is being planned. In view of the varying adaptability of individuals to change, the identification of the individual or groups affected, as defined in a socioeconomic space, would appear important. This may involve the application of existing techniques for describing the social characteristics of a population (20). Alternatively, a set of groups may be defined using variables such as income, race, occupation, education, age, marital status, and family size or composition. In some situations, it may be necessary to specify groups in both a spatial and a social space.

The suggested community consequences matrix could be readily estimated for all linkages within the metropolitan area for one time period. Such an approach would appear undesirable for several reasons. One important effect of improved transportation is to permit interaction to take place within an increasingly large area. It is, therefore, relevant to specify changes in linkages in a spatial dimension. Three spatial realms, each having potential social importance (47) are suggested: the neighborhood, the community which is composed of a set of neighborhoods, and the metropolitan area. Since people are adaptable to changes in their environment, they respond to changes in the transportation system by altering their linkages and resources devoted to communications. The "disruption" caused by a new facility may dissipate rapidly, and it is important to clarify the linkage and cost changes in a temporal dimension. Two measurement periods are proposed: at the time immediately following construction of the facility and a long-term period of perhaps two years. Overall, it is hypothesized that the long-run consequence of transportation improvements is the initiation of linkages over an increasingly broad spatial realm.

APPLICATION OF THE INFORMATION PACKAGE TO THE ISSUE OF RELOCATION

Relocation of people and activities is a particularly difficult phase of a transportation construction program. Current freeway location procedures measure its effect by estimating the number of people who will be relocated. Such an approach does not consider the differential consequences of relocation for various socioeconomic groups. It is suggested that households not involved in the life of an area may be inconvenienced

(A) THE RESIDENTIAL SITES WHICH WILL BE TAKEN	Group Affected
Number of dwelling units taken	
Number of people to be relocated	
Total number of linkages to neighborhood (by linkage type and the mode of communication)	
Total number of linkages to community (by linkage type and mode of communication)	
Total number of metropolitan linkages (by linkage type and mode of communication)	
Proportion of people who <u>could</u> relocate within the same community	
Physical condition of the dwelling units which are to be taken	

(B) NON-RESIDENTIAL ACTIVITY SITES	Type or Name of Activity Opportunity
Number of linkages from the neighborhood	
Number of linkages from the community	
Number of linkages from the metropolitan area	
Probability of relocating this activity at an alternate site	
Proportion of people who maintained a linkage at the old site who will initiate a linkage at at the new site (a) Total (b) Previous linkages within the neighborhood (c) Previous linkages within the community (d) Previous linkages within the metropolitan area	
Physical condition of the facilities which are to be taken	
Conformance of the facilities to existing and projected land use plans and regulations	

Figure 3. An information package for considering the implications of taking land for the right-of-way of a transportation facility.

but not seriously affected by relocation, whereas those more heavily involved may suffer considerable unhappiness.

An attempt is made in Figure 3 to define an information package for considering the implications of taking land for the right-of-way of a transportation facility. The package is divided into two sections considering, respectively, the implications for the residents displaced and the implications for businesses and institutions such as stores and schools. For both cases, the residential linkage construct appears to offer an operational approach to defining the implications of relocation. As previously, it may be important to define differential impact by defining the groups affected in a spatial and/or social space.

It is suggested that the implications of relocating an individual are a function of the proportional change in the communications costs associated with initiating linkages to the nonresidence sites of his previous linkages. If an individual's linkages are metropolitan in scope, the combination of relocation in a reasonable location and the new transportation service may result in a reduction in net communication costs. On the other hand, if the individual maintains linkages with his proximate spatial environment and is not able to relocate in the immediate vicinity, the implications of relocation may be quite negative. The spatial distribution of the relocated population's linkages and the probabilities of relocating in the neighborhood and community have, therefore, been introduced into the suggested information set.

The consequences of relocation for nonresidential activities would appear to be a function of the number of old linkages which will be initiated with the activity at the new site although this is only a first estimate, since other new linkages would probably be developed. It is suggested that the broader the spatial extent of the linkages, the smaller the effects of relocation. Finally, the physical condition of the facility and its conformance to existing and future land-use plans and regulations are important considerations in evaluating the effect of relocation.

Admittedly, the symbolic import of a home or facility in a certain area is not considered in this approach. If this symbolic significance represents a collective value which is reflected in property value, the individual is compensated for his loss in the price which the purchasing group pays for the land. Examples of property values reflecting symbolic values exist in many cities, for example Georgetown in Washington, D. C., and Beacon Hill in Boston. On the other hand, the values ascribed to social contacts in the proximate environment are less likely to be generally held and may not be reflected in property values. The present analysis could be viewed, then, as a device for measuring these social values.

SOME PROBLEMS AND PROSPECTS

The prototypical information packages for describing the community consequences (Figs. 2 and 3) are deficient in several respects. These packages are cumbersome and considerable problems may be encountered in obtaining and comprehending this mass of data.

Suppose that a decision-maker is concerned with choosing among five alternative routes having community consequences for two groups in each of five communities. With 5 pieces of information in each cell, 8 linkage types, and 6 consequence matrices, 2400 data points must be furnished for each alternative. Presenting 12,000 pieces of information on community consequences would probably overwhelm most decision-makers and make it difficult for them to draw any conclusions whatsoever. The fact that the community consequences form only a relatively small portion of the information set required to evaluate alternative transportation plans merely compounds this problem. The preceding clearly leads to a requirement for a synthesis at the technical level of the community consequences information. Through this interpretation, a decision-maker would be furnished with an estimate of the impact on a community, perhaps on a 7 point scale ranging from very positive through neutral to very negative, and the ability of negatively affected communities to adapt to the new situation. Considerable further research on the impacts of existing transportation facilities would be needed in order to establish a data base for this interpretive activity.

Current modeling capabilities for determining the consequences for the linkage matrix of changes in the transportation system are insufficient for obtaining all of the data suggested in Figure 2. Existing transportation planning techniques could probably be adapted to determine and predict linkages at the metropolitan level. At present, the problem of estimating impact on neighborhood and community linkages appears less tractable. New procedures will have to be devised to predict the effect of changes in communications costs on the pattern of linkages and the implications of linkage alterations for the functioning of the community.

These problems are not insurmountable and should be rendered less so by the following observations. It is not the intent of the preceding discussion to suggest that the information outlined in Figures 2 and 3 should be collected for every transportation alternative proposed for an urban area. Levels of detail exist in the planning process, and the suggested information packages are intended for application at the most extensive level of analysis. Useful but less detailed estimates of community consequences could probably be derived from readily available census and travel data.

Furthermore, it does not appear necessary to develop this information for all of the groups in all of the areas traversed by a facility. Portions of the existing literature can be interpreted to define socioeconomic groups and areas which are of particular concern. Results obtained by Greer and Kube (48) suggest that the social importance of a local area is related to the life style as defined by the urbanization index (20). Their cross-sectional analysis of areas in Los Angeles showed that the smaller the proportion of women in the labor force, the greater the fertility index, and the greater the proportion of single-family dwelling units, the greater the proportion of people for whom the local community is important. Studies of the West End of Boston clearly show the social importance of the proximate environment for an ethnic, low socioeconomic status community (4, 43, 44). In this case, the social life of the inhabitants took place within an extremely confined area. Areas and groups of particular concern can, therefore, be defined prior to expensive field surveys, and extensive analysis can be confined to these areas.

Not all linkage types should be viewed as being of equal importance. Although this has not been empirically established, linkages to work, social activities, community groups, and schools would appear to be more important to the individual than linkages to shopping facilities. Undoubtedly, linkage importance will vary with the group in question, but this observation does suggest study priorities for field investigations. Finally, it is suggested that the immediate consequences are of somewhat greater importance to the political decision-maker, particularly if these are the consequences on which his constituents base their decisions at election time. In this case, the more easily predicted short-run impacts are more important than the long-term effects.

Two criteria, delineation of the physical and social framework of the community and measurement of community impact, were suggested for evaluating alternative approaches for defining the community consequences of the transportation system. Properly applied, the residential linkage construct defines the boundaries and the internal organization of the community. In particular, facilities, such as stores, parks, and schools, which play a critical role in the community's functioning would be identified, thus furnishing the transportation planner with information critical to the minimization of community description. As an evaluation tool, the construct provides an unambiguous and theoretically appropriate measure of community effect. Instead of measuring the inputs (i. e., noise, air pollution) or the results (i. e., changes in land value) of the impact process, it examines the process itself. This feature will permit controlled investigations of the consequences for various groups of different types of transportation facilities. Through this research, hard information can be obtained on the community effects of transportation facilities.

Although the preceding discussion must be viewed as highly exploratory, it would appear that the existing transportation planning methodology can be usefully applied to operationalizing the residential linkage construct. The existing data acquisition and manipulation technology could be adapted for use in field surveys to define residential linkages. Transportation planning models could be refined to provide metropolitan level linkage information, although more difficulty would be encountered at the neighborhood and community levels. Finally, the use of the construct as a design tool appears particularly promising. Through research, procedures that define the transportation program providing the maximum positive or minimum negative community consequences could be developed. In this way, higher level community goals could be entered directly into the transportation planning methodology.

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Measurement of Community Values: The Spokane Experiment

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Experience in working with citizens advisory committees has shown that better communication between the citizen and professional planner is needed. To accomplish this new planning tools are needed to assess and combine more accurately intangible or difficult to define factors with tangible or easily measurable factors in preparing specific proposals.

This is a pilot study and description of such a tool for determining the relative importance of four tangible and five intangible factors and a means of applying these measures of importance in selecting the most acceptable one of three hypothetical roadway solutions. The method requires the assumption that frequency of citizen preference for one factor over another is directly related to importance of that factor. It further assumes that the average measure of a set of tangible factors is equal to the average measure of a set of intangible factors. Using this "equality of averages" assumption, tangible and intangible factors can be assigned a value within a common scaling system. By combining these common system values with measures of the relative importance of the factors involved, an evaluation table can be prepared which provides a total weighted score for each alternative solution.

Included is a resumé of further SMATS research on value measurement.

•THE history of the planning process is cluttered with failures to include intangible considerations in decision-making. Failure to include intangibles in the decision-making process stems from the difficulty in defining, formulating or grasping satisfactorily these factors, from the difficulty in obtaining valid measures of these considerations, and from the failure to apply social science techniques to this problem. Modern decision-making is moving from the austere considerations of tangible factors expressed in cost only to an affluent society's consideration of both cost and the so-called intangible aspects. This additional constraint on decision-making has produced public hearings and citizen committees, the development of rating techniques, and an increased responsiveness to the wants and desires of the community. Existing methods for "measuring" intangibles are not sufficiently objective or dependable to be of much real use in decision-making.

MEASURING RELATIVE IMPORTANCE OF TANGIBLE AND INTANGIBLE FACTORS

Part of the problem of measurement is the way in which intangibles are viewed. People seem to assume that objective truth exists and must be somehow measured. For measurement purposes it would be more appropriate to view intangible considerations as being the result of the physical, social, economic, psychological, etc., stimuli interacting with the individual or group. This interaction requires an internal adjustment which predisposes the individual or group to react in a given way to a particular

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set of intangible considerations. Since the only measurable aspect of these intangible considerations is response behavior, measurement of these intangibles means measurement of this response.

The decision-making process, ideally, takes into account factors of cost, possibility of physical accomplishment, legality, political implications, social implications, and economic aspects. Many of these are intangibles, existing in the mind of the decision-maker and/or as overt responses of those affected by his decisions. Where a decision must satisfy the desires of a group, the decision-maker will be aided by knowing how that group will respond to each alternative. Practical measurement of intangibles need be only a measure of the probable group response to a particular set of tangible and intangible considerations.

Two steps required to mix tangible and intangible considerations logically in the decision-making process are: (a) measurement of the relative importance of the tangible and intangible considerations involved; and (b) a measurement of the extent to which each consideration is realized in each alternative. The first portion of this report describes a method of determining the relative importance of selected considerations and initial measurement results. The second section shows a method for measuring the extent each consideration is realized in each alternative and how both steps are combined through an "equality of averages" assumption in the decision-making process.

Measuring Attitude Strengths

The Successive Test Attitude Measuring Scale (STAMS) method is simply a means of developing the relative importance of a series of transportation considerations in terms of the responses of an individual or group. Relative importance is determined by finding out the frequency one consideration would be selected as most preferred over all others being evaluated. To calculate the STAMS unit (SU) rating for each transportation planning consideration, each consideration is compared with each other consideration to determine which is the more important. With the results of these comparisons the STAMS value of each consideration is calculated.

Method of Calculating STAMS Units

To illustrate the method of calculating the relative importance of several transportation planning considerations, the following example is helpful:

One thousand persons were tested for their responses to three transportation planning considerations A, B, and C. When transportation planning considerations A and C were compared to see which component of the couplet was considered more important, 800 selected A and 200 selected C. This provided the following sample proportions for A and C, respectively: 800/1000 = 0.8 and 200/1000 = 0.2.

When transportation planning considerations B and C were compared, 889 selected B and 111 selected C as more important, providing the proportions 0.889 and 0.111, respectively. The remaining relationship, between transportation planning considerations A and B was determined with 333 preferring A and 667 preferring B. Their respective proportions were 0.333 and 0.667.

STAMS units were calculated by successively comparing each consideration or attitude with all others being measured. This is accomplished in the following steps:

1. Initially, C was assigned a one SU value. The SU measure for each other factor with respect to C was calculated by dividing the couplet proportion of that factor by the couplet proportion of C (note: f denotes response frequency).

$$A = \frac{\frac{fA}{fA + fC}}{\frac{fC}{fA + fC}} = \frac{fA^*}{fC} = \frac{800}{200} = 4 \text{ SU}$$

*Computation is more direct by using the response frequencies.

$$B = \frac{889}{111} = 8 \text{ SU}$$

and by definition, C = 1 SU

These figures were placed in the "uncorrected" table as shown in the following diagram:

	UNCORRECTED C	B	A
A	4.00		
B	8.00		
C	1.00		

2. Columns B and A were filled in in the same manner, except that B and A were successively treated as a one SU value as C was in Step 2. Completion of these calculations produced the following uncorrected table:

	UNCORRECTED C	B	A
A	4.00	0.50	1.00
B	8.00	1.00	2.00
C	1.00	0.13	0.25

3. The uncorrected table was corrected by applying the column relationships for any consideration arbitrarily assigned a one SU value. In this case C was selected and the relationships in Column C were used to correct the other columns (each column value was multiplied by the number in parentheses under the column label).

	CORRECTED C (1.00)	B (8.00)	A (4.00)
A	4.00	4.00	4.00
B	8.00	8.00	8.00
C	1.00	1.00	1.00

Measuring Values

The STAMS method was tested on three groups: 14 staff and city hall employees, 35 Citizens Advisory Committee members, and 23 Spokane Community College freshmen. The findings from the largest group, the Citizens Advisory Committee, are reported in detail. The following nine transportation planning considerations were weighted by the STAMS method.

Transportation Planning Considerations

Travel Time Cost (TTC)—TTC refers to the value that you place on your time and that of your passengers. It can include the value you place on convenience or inconvenience; your increased or reduced earning power; and/or the amount of free time you have available.

Vehicle Operation and Maintenance Cost (VOMC)—VOMC includes the costs of gasoline, oil, tires, wear and tear on the vehicle, etc. Roadway design can either increase or decrease these costs to the user.

Accident Cost (AC)—AC involves lost time, vehicle repair costs, medical bills, loss of income, property damage, insurance rates, etc. The kind of roadway facilities provided can have an important influence on the frequency and severity of accidents.

Economic Cost (EC)—Transportation costs of both the vendor and consumer are often an important part of the cost of a goods or service. EC includes the cost of transporting personnel, raw materials, finished products, food, and fuel on the roadway system. This can mean a gain or loss in sales or employment due to the superior or inferior competitive position of the local businesses.

Construction Cost (CC)—CC includes the cost of right-of-way, structures, design, roadway, relocation, and any other costs involved in providing the physical roadway facility. Increased or decreased construction costs can mean an increase or decrease in gasoline taxes.

Social Factors (SF)—A roadway facility can have a positive, negative, or little social effect on the community. It can either break up or define a neighborhood; it can separate or bring together different kinds of development; it can separate or bring people together; it can shape development. This can have an important influence on how well people enjoy their community.

Appearance (A)—Appearance can have either a positive or negative effect on the roadway user, immediate neighbors, and the entire community. It refers to the landscaping and structural design of roadway facilities as they appear when completed and in use. Appearance can affect either positively or negatively the desirability of the area as a place to live or do business.

Governmental Costs (GC)—GC involves the cost of changing or not changing school, police, and fire protection areas, as well as the gain or loss of property from tax rolls. It includes the maintenance of roadway facilities, and the increased or decreased costs of providing municipal services as a result of the roadway. An increase or decrease in these costs can mean an increase or decrease in property taxes.

Influence on Neighboring Property (IONP)—Roadways can raise or lower the value of neighboring land by affecting the ease of reaching the property, changing local and regional travel patterns, and by the effect of noise and fumes. As a result of roadway facilities, some citizens will experience economic gains or losses.

Item weightings were established using an item preference couplet inventory i.e., comparing each consideration with each other consideration. Each respondent was supplied with a complete definition and careful verbal description of each transportation planning consideration. The inventory was administered to the Citizens Advisory Committee.

Sample Size—Thirty-five persons completed the inventory. This sample size was considered adequate to test the measuring technique.

Inventory—The inventory consisted of two forms, A and B. Form B was the same as Form A, except the sequence of consideration comparison was reversed and the item order rearranged. Each of the nine transportation planning considerations was paired randomly with the remaining eight, providing a total of

$$(N)\ (N - 1) = (9)\ (9 - 1) = 72 \text{ couplets}$$

When considered as unidirectional, there are 72/2 = 36 couplets.

To avoid social pressures, the completed Citizens Advisory Committee questionnaires, Forms A and B, were not signed. Inventory Forms A and B were handed out in envelopes and Forms A and B were matched by the same serial number. The respondents were instructed to complete Form A and drop it in a "ballot box" before starting on Form B. To assist in test supervision, Form A was green and Form B was pink. Of the 37 forms administered to the Citizens Advisory Committee, only two were rejected for unsatisfactory completion.

TABLE 1

ORIGINAL PASS 35 CITIZENS ADVISORY COMMITTEE

Consideration	EC	SF	IONP	TTC	AC	CC	GC	A	VOMC
AC	4.85	7.77	4.85	3.37	1.00	6.75	9.00	6.75	4.38
TTC	1.12	1.33	0.71	1.00	0.30	1.80	1.92	0.95	1.70
IONP	1.70	1.26	1.00	1.42	0.21	1.50	2.50	1.26	1.92
SF	1.06	1.00	0.80	0.75	0.13	0.95	1.33	0.71	1.09
EC	1.00	0.95	0.59	0.89	0.21	1.59	2.18	0.67	0.80
VOMC	1.26	0.92	0.52	0.59	0.23	1.30	1.59	0.75	1.00
A	1.50	1.42	0.80	1.06	0.15	1.65	2.18	1.00	1.33
GC	0.46	0.75	0.40	0.52	0.11	0.56	1.00	0.46	0.63
CC	0.63	1.06	0.67	0.56	0.15	1.00	1.80	0.61	0.77

Respondent Comprehension—Respondent comprehension appeared satisfactory on all items. Some commented that at first they had to refer to the definitions sheet, but later they were able to answer without this reference. Examination of the completed forms indicated no apparent minunderstandings of the nine item definitions. Most respondents seemed to develop their own definition or understanding of the listed transportation planning considerations.

Analysis of Citizens Advisory Committee Data

The completed interview forms were examined for completeness. Form A and Form B were paired using the assigned serial number. Results were put on the same summary sheet. In the analysis, each couplet was treated as unidirectional. This provided two responses for each of 36 couplets.

The SU values for each transportation planning consideration were calculated in the following manner:

1. All studied transportation planning considerations were compared in couplets to determine which the respondent felt was more important.
2. A preliminary ranking of the transportation planning considerations was accomplished using frequency of preference. A convenient centrally ranked item (EC) was selected and assigned a one SU rating.
3. The STAMS rating for each other transportation planning consideration was determined by dividing its couplet proportion by the couplet proportion of the one SU consideration (EC).
4. Step 3 was repeated for each transportation planning consideration, successively setting each equal to one SU and relating it to all others. This process resulted in the uncorrected 9 × 9 matrix (Table 1).
5. The STAMS ratings resulting from Step 4 (Table 1) are corrected by the inter-item relationships in Column EC. EC was selected to be the one SU factor. This correction produced the succeeding corrected 9 × 9 matrix (Table 2).

TABLE 2

ORIGINAL ITERATED PASS CORRECTED ON ECONOMIC COSTS FOR CITIZENS ADVISORY COMMITTEE

Consideration	EC	SF	IONP	TTC	AC	CC	GC	A	VOMC	Total	Avg. STAMS	$\bar{D}/\sigma D$
AC	4.85	8.24	8.25	3.77	4.85	4.25	4.14	10.13	5.51	53.99	6.00	0.62
TTC	1.12	1.41	1.21	1.12	1.46	1.13	0.88	1.42	2.14	11.89	1.32	0.58
IONP	1.70	1.34	1.70	1.59	1.02	0.95	1.15	1.89	2.42	13.76	1.53	0.75
SF	1.06	1.06	1.36	0.84	0.63	0.60	0.61	1.07	1.37	8.60	0.96	0.80
EC	1.00	1.01	1.00	1.00	1.02	1.00	1.00	1.01	1.01	9.05	1.00	0.00
VOMC	1.26	0.98	0.88	0.66	1.12	0.82	0.73	1.13	1.26	8.84	0.98	0.59
A	1.50	1.51	1.36	1.19	0.73	1.04	1.00	1.50	1.68	11.51	1.28	0.64
GC	0.46	0.80	0.68	0.58	0.53	0.35	0.46	0.69	0.79	5.34	0.59	0.66
CC	0.63	1.12	1.14	0.63	0.73	0.63	0.83	0.92	0.97	7.60	0.84	0.60
												$\bar{\bar{D}}/\sigma D$ = 0.66

TABLE 3

CITIZENS ADVISORY COMMITTEE MEMBERS

Range	Obs.	Exp.	χ^2
0.00 - 0.19	59.0	49.0	2.04
0.20 - 0.39	86.0	77.0	1.05
0.40 - 0.59	52.0	42.0	2.38
0.60 - 0.79	16.0	21.0	1.19
0.80 - 0.99	8.0	7.0	0.14
1.00 +	30.0	56.0	12.07

Sum χ^2 = 18.87
df = 5
Significant at 0.01 level.

6. The corrected SU ratings in Step 5 are averaged to determine the average SU rating for each transportation planning consideration.

Findings

An examination of the Citizens Advisory Committee STAMS ratings (Table 2) for the nine transportation planning considerations disclosed average ratings ranging from 0.59 SU for GC to 6.00 SU for AC. It was found that EC, VOMC at 0.98 SU, and SF rated at 0.96 SU did not differ practically. TTC and A had similar SU ratings of 1.32 and 1.28, respectively. CC rated at 0.85 SU and GC at 0.59 SU were the lowest. AC, the highest rating of 6.00 SU, was significantly above the next highest rating of 1.53 SU for IONP.

To determine whether the successive estimates of each STAMS rating for each item differed significantly from chance, the following application of $\sqrt{pa/N}$ was used:

$$\frac{D}{\sigma D} = \frac{D}{\sqrt{\frac{pq}{N_1} + \frac{pq}{N_2}}} = \frac{D}{\sqrt{PQ\left(\frac{1}{N_1} + \frac{1}{N_2}\right)}}$$

where

D = difference in proportions,
σD = standard deviation of the proportions,
N_1 = number of cases in one of the proportions, and
p = larger one of the proportions.

P is calculated by combining the two sets of data. The right-hand form of the equation was suggested where less than 100 cases were involved and when q, the smaller proportion, was small.

The $\bar{D}/\sigma D$ column (Table 2) gives the average of the 36 possible calculations for each row. $\bar{\bar{D}}/\sigma D$ gives the overall value for the matrix. Values of 1.96 and 2.57 would mean a difference significant at the 5 and 1 percent levels, respectively. A value near 0.67 would be expected to be the average value.

If the order of the considerations is reversed, a relatively homogeneous group of respondents would change their item preference more frequently the closer the two considerations were in SU ratings. In other words, crossovers in the selection of any one of two considerations will be more frequent as the STAMS ratings of the two considerations approach equality.

TABLE 4

COMBINED STUDY RESULTS

Consideration	Pilot Test 14 Civil Service		Cit. Adv. Com. 35 Members		Freshman SCC 23 Students	
	SU	Rank	SU	Rank	SU	Rank
AC	10.81	1	6.00	1	5.40	1
TTC	1.63	2	1.32	3	2.09	2
IONP	1.46	3	1.53	2	1.74	3
SF	1.23	4	0.96	7	0.94	9
EC	1.00	6	1.00	5	1.00	7
VOMC	1.20	5	0.98	6	1.13	6
A	0.61	8	1.28	4	1.39	4
GC	0.79	7	0.59	9	0.98	8
CC	0.29	9	0.84	8	1.24	5

To test the "crossover" hypothesis, differences in STAMS value ratings between all of the transportation planning considerations were calculated. The frequency of crossovers was determined for each of seven SU differences interval categories.

A χ^2 test was used to evaluate the hypothesis (Table 3). The test of the crossover hypothesis showed that the closer the two considerations were in STAMS ratings, the more crossovers. This was supported at the 1 percent level of significance.

Table 4 shows the STAMS units and ranks for the Citizens Advisory Committee and two other groups tested. In all administrations of the inventory, AC was clearly the most important. TTC and IONP in all instances were rated over the other considerations. GC and CC usually received the lowest ratings except where the Spokane Community College Students considered construction costs 1.24 SU. Appearance was considered above EC by both the nongovernmental groups, but of lesser importance by the pilot test group of civil servants.

Conclusions and Discussion

Evidence from three tests of the scaling method indicates STAMS units are reasonably stable. The data also support the crossover hypothesis, which would be expected if dealing with probabilities.

The STAMS units can be easily converted to relative probabilities by the following formula:

$$P_i = \frac{SU_i}{\sum_{i=1}^{n} SU_i}$$

where

P_i = the relative probability that consideration i would be picked as more important, and

SU_i = the SU rating of consideration i.

This was not used, however, since the STAMS values later become part of a weighted score.

Although from a methods standpoint these results are encouraging, it is apparent the transportation planning considerations used in these initial tests are far too general and ambiguous to be of much use in planning. A serious application of the procedure would require a better definition of the transportation planning considerations and an identification of the comprehensible components of these considerations. The STAMS ratings would be based upon a comparison of the components rather than the total considerations. The STAMS rating for each transportation planning consideration would be the sum of the component ratings.

The preparation of scales to measure the extent to which each intangible transportation planning consideration is realized in a particular alternative requires use of methods previously described as well as those common in the fields of psychological and sociological measurement and questionnaire construction. It is proposed that measurement of transportation planning considerations be developed by the following method:

1. Identify the component factors in each transportation planning consideration. Through research of the literature, expert judgment, and preliminary tests, component factors in each transportation planning consideration should be identified and carefully defined. Where possible, definition should involve observable and measurable characteristics. Each component must be small enough to be comprehensible to the average layman. As a result of this analysis the original transportation planning consideration might require modification and redefinition.

2. Determine by STAMS approach the relative importance of each component factor in developing the consideration measuring scale, using the responses of a jury of experts.

3. Establish the relationship between measurable physical facts and the extent to which a jury of experts indicates each component factor is realized in a series of roadway alternatives. Use a multiple regression equation to establish the relationship between the component factor jury ratings and the observable and measurable character-

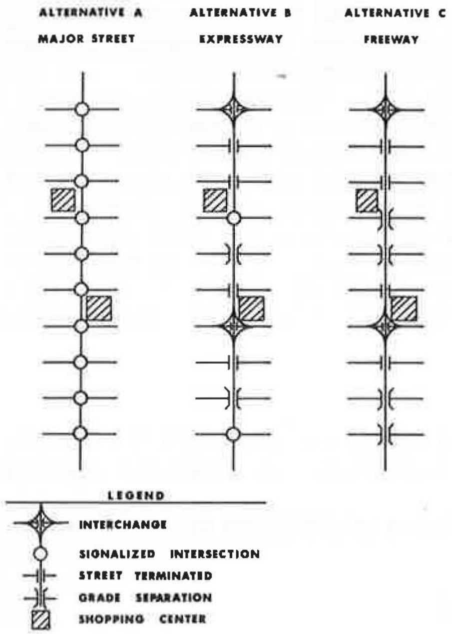

Figure 1. Roadway alternatives.

istics. This analytic process will help define and provide a means by which each component factor can be measured with an empirically developed scale.

4. Measure the extent to which a given transportation planning consideration is realized in a particular alternative by combining the relative weights and measures of the component factors and preparing a total transportation planning consideration "score." This total score serves to show the extent to which a particular transportation planning consideration is realized in a given roadway alternative.

APPLICATION OF STAMS UNITS IN THE DECISION-MAKING PROCESS

It is one thing to measure the relative strength of values and another to apply them in the decision-making process. The use of tangible and intangible factors in this process requires two steps: (a) determination of the relative importance of the various planning considerations, and (b) measuring the extent to which each planning consideration is realized in each alternative. The method of determining the relative importance of each consideration was described previously; this section shows a method for measuring the extent each consideration is realized in each alternative and how both steps are combined in the decision-making process by use of an "equality of averages" assumption.

The nine transportation planning considerations used in the initial tests might be divided into two groups; those appearing to be tangible, and those appearing to be intangible. In the past, transportation planning has been dependent on tangible costs to evaluate alternatives. Because of this, accident costs, travel time costs, vehicle operation and maintenance costs, and construction costs have been well documented and valid estimates can be calculated. The largely intangible values such as influence on neighboring property, social factors, economic costs, appearance, and governmental costs have been difficult, if not impossible, to include as factors in the decision-making process.

To show how the STAMS unit may be applied in decision-making, three hypothetical roadway proposals are evaluated (Fig. 1). For the sake of description, it will be assumed that adequate rating scales for influence on neighboring property, social factors, economic costs, appearance, and governmental costs have been developed. (For purposes of describing the alternative evaluation technique, judgmental ratings were made up; actual application would require development as described in the text.)

Each roadway alternative traverses approximately the same residential area and must accomplish the following:

1. Connect two points five miles apart.
2. Handle a 24,000 ADT.
3. Have a DHV of 2650 for an 11 percent peak hour with a 60-40 directional split carrying 5 percent trucks.

TABLE 5

RAW CONSIDERATION MEASURES

Consideration	Alternative A Major Street	Alternative B Expressway	Alternative C Freeway
Tangible Type:			
AC, $	336,000	285,000	130,000
TTC, $	1,752,000	1,226,400	963,600
VOMC, $	1,883,400	1,664,400	1,752,000
CC, $	274,990	624,368	843,040
Intangible type:			
IONP	80	65	95
SF	75	15	15
EC	50	80	64
A	60	20	90
GC	50	80	30

Although many solutions are possible, the introduction of a new major street, expressway, or freeway will be evaluated. The alternatives will have the following characteristics:

1. Major Street (at-grade intersections will control the design—two signalized intersections per mile).
2. Expressway (two signalized intersections, two interchanges, two grade separations, and other intersections terminated).
3. Freeway (no at-grade intersections, two interchanges, four grade separations, other intersections terminated).

Table 5 indicates the raw measures of each planning consideration. The raw tangible measures are the cost estimates. The raw intangible measures are hypothetical scale values for each alternative for each consideration.

Computing the Comparative Rating

To use the measures of each transportation planning consideration in the evaluation of three roadway alternatives, it was first necessary to develop a relative score. One is the highest alternative relative score with each other alternative being rated equal to, or less than, one. Where a low value is favorable, that alternative value is placed in the numerator (this was used with AC, TTC, VOMC and CC). Where the higher measure is considered favorable, that number is placed in the denominator (this was the case with IONP, SF, EC, A, and GC).

Table 6 shows how the rating for each alternative was calculated in the raw numbers column. The result is shown in the relative score column. Because the relative score eliminates row differences, the row weight was calculated. The row weight is the sum

TABLE 6

COMPARATIVE RATING COMPUTATION—UNCORRECTED TABLE

Consideration	Row Weight	Alternative A		Alternative B		Alternative C	
		Raw Numbers	Rel. Score	Raw Numbers	Rel. Score	Raw Numbers	Rel. Score
Tangible type:							
AC	0.0639[a]	\$ 130,000 / \$ 336,000	0.39	\$ 130,000 / \$ 285,000	0.46	\$ 130,000 / \$ 130,000	1.00
TTC	0.3360[a]	\$ 963,600 / \$1,752,000	0.55	\$ 963,600 / \$1,226,400	0.79	\$ 963,600 / \$ 963,600	1.00
VOMC	0.4517[a]	\$1,664,400 / \$1,883,400	0.88	\$1,664,400 / \$1,664,400	1.00	\$1,664,400 / \$1,752,000	0.95
CC	0.1484[a] / 1.0000	\$ 274,990 / \$ 274,990	1.00	\$ 274,990 / \$ 624,368	0.44	\$ 274,990 / \$ 843,040	0.33
Intangible type:							
IONP	0.2762[b]	80 / 95	0.84	65 / 95	0.68	95 / 95	1.00
SF	0.1208[b]	75 / 75	1.00	15 / 75	0.20	15 / 75	0.20
EC	0.2233[b]	50 / 80	0.63	80 / 80	1.00	64 / 80	0.80
A	0.1956[b]	60 / 90	0.67	20 / 90	0.22	90 / 90	1.00
CC	0.1841[b] / 1.0000	50 / 80	0.63	80 / 80	1.00	30 / 80	0.38

[a]Uncorrected.
[b]Corrected.

Raw numbers are obtained from measuring scale or cost analysis.

$$\text{Relative score (high is bad)} = \frac{\text{Best measured condition of row}}{\text{Measured condition of alternative}}$$

$$\text{Relative score (high is good)} = \frac{\text{Measured condition of alternative}}{\text{Best measured condition of row}}$$

$$\text{Uncorrected row weight} = \frac{\text{All measures of type in each row}}{\text{All measures of type}}$$

TABLE 7

ROADWAY ALTERNATIVE EVALUATION TABLE

Consideration	SU Weight	Cor. Row Weight	Alternative A		Alternative B		Alternative C	
			Rel. Score	Weighted Score	Rel. Score	Weighted Score	Rel. Score	Weighted Score
AC	6.00	0.05[a]	0.39	0.117[b]	0.46	0.138	1.00	0.300
TTC	1.32	0.27[a]	0.55	0.196	0.79	0.282	1.00	0.356
VOME	0.98	0.36[a]	0.88	0.310	1.00	0.353	0.95	0.335
CC	0.84	0.12[a]	1.00	0.101	0.44	0.044	0.33	0.033
IONP	1.53	0.28	0.84	0.360	0.68	0.291	1.00	0.428
SF	0.96	0.12	1.00	0.115	0.20	0.023	0.20	0.023
EC	1.00	0.22	0.63	0.139	1.00	0.220	0.80	0.176
A	1.28	0.20	0.67	0.172	0.22	0.056	1.00	0.256
GC	0.59	0.18	0.63	0.067	1.00	0.106	0.38	0.040
Total weighted scores				1.577		1.513		1.947

[a]Correction for row weight of tangible row i = $\left(\frac{\text{Mean row wt. intang.}}{\text{Mean row wt. uncor. tang.}}\right)\left(\text{Row wt. uncor. tang. row}_i\right)$

[b]The weighted score is calculated in the following manner: Wt. score = (STAMS) (row wt.) (Alternative$_i$ relative score)

Note: Since the average row weight is established on the intangible items, no row correction is required for those row weights.

of the measures in a given row divided by the total of all like measures. Since the row weights for like tangible considerations and like intangible considerations separately add up to one, the tangible row weights need to be corrected for the difference in the number of rows by a factor of 4/5. (Note: the same kind of adjustment could be made on the intangible row weights, with the tangible rows remaining as originally calculated.)

Roadway alternative evaluation is accomplished by calculating and summing the weighted score column in Table 7. The weighted score column is the product of the STAMS weight times the corrected row weight times the relative score for each alternative. Alternative C has the highest overall score of 1.95. Alternative A received the score of 1.58, and Alternative B, 1.51. It should be recognized, however, since the intangible scores were manufactured for illustrative purposes, their use in this evaluation is merely to show how the method would work if proper measures were available.

Conclusions

The roadway alternative evaluation table, properly accomplished, would be of considerable value to decision-makers. It would give them advance knowledge of the response that could be expected from various community groups tested. It is a tool that will require a large amount of further work, but will not necessitate any significant breakthroughs in social science.

With refinement and improvement, this procedure could also be used as a guide in the design process. The designer would know in advance the best way to spend roadway money to optimize the satisfaction of the consumer.

The reader should be cautioned not to apply the findings of the relative importance of the various transportation planning considerations because the considerations were far too broad and ill-defined to be accurately interpreted by the respondent. Table 7 consists of "manufactured" intangible measures and, consequently, is for illustrative purposes only. Both major steps, determining the relative importance of each transportation planning consideration and measuring the extent to which these considerations are realized in each alternative seem to work out in a satisfactory manner. It seems safe to conclude that the method described shows promise as a useful tool of the planner, engineer, and decision-maker.

FURTHER SMATS RESEARCH

To develop some intangible factor measuring scales a $42,000 study financed jointly by the Federal Highway Administration, the Washington State Highway Commission, the County of Spokane, the City of Spokane, and by citizen subscription, is in process at Washington State University, under the direction of G. A. Riedesel, Highway Research Engineer, College of Engineering, Pullman, Washington. The following is an excerpt from the project prospectus entitled, A Study of the Social, Economic, and Environmental Impact of Highway Transportation Facilities on Urban Communities.

PROJECT DESCRIPTION

A. The Problem

The aesthetic, economic, environmental, and sociological effects and considerations are having increasing influence on the location and construction of urban highways, and the highway locator and designer needs to be familiar and concerned with the affairs of sociology, landscape architecture, community planning and aesthetics.

There is a need for better communication, understanding, and cooperation among all professions and disciplines engaged in highway and community development.

The citizens and officials of the City and County of Spokane, Washington, in cooperation with the Washington Department of Highways, and the Federal Highway Administration are especially interested and involved in a comprehensive transportation study and are desirous of undertaking a study on the subject of this prospectus.

This study will be in the program area of social impact—environmental quality, community effects, and highway transportation as presented by the U. S. Bureau of Public Roads, Office of Research and Development, November 26, 1966.

B. Objectives

1. Write a glossary of professional terms; engineering, architectural, community planning, sociological, governmental, that are necessary for broad discussion of urban development and arterial roadways location and design.

2. Develop a methodology and an outline of procedures for considering and accommodating all the factors involved in urban arterial highway locations and design.

   a. aesthetic—in detail
   b. social and sociological—in detail
   c. engineering—by reference
   d. economic and financial—by reference
   e. legal—by reference

3. Describe a set of desirability standards to be met by various functional classes of urban highways with regard to:

   a. aesthetic
   b. social, environmental, and sociological (including economic impact on the community, both short and long range)
   c. engineering
   d. economic—by reference
   e. legal—by reference

These standards will be for application to any highway location. However, the SMATS people will apply them specifically to their study.

4. Develop a procedure for determining the relative acceptability of a proposed highway location and design:

   a. evaluation and rating by qualified persons (preparation and use of a rating scale)
   b. public hearings
   c. professional conferences

As a result of this study, prototype measuring scales will be produced which should be helpful in evaluating alternatives. Initial efforts will be crude and results will require intelligent interpretation by the user. It is expected that this kind of evaluation procedure will be refined and eventually be of considerable value in better decision making.

WHAT NEEDS TO BE DONE

Further research is needed to define adequately the different consideration scales. At present, the application of any or part of the findings of this study in a practical situation would be hazardous except as an experiment. With development of more accurate and reliable measures and STAMS weightings of the pertinent considerations, an alternative evaluation table could be prepared and used. It is recommended that a large-scale, well-financed, and properly coordinated research program be initiated to develop the appropriate consideration scales, and to test the method in real decisions. Once this has been done, a follow-up study should be made to see how well the method works or would have worked. Through intelligent trial and error, the STAMS method can improve the planning and decision-making process.

ACKNOWLEDGMENT

The costs for the major street, expressway and freeway alternatives were estimated by Wayne T. Gruen.

A Survey of Citizens' Opinions of the Effectiveness, Needs, and Techniques of Urban Transportation Planning

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A home-interview technique was used to obtain information regarding citizens' opinions of the effectiveness, needs and techniques of urban transportation planning. Among the questions investigated are perceptions of the relative importance of investments in transportation as compared to other urban facilities and services, perceptions of the adequacy of consideration given to individual needs and desires in the planning process, opinions about the most urgent needs for improvement in transportation, and attitudes toward the relationship between transportation facilities and community health, safety, and aesthetics. Opinions are analyzed to reveal systematic relationships between the opinions expressed and the socioeconomic and travel characteristics of the respondents, and the implications of the results of this analysis are discussed.

•URBAN transportation planners have in recent years broadened their concepts of cost and benefit in the evaluation of alternative transportation plans and projects. Today more and more attention is being given to the possible positive and negative effects of transportation projects on the total urban environment. Evaluations which consider only the economic benefits to users and the economic costs to users and government are increasingly criticized as being insufficient. Clearly, plans and policies which take account of a wide range of environmental consequences concomitant to the provision of transportation facilities, as well as their transportation service consequences, will not necessarily coincide with those which consider the transportation consequences alone.

While the methodology for the quantification of user benefits and highway costs may be criticized for its failure to correspond to the benefits and costs as perceived or experienced by the user, the environmental influences of transportation projects have been even more difficult to evaluate because they are as yet difficult to quantify at all. Although these environmental consequences may best be treated subjectively rather than quantitatively through indices and rating schemes, it is probably the difficulty of measurement and quantification which has led to inadequate consideration of them in transportation planning.

This research is based on the contention that the transportation planner has the responsibility to delve into the difficult problems of identifying and measuring the relationships between the transportation system and its concomitant effects on the urban population and environment. A home-interview technique was employed to elicit the respondent's perceptions of the relative importance of investment in the transportation system compared to other urban facilities and services which influence the quality of urban life.

Paper sponsored by the Department of Urban Transportation Planning.

Questions were asked to determine whether or not the citizen felt that his needs and desires were adequately considered in the political decision-making process which results in the allocation of resources to transportation facilities and to other facilities vital to the economic and physical health of the community. The citizen's impressions of the more urgent needs for improvement of transportation facilities were sought, along with his impressions of how such facilities affect the health and safety of the residents of the community. Opinions were also analyzed to determine what, to the respondent, would be the ideal criteria for locating and building transportation facilities in order to minimize disruption of neighborhoods and hazards to health and safety, while maximizing the perceived value of the transportation system as a whole.

Responses to these questions were statistically treated to determine if any systematic variations exist which are related to the socioeconomic and demographic characteristics of the respondents or their travel habits. The presence of such systematic variations would imply that the attitudes of citizens toward the issues examined are stable and possibly predictable, and hence that such opinions may be employed as a useful tool in planning and evaluation.

HOME-INTERVIEW PROCEDURE

To facilitate the quantitative analysis of the data, constrained-response type questions were used for the collection of most of the information in the home-interview procedure (4). Constrained-response questions often reflect the views and attitudes of the person constructing the interview form, and thus tend to introduce bias into the results obtained. In order to minimize such bias, about 20 test interviews were conducted. These consisted of open-ended questions, and the constrained-response questions were constructed only after a careful study was made of the answers to these open-ended questions. Every effort was made to word the questions in a neutral manner, and to incorporate the points raised by the respondents in the open-ended pilot interviews.

In addition, some redundancy was introduced into the final questionnaire form by including both open-ended and constrained-response questions on several issues. The comparison of the responses to the two types of questions enabled the author to know how the respondents interpreted some of the key words used in the constrained-response questions.

A sample of several hundred potential subjects was drawn at random from the city directory of Evanston, Ill. Prospective subjects were first mailed a letter which explained the purposes of the research and the nature of the interview. About one week after the mailing of the letter, telephone calls were made to the prospective subjects in order to make an appointment for the interview. About 20 percent of the people in the sample had moved, died, or had become impossible to reach since 1963. Of the people to whom letters were sent, 35 percent refused to cooperate. The remaining 45 percent agreed to participate and were interviewed. The refusal rate in the non-white neighborhoods of Evanston was approximately ten times the refusal rate in the white areas. In future studies of this type, it might prove desirable to employ members of particular ethnic groups to contact and interview members of their own groups. In addition, women refused to participate about twice as often as men. As a result, the sample is biased toward white males as compared with a truly random sample of the population of Evanston.

A total of 139 respondents were interviewed. Of these, 21 percent were women and 79 percent were men. The mean age of the respondents was 49 years, although they ranged in age from 19 to 78 years. Household sizes varied from 1 to 8 persons, with a mean value of 3 persons per household. The average level of education among the subjects was 14.7 years, with the lowest level being 6, and the highest 20 years. Twelve percent of the people were engaged in blue collar occupations, 72 percent were in white collar but nonprofessional positions, and 16 percent were professionals. The sample had a mean family income of approximately $14,800 per year, and 65 percent of the respondents owned their own homes. Only 35 percent rented houses or apartments. About 85 percent had moved to their present homes from others in the Chicago Metropolitan Area; 15 percent had come from outside the metropolitan area. The average family had lived at its present address for a little more than 9 years. Only 35 percent of the sample, however, was born in the Chicago Metropolitan Area. Approximately 43 percent worked in the CBD of Chicago, and the respondents had an average trip to work of 28 minutes, covering 9.7 miles.

This brief profile of the sample indicates that the responses measured are those of the citizens of a stable upper-middle class commuter suburb, with a lower proportion of homeowners than most typical commuter suburbs. The members of the community are relatively well educated.

The characteristics of the respondents should be borne in mind by the reader, because the measurements made and the relationships found can be assumed to be valid only over the ranges of the variables actually observed in the sample. The limited size of the sample, and its particular characteristics emphasize that the nature of the investigation is that of a pilot study, useful nonetheless for the testing of the methods of analysis and for the formulation of hypotheses regarding the interactions between the opinions and personal characteristics measured.

TABLE 1

MEAN RATINGS OF QUALITY OF PUBLIC FACILITIES IN THE CHICAGO AREA

No.	Quality	Rating
1.	Water for drinking and recreation	3.13
2.	Police and fire protection	3.10
3.	Health and hospital facilities	3.01
4.	Parks and recreation facilities	2.95
5.	Education	2.72
6.	Highway system	2.72
7.	Mass transit system	2.59
8.	Public welfare programs	2.50
9.	Urban renewal program	2.36
10.	Air	2.04

Scale: 0 = very poor; 4 = very good.

PERCEIVED RETURNS FROM INVESTMENTS IN TRANSPORTATION AND OTHER PUBLIC PROJECTS

To begin the analysis of the perceptions of the transportation system as an environmental component, estimates were made of how the respondents viewed the quality and value of the transportation system in comparision to the quality and value of several other major urban services. This was done in two ways. In one question the respondents simply rated the quality of the various urban services on a scale of 0 (very poor) to 4 (very good). In another question they were each asked to allocate $100 among several types of improvements to the public facilities of the metropolitan area in any proportions which they saw fit. This question required the respondents to consider two effects operating simultaneously. First, they had to rate the quality of the facility. Second, they had to estimate the relative payoff to be gained from an investment in that type of facility, in terms of the improvement of the urban environment, as opposed to the payoff of an investment in other facilities or services. Thus, a large allocation to a particular form of public investment might indicate that the respondent feels that the service or facility is of poor quality and needs much improvement. It could also indicate that a particular service or facility which is perceived as being of high quality yields a high level of satisfaction, and is thus seen as being worthy of a larger allocation.

TABLE 2

MEAN MONETARY ALLOCATIONS TO PUBLIC IMPROVEMENTS

No.	Improvement	Allocation ($)
1.	Education	20.47
2.	Transportation	12.73
3.	Urban renewal and slum clearance	12.08
4.	Air	9.58
5.	Police protection	9.52
6.	Water	8.80
7.	Public health programs and hospitals	8.25
8.	Parks and recreation facilities	7.04
9.	Public welfare programs	5.41
10.	Fire protection	4.72
11.	Other (specified)	1.40
		100.00

Tables 1 and 2 summarize the responses to the two questions. It is apparent, for example, that although the quality of education provided in the area is considered reasonably high, the perceived payoff to be received from investment in the improvement of education is relatively high. This may be deduced from the fact that education received the highest mean monetary allocation although it received a mean quality rating which was equal to the median of the quality ratings for the facilities and environmental factors rated. Similarly, although the transportation system (both highway and transit) received quality ratings

TABLE 3

SUMMARY OF SOCIO-ECONOMIC AND DEMOGRAPHIC VARIABLES MEASURED FOR EACH RESPONDENT

No.	Variable
1.	Respondent's sex (male; female)
2.	Respondent's age (years)
3.	Respondent's race (white; non-white)
4.	Size of respondent's household (people)
5.	Respondent's occupation (blue collar; white collar nonprofessional; professional)
6.	Education of respondent (years)
7.	Number of drivers in respondent's household
8.	Time respondent lived at present address (years)
9.	Time respondent lived at previous address (years)
10.	Previous address location (in Chicago metro. area; outside Chicago metro. area)
11.	Place of birth of respondent (in Chicago metro. area; outside of Chicago metro. area)
12.	Home ownership status (own; rent)
13.	Respondent's time on present job (years)
14.	Respondent's family income (thousands/year)
15.	Respondent's family car ownership
16.	Type of residence (one-family; two-family; apartment)
17.	Number of miles driven by respondent in previous year (thousands)
18.	Stage in family life cycle (six categories based on age, marital status, and number of children)
19.	Proportion of trips to work made by modes other than driving
20.	Length of trip to work (miles)
21.	Distance from residence to nearest freeway (miles)

approximately equal to the median rating, transportation system improvement obtained the second-highest average monetary allocation. Thus, we may conclude that although the quality of the transportation system is not perceived to be particularly poor, the respondents still feel the advantages to be gained by transportation improvements merit the required monetary inputs. In contrast, although the quality of air in the region was considered quite low compared with the quality of the transportation system, the respondents gave improvement of air through reduction of pollution a mean monetary allocation which was a good deal smaller than the allocation to transportation improvements. Apparently, they felt that a dollar could not buy enough improvement in air quality to warrant a higher expenditure on it, or that improved air quality did not improve their satisfaction with the environment as much as did transportation facility improvements.

The χ^2 contingency test for two independent samples (3) was used to determine whether monentary allocations and environmental quality ratings were related to the socio-economic variables listed in Table 3. Since the ratings and allocations for the transportation variables are of most concern, the relationships found for these variables only will be cited here. The variables found to influence the allocations to transportation significantly (at the 95 percent level) were the sex of the respondent, the number of miles he had driven last year, the frequency with which he used modes other than driving, and the number of cars he owned. Men allocated more money than women to transportation improvements, with 56 percent of the women and 30 percent of the men allocating less than $5, and 21 percent of the men and 11 percent of the women allocating more than $20. Those who drove fewer miles last year (and women tended to drive less than men, so this finding is not wholly independent of the previous one) allocated less money to transportation than those who drove more. Of those who drove less than 5,000 miles last year, 83 percent allocated less than $10 to transportation improvements, and 17 percent allocated more than $10; of those who drove more than 15,000 miles last year, only 67 percent allocated less than $10 to transportation while 33 percent allotted more. Frequent users of modes of travel other than driving for the trip to work stated that they would spend significantly more on transportation than infrequent travelers by other modes, and people who own two or more cars would spend more than those who own none or one. Sixty-nine percent of the zero and one car respondents allocated less than $10 to transportation projects, but only 56 percent of the two or more car owners allocated less than $10. The analysis showed this difference to be statistically significant.

It can be concluded that, for the sample interviewed, people who travel more are likely to perceive a greater payoff from transportation investments than those who travel less, and that those who spend more on privately owned transportation (as indicated by high car ownership) are likely to feel that large benefits are to be gained from public investment in transportation as compared with other public facilities. Transportation investments as a whole appeared to yield the greatest returns to the respondents of any public investment except education.

TABLE 4

MEAN MONETARY ALLOCATIONS TO TRANSPORTATION IMPROVEMENTS

No.	Improvement	Allocation ($)
1.	Build additional new rapid transit lines	22.20
2.	Improve maintenance on existing highways	14.08
3.	Modernize existing rapid transit facilities	12.15
4.	Build additional downtown parking facilities	10.19
5.	Build additional new highways	10.02
6.	Add safety features to existing streets and highways	9.33
7.	Reduce traffic congestion by adding signals and signs to existing street and highway system	8.48
8.	Improve traffic law enforcement	6.60
9.	Beautify highways and rapid transit facilities	4.12
10.	Other (specified)	2.83
		100.00

In large part, the answers to the previous questions are evaluations of how well certain problems regarding the urban environment have been solved. It would be interesting to extend this research by repeating these questions over time to determine whether responses to them may be invariant or whether they may change with variations in the environment. It would also be interesting, if possible, to relate these statements of projected behavior to observed decisions of the citizens, and thus to evaluate the validity of the questioning procedure. These questions pertain to many of the following issues, as well as to those just discussed.

PERCEIVED RETURNS FROM INVESTMENTS IN ALTERNATIVE TRANSPORTATION IMPROVEMENTS

In addition to estimating how the respondents viewed the returns from investments in transportation projects as opposed to other public facilities and environmental characteristics, a further effort was made to isolate their perceptions of the relative returns to be gained from investments in various types of transportation improvements. This was done, again, by asking each respondent to allocate $100 among the several types of transportation improvements which were cited most frequently in the pilot interviews. The mean allocations among all the respondents are given in Table 4.

The results indicate extremely high mean allocations given to the two rapid transit variables. The largest mean allocation was for the building of new rapid transit lines in the Chicago Metropolitan Area, and the third highest allocation was for the modernization of existing rapid-transit facilities. Apparently, the respondents (most of whom drive to work quite regularly) feel that public investment in high quality mass transit will produce benefits to them which warrant these high allocations. The χ^2 contingency tests show that the sex of the respondent exerts a significant effect (at the 95 percent level) on his allocation to the building of additional new rapid transit lines. Women were found to make either very large or very small allocations to this variable; whereas men made less extreme allocations. Blue collar workers made significantly lower allocations to both the building of new transit and the modernization of existing transit facilities than did white collar workers and professionals. This finding is consistent with the additional result that allocations to the transit variables are significantly positively related to years of education. As the length of the respondent's work trip increased, his allocation to the building of new rapid transit facilities increased, but work trip length had no significant effect on allocations to the modernization of existing transit facilities. As the respondent's frequency of using modes of travel other than driving increased, his allocations to transit modernization increased, but the frequency of using other modes had no effect upon allocations to the construction of new transit facilities. Those born in the Chicago Metropolitan Area assigned significantly larger amounts of money to the transit variables than those from elsewhere. We may hypothesize that increasing benefits from rapid-transit investment are perceived by those who are more highly educated, by those who would have more opportunity to use transit facilities (e.g., those with longer work trips), and by those more oriented to urban styles of living (e.g., those born in the metropolitan area). In addition, the indication that those presently using transit most often would spend more on modernization of the facilities but not on building new facilities, may indicate that their destinations are likely to be served well by existing routes, and that new construction is not needed to fill their needs.

TABLE 5

PERCENT OF RESPONDENTS SELECTING EACH TYPE OF TRANSPORTATION SERVICE AS ONE OF THREE MOST URGENTLY NEEDED

No.	Service	Percent
1.	Additional crosstown routes	72
2.	Mass transit to downtown	68
3.	Parking downtown	49
4.	Bypass routes around city	31
5.	Freeways to downtown	30
6.	Better connections to airports	16
7.	Other[a]	14
8.	Better routes to recreation areas and open space	8
9.	Better highways to other cities	6
10.	More scenic parkways	5

[a]The other improvements most frequently cited were parking lots at outlying shopping areas and street and alley lighting.

Table 4 also indicates an extremely low importance assigned to the beautification of transportation facilities, which is interesting in light of the recent publicity on the subject from the White House. Women assigned more money to beautification than men, homeowners allotted more than renters, and those who drove to work less often than they took other modes allocated more to this variable than those driving more frequently.

It may be concluded that perception of benefits to be received from an investment in a particular type of transportation facility were related to the respondent's potential for use of that type of facility. Allocations to the construction of new highways were found to be higher among multiple car owners than among respondents from no and one-car households, and were also much lower among people most frequently using other modes than driving. Money allocated to the construction of new highways was also significant, positively related to the distance driven by the respondents in their work trips.

The people interviewed were also asked what types of transportation services they felt were most urgently needed. They were told to select three from the list of nine which resulted from an open-ended question on this subject asked of the subjects in the pilot interviews. They also could specify services not on this list. Table 5 gives what percentage of the total sample cited each type of transportation service.

Nearly three-fourths of the respondents cited a need for additional crosstown routes. The interviews were administered at a time when public controversy was raging over the location of the proposed Cicero Expressway, a major crosstown route. This may help to explain the importance attached to the need for crosstown routes. In addition, mass transit to downtown was cited by 68 percent of the respondents. Nearly half saw downtown parking as being among the three most urgently needed transportation improvements.

Discriminant analyses (1, 2) were performed to determine whether or not respondents citing a given need differed significantly from those not citing it. Those seeing a need for mass transit to downtown differed only in that they were significantly more highly educated. Perception of a need for more crosstown routes was found to be associated with frequent use of other modes than driving in the work trip and high milage driven last year. Younger respondents were also more likely to perceive this need than older ones. Those perceiving a need for more downtown parking were people who drove to work more often and might make greater use of downtown parking facilities.

Very few respondents saw needs for better routes to recreational areas and open space, or for better highways to other cities. Apparently the Interstate Highway System has served to improve intercity travel and weekend or vacation trips for recreation. Also, very few respondents perceived a need for more scenic parkways. This seems to be consistent with the low ratings assigned to beautification. Those who did cite a need for better routes to recreational areas and open space had a mean age of 58 years; those who did not averaged 49 years of age. These two groups did not differ significantly in any other variables. Those who saw a need for more scenic parkways were younger and at earlier stages in the family life cycle than those who did not perceive such a need.

RESPONDENT IMPRESSIONS OF THE EFFECTS OF NEARBY FREEWAYS ON RESIDENTIAL NEIGHBORHOODS

A group of questions was included to determine what effects the respondents felt a freeway built through their neighborhood might have on their property and on health and safety. Would they find the freeway to be of "negative benefit" or not? Would they regard the freeway as a source of noise and fumes and as a hazard to the safety of their children or not? The questions dealt primarily with a freeway which might be built within five blocks of the respondent's home, but did not deal with his home's being taken as part of the right-of-way.

When asked if they would like to live closer to a freeway than they are presently living, 80 percent of the respondents said no, 15 percent said yes, and 5 percent did not know. Interestingly, their present distance from the nearest freeway did not enter as a significant variable when discriminant analysis was used to find the dimensions which differentiated between those saying yes and those saying no. Those who said they would not like to live nearer to a freeway had held their present jobs for a mean period of 17 years, and had lived at their present addresses for an average of 11 years, whereas those who would have liked to have lived closer to a freeway had held their present jobs for an average of eight years, and had lived at their present addresses for about seven years. Those who did not wish to live closer to a freeway were significantly more highly educated than those who did, and had a larger number of drivers in their households.

In spite of the fact that 80 percent of the sample surveyed did not want to live closer to a freeway, it was found that 73 percent said they would not move away if a freeway were to be built within five blocks of their homes; 14 percent said they would move; and 13 percent did not know whether or not they would move. Among those who said they would move, there was a significantly higher proportion of homeowners than among those who said they would not. The group which said it would move had a significantly higher mean annual income than the group which said it would not move; and those who would move were also more highly educated than those who would not.

The results of the above two questions indicate that although very few respondents wanted to live closer to a freeway, very few would move if one were built very close to their homes. Apparently the perceived advantages of a particular house and general location outweigh the immediate benefits and "disbenefits" of a nearby freeway, particularly if one has lived there for a long time. Those who would move if a freeway were built appear to be those with a greater investment in their homes (owners) rather than those without as large an investment and those who could move more easily (renters). We may hypothesize that property owners, particularly those with higher levels of income and education, are more sensitive and less favorable to the presence of freeways in their immediate neighborhoods.

When asked how they felt a freeway within five blocks of their homes would affect property values in their neighborhoods, 17 percent said property values would rise, 46 percent said they would fall, 26 percent felt the freeway would have no effect, and 11 percent did not know what the effect would be. Once again, those less favorable toward freeways—those who felt that property values would fall—were distinguishable by the fact that they had higher incomes and higher educational levels. They also tended to be farther along in the life cycle than others. This finding is consistent with the previously formulated hypothesis.

Looking at freeways as a safety hazard to children, 60 percent of the respondents said that a freeway in their neighborhood would not be dangerous to children, 33 percent said that it would be, and 7 percent did not know. Those who saw the freeway to be a safety hazard had lived at their present addresses for a mean period of nearly 16 years; those who did not consider the freeway dangerous had resided at their present addresses for a mean period of 8 years. Those who considered the freeway dangerous to children were also more highly educated than the others in the sample, and were more likely to be in white collar or professional jobs than the others.

In response to a question about whether or not the respondents felt a freeway within five blocks of their homes would make their neighborhoods more noisy, 68 percent said yes, 26 percent said no, and 6 percent said they did not know. Those who felt that the freeway would make their neighborhoods noisier again tended to live at their present addresses for a longer period of time, and to have higher levels of education than those who said it would not. They were also less likely to have been born in the Chicago Metropolitan Area, and were at earlier stages in the life cycle than those who felt the freeway would make their neighborhoods noisy.

Half of the respondents felt that a freeway within five blocks of their residences would not make their communities unsightly or unattractive, while one-third of the sample stated that such a freeway would make their neighborhoods unsightly. The remaining 17 percent of the respondents expressed no opinion on this question. Once again, the respondents who felt that a highway would make their communities unsightly could be discriminated from the others by their high levels of education and longer times of residence at their present addresses. Those who felt that the freeway would be unsightly also had lower mean car ownership and tended more toward white collar and professional jobs than the other respondents. Half of the respondents did feel that a nearby freeway would tend to make their neighborhoods dirty and smelly, with 38 percent feeling that dirt and odors would not result, and 12 percent not responding. Those who stated that the freeway would make their neighborhoods dirty or smelly were more likely to be homeowners than those who did not, had lived at their present addresses an average of nearly 5 years longer than those who did not, and tended to be in later stages of the life cycle.

Finally, when asked if they felt that a nearby freeway would make their neighborhoods more or less convenient, 61 percent of the sample responded by saying more convenient; 8 percent said less convenient; 23 percent saw no change in convenience resulting from the construction of a freeway; 8 percent did not reply. Those who said that the freeway would be less convenient could be differentiated from the others in that they lived at their present addresses for an average period of more than 16 years; those who saw the freeway as making their neighborhood more convenient had a mean tenure of residence of about 9 years. This was the only variable which was found to be a statistically significant discriminator between the groups at the 95 percent level.

The results of these questions exhibit a clear trend among the respondents. Those who were most likely to perceive a nearby freeway as a source of "negative benefits" were, to a large extent, those with deeper roots in their neighborhoods. They were more likely to be the homeowners rather than the renters, and those who had lived at their present addresses for longer periods of time. They also tended to be people of higher levels of education, and not independently, they were more likely to be in the professions or white collar positions, while those who responded more favorably about freeways near their homes were more likely to be of the lower socioeconomic strata.

RESPONDENTS' PERCEPTIONS OF THE ADEQUACY OF THE PLANNING PROCESS, PARTICIPATION, AND RATINGS SUGGESTIONS FOR FREEWAY LOCATION CRITERIA

In previous sections the focus of this study has been on the citizens' impressions of the values, limitations, and evironmental influences of transportation system characteristics. Little attention was given to their impressions of the process of system planning; rather they were asked to respond to statements which treated the characteristics of the transport system as accomplished facts. In this section, however, the respondents' views of the adequacy of the current planning process are examined, and the degree to which they have participated in the planning process will be measured. In addition, respondents' ratings of several alternative methods of making planning decisions will be presented, and the influences on these ratings of personal characteristics will be sought. Finally, their preferences among alternative generalized criteria for freeway location decisions will be examined, and these too will be analyzed to determine the influences of personal characteristics on such preferences.

When asked whether they felt that their interests and needs, and those of their friends and neighbors, are adequately considered in the provision of transportation facilities in the Chicago area, 55 percent of the respondents said that such needs were not adequately considered, and 45 percent said that they were. When asked to state the reasons for their answers to the above question, the respondents did not speak about the planning process at all, but referred to the specific characteristics of the system which affected them directly. Those who felt that their needs were met often said, "I make good time in my trip to work," and those who said that their needs were not met often cited specific sources of irritation, e.g., "The Dan Ryan Expressway is a monstrosity." Careful statistical analysis, using both univariate and multivariate methods, failed to show any significant differences between the personal characteristics and travel habits of the group saying its needs were met and the group stating that its needs were not. It appears that only satisfaction or dissatisfaction with specific facilities differentiates between the two groups.

In answer to the question: "The way transportation facilities are presently planned and built, what do you think you can do to help see that your needs are best satisfied?", nearly 70 percent of the people interviewed responded by simply saying that there was nothing, or very little, that they could do. About 15 percent said that they could write letters to newspapers or elected officials, and about 5 percent said they could organize committees and try to sway public opinion or that they could confront public officials.

When asked whether or not they had ever attended public hearings to express their views about planned or proposed transportation projects, 88 percent of those interviewed said that they had not, and only 12 percent said that they had. Nearly every person who had attended a public hearing would have in some way been affected by the project which was to be discussed at that meeting. They usually attended because they feared loss of their property to make way for a freeway right-of-way. Once again, the only evidence, in this context, of concern with or involvement in the planning process resulted from personal dissatisfaction with specific projects rather than concern about planning as a process or about goals for the community. Once again, no socioeconomic or travel characteristics differentiated the groups. More than half of the respondents (53 percent) said that they would not take a more active part in public hearings if they were better publicized by the mass media, and only 28 percent said that they would. The remaining 19 percent did not know whether or not they would take a more active part under those conditions.

The picture gained thus far of the respondents' views of the transportation planning process is one of general disinterest except in the cases where individuals were inconvenienced by specific projects or facilities. If they arrived at their destinations quickly, the respondents were generally satisfied with the results of the planning process. When their own property was not endangered, most respondents took little interest or part in that process, and would continue to take a small part even if they were made more aware of the issues. Most respondents felt that there was little that they could do to influence decisions which resulted in transportation plans.

An attempt was made to determine what, to the respondents, would be the best method for making decisions about where, when, and how to build transportation facilities. To accomplish this, they were instructed to rate six suggestions for decision-making methodologies on a scale which ranged from 0 (very bad) to 4 (very good). The results are summarized in Table 6, where the mean ratings found for each method are presented in descending order.

It is interesting to note that the suggestions for decision processes which received the highest mean ratings were the methods which would give the planners much stronger powers than they presently posses. The method which would leave the decisions to the planners, but require them to consult with a group of leading citizens throughout the planning process, received the highest mean score. The method which would simply leave the decisions completely to a staff of trained professionals received the second highest mean rating. Leaving the planning decisions completely to the elected officials received the lowest mean score, and the suggestion to let the citizens decide, by referendum, about the location and nature of transportation projects received the second-lowest score. Clearly, the respondents interviewed felt that trained professional planners were most highly qualified to make such decisions, and they did not feel that

TABLE 6

MEAN RATINGS ASSIGNED TO ALTERNATIVE METHODS FOR MAKING TRANSPORTATION PLANNING DECISIONS

No.	Method	Mean Rating
1.	Leave the decisions to the planners, but have them work closely with a leading group of citizens before, during, and after the time when the decisions are made.	3.08
2.	Leave the decisions as to where, when, and how to build highways to a trained staff of professional engineers and planners.	3.01
3.	Elect a formal review board of citizens with the sole job of hearing the planners' proposals and deciding which is the best for the city as a whole.	2.29
4.	Let the planners put forth their concepts of the best plans at a public hearing at which anyone may object. After hearing all objections, let the elected officials decide which plan to adopt.	2.21
5.	Put the various alternatives proposed by the planners on the ballot at election time, and let the majority vote decide which plan to adopt.	1.63
6.	Give our elected officials complete power to decide which of the planners' proposals should be accepted.	0.99

elected officials were nearly as competent to make these choices. The low score obtained by the method which would give the decision power to the citizens may reflect a low estimation of the ability of the average person to make planning choices, or it may reflect the general disinterest in the planning process found above among the respondents. The decision-making methodology which bore the closest resemblance to current procedures received the fourth-highest rating among the alternatives.

The planning method which would leave the decisions entirely in the hands of the planners was found to be significantly more popular among apartment dwellers than among homeowners, and more popular among white than among non-white respondents. The alternative which would place the planning questions on the ballot for decision by referendum was found to be significantly more popular among homeowners than among renters. Once again, we may conclude that homeowners, with a greater investment in their community, are more concerned about exerting an influence upon the impacts of planning than are the tennants, who may move more easily, and who do not have as great an investment in their homes. The respondents with the highest levels of education and income were found to favor the alternative which would have an elected review board of citizens with the job of hearing the planners' proposals and deciding what would be best for the city as a whole. This group also tended to give a low rating to the alternative which would give all of the decision-making power to elected officials.

To complete this section, an examination will now be made of the respondents' rankings of broad and generalized criteria which could be applied to problems in the selection of rights-of-way for new freeways. Since all eight of the criteria considered could be viewed as desirable, but the satisfaction of all of them would be impossible, the respondents were asked to rank the criteria in the order of importance which they would attach to each. The criteria and their mean rankings are given in Table 7, arranged in the order of their mean rankings.

The most salient result of the rankings of freeway location criteria is that the criterion which have the freeway built where it would provide drivers with the quickest routes to their destinations received the highest ranking. Transportation planners are often criticized for planning and building routes which meet standards of transportation efficiency but which neglect the disruptive social and environmental effects of highways upon the community. Here we find, at least, that the citizens also place transportation efficiency at the top of the list of criteria, although this does not mean that they have given other criteria no consideration at all. After the criterion of getting drivers to their destinations most quickly, the second highest rating was given to the location of freeways so that they would not require the destruction of homes in healthy residential areas. Although χ^2 contingency tests of the first criterion showed no significant relationships with any of the socioeconomic or travel characteristics, the second was found to receive higher rankings among renters than among homeowners, and higher ratings among people of low educational levels than among those of higher levels. This finding

TABLE 7

MEAN RANKINGS OF FREEWAY LOCATION CRITERIA IN ORDER OF AVERAGE RANKING

No.	Criterion	Mean Ranking
1.	Try to build the freeway where it will provide drivers with the quickest routes to their destinations.	3.22
2.	Try to put the freeway where it will not require the destruction of homes in healthy residential neighborhoods.	3.53
3.	Try to put the freeway where it will not go through parks and recreation areas.	3.93
4.	Try to put the freeway in such places that the construction cost will be the lowest.	4.07
5.	Try to build the freeway where it will avoid the dislocation of business and industry.	4.12
6.	Try to put the freeway through the slums and therefore aid urban renewal.	4.80
7.	Try to build the freeway where it will fit in best with surrounding scenery, even if this route is not the most direct.	5.87
8.	Try to build the freeway where it will provide pleasant views and varied scenery to the driver.	6.27

is in direct contrast with some of the previous findings, in which it appeared that property owners had a stronger interest in their immediate residential community than did renters.

The third-highest mean ranking was given to the objective of locating freeways where they would not go through parks and recreational areas. This criterion received higher rankings among older people than among younger ones, and was less important to multiple car owners than to zero or one car owners. Presumably multiple car families have easier access to wide ranges of recreational areas, and do not place a premium on a particular one which might be taken for a freeway.

Homeowners gave significantly higher ratings than did renters to the placement of freeways where construction costs would be lowest. Perhaps homeowners are more conscious of tax rates than renters, in spite of the fact that transportation improvements are normally financed largely through user taxes rather than through property taxes. Placing the freeway where it would avoid the dislocation of business and industry received higher rankings among the most highly educated respondents than among others.

Once again the suggestions for freeway location which involved providing pleasant scenery for the driver and harmony with surrounding scenery received the lowest rankings. This is consistent with the repeated findings that the respondents attach low levels of importance to scenic and aesthetic considerations. It was found, however, that with increasing annual mileage driven by the respondent, pleasant views and varied scenery increased in importance.

CONCLUSION

Opinion surveys can be a useful tool for "market research" in transportation planning. They constitute one of the few ways, and certainly one of the least expensive ways, in which planners may learn something of the impact of their nebulous products on the satisfactions and attitudes of the users and the nonusers in the community. If the opinions gathered in such studies bear statistically significant and interpretable relationships with the socioeconomic and travel characteristics of the respondents, such studies become something more than an academic exercise in that they help the planner mold the complex systems with which he works to the stated needs of the populace. Surveys of this nature can also be useful in pointing in advance to particular aspects of the planning program which might later be controversial, and may thus help the planner to avoid, or at least to prepare for, the public opposition which often follows the publication of transportation plans. The results of this survey reveal both enlightening and somewhat disappointing aspects of the nature of public opinion toward transportation planning.

It was found that attitudes toward transportation improvements and toward the planning process are reasonably consistent and can often be related to the characteristics of those expressing the opinions. The results indicate that the study of attitudes holds promise as a useful tool for use in goal formulation, in the development of planning principles and standards, and in the establishment of the need for transport facilities in various areas. It was found that the respondents regard investment in transportation to be valuable, in spite of the fact that they perceive the quality of the transportation system to be high. They particularly feel that there is a need for further attention to questions of mass transit, but do not attach much importance to the beautification of transportation facilities.

The survey results may be somewhat disheartening to the idealistic planner who is interested in the effects of his projects upon the overall welfare of the community, since the citizens who participated expressed little interest in taking part in the planning process unless directly affected by proposed facilities or very irritated by existing deficiencies. Responses to questions about a freeway's effect on neighborhoods were found to be consistently related to home ownership status, level of education, and length of residence at present address. This finding might imply the possibility of predicting community reactions toward proposed projects on the basis of a few significant and easily detemined variables.

ACKNOWLEDGMENTS

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Implications of the New Haven Census Use Test for Transportation and Land-Use Planning

GEORGE P. LEYLAND, New Haven Census Use Study

The New Haven Census Use Study was set up to demonstrate how census techniques can be employed to display information about the use of land and the distribution of people within cities. Using the New Haven Special Census of 1967 (a trial run of the 1970 national census) for its test data, the study first established liaisons with over 70 local agencies which might use census-obtained information, and then: (a) translated their demands into detailed specifications which could be programmed; (b) developed computer methods to tailor census output directly to local needs by tabulations and computer-produced maps; and (c) developed non-computer methods leading to better use of data on small areas. The study centered its technical effort on the formation of an accurate geographic base file reflecting the city map, and on the testing of computer programs which use this file to make non-standard tabulations, to match diverse data, and to produce maps. The study has tentatively concluded that the geographic base file is a very important tool for planners, that programs for handling data must be far more flexible than those now available, and that work must continue in order to develop an efficient and inexpensive planning-information system.

•THE 1970 U.S. Census will count a larger population and provide more data to more users than any other census in the history of mankind. Recognizing that the users of census data will require more information on smaller areas than ever before, the Census Bureau is searching for procedures to help planners profit from the "new dimension of statistical intelligence about the American population" (1) which will be available after 1970.

The New Haven Census Use Study was organized to explore the ways that local, state, and Federal agency administrators could increase their access to census data while still protecting the confidentiality of information about individuals in the population. As part of its work, the study has achieved cooperation with more than 70 agencies which are together involved in 40 different planning and research projects.

The local projects, which included several dealing with transportation and land-use planning, allow the study to do on-site testing of methods of gathering, presenting and using data which can be applied to America's cities after the 1970 census.

The objectives were presented last year by Hanson and Voight (2), who described how the suggestions of the Census Advisory Committee on Small Area Data resulted in the opening of the office in New Haven in 1966.

In brief, the Census Use Study was established to help the nationally oriented Census Bureau produce improved information about small areas—roughly to the scale of the city block. Often this information can be obtained by translating the general needs

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GENERAL RESPONSIBILITY: Support by Federal and State Agencies	SPECIFIC RESPONSIBILITIES: Support by Local, Public, and Private Agencies
1. Create Geographic Base File	1. Transportation Planning:
	• Traffic Zone Tabulations for 256 Small Areas
2. Tabulate Census Data	• Tabulations for 10 Selected Traffic Generated Areas of High Population Density
3. Match Local Data to Census Areas and Census Data	• Area Travel Survey (Origin and Destination Survey) for 2.5% of the Population
4. Map Census Data to Local Data	2. Land Use Planning:
	• Community Action Program Tabulations for 81 Small Areas
5. Expand the Data Base	• Tabulations for 10 Selected Areas of Federally Supported Housing
	• Tabulation for Housing Model and Market Analysis
	• Observatory for Redevelopment Director Decision Support

Figure 1. Census use study responsibilities.

stated by the local data user into detailed specifications—which can then be programmed, and the information quickly obtained from available raw data. Computer methods are also being developed to tailor census data directly to local agency needs, and non-computer procedures devised to give a better understanding of the uses of small-area data.

Figure 1 shows the study's responsibilities with respect to national agencies and local agencies dealing with transportation and land-use planning.

Although we do not anticipate that all of the activities in Figure 1 will be applied on a nationwide scale in 1970, we will certainly be able to determine their feasibility and costs. Some of the suggestions from the Census Use Study will be integrated into the planning for the 1970 Census and other continuing programs of the Census Bureau. In addition, close liaison with HEW, HUD, DOT, and other Federal agencies will help us adapt the programs developed for New Haven's data users for future users in other cities. The prime payoff of our cooperative effort, however, will be in the long-term, intelligent use of urban information.

This report describes how the study has been applied to New Haven and to national needs, noting some of the problems encountered in producing small-area data. Most of the specific programs and procedures being developed will directly affect land-use and traffic planning, though the capabilities being generated will have more general application also. Several preliminary conclusions are drawn, based on technical procedures in New Haven.

APPROACH

Local and National Orientation

Shortly after the New Haven office was opened, the Census Use staff held a series of meetings with Federal, state, city, university, and private-agency representatives to acquaint them with the operations of the Census Bureau, the nature of the population and housing census pretest which was soon to be held, and the objectives of the Use Study (3). These meetings have continued at the local level during the past year and have helped to focus divergent interests on the practical use of small-area data.

The Census Use staff has encouraged representatives of local agencies to develop their own projects based on Census materials which can help them make decisions about their future programs or plans. Our staff is neither developing nor testing specific mathematical models for local programs; as a result of our work though, conceptual models are being developed and tested by local agency personnel for their own use. Neither is the study strongly influenced by the needs of Yale University researchers in sociology or city planning—it is oriented to local agencies which directly influence the activities of local government and industry.

On a national level, our efforts have been primarily directed toward developing uniformity in the release, format, and content of census data. This uniformity should be based on the needs of the local communities which will ultimately use the information for planning; hopefully many of the standardized computer programs developed by the study can convert 1970 census data into forms useful for local analysis soon after the census is taken.

Major Developmental Programs

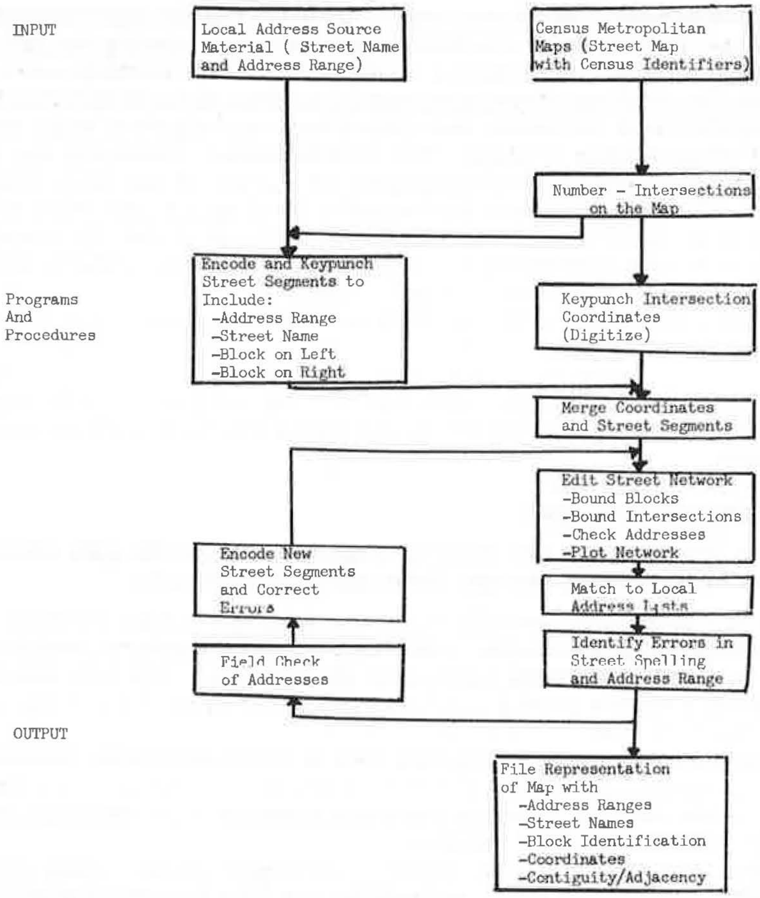
The Census Use Study has also developed data-handling techniques which are being used right now by the Census Bureau; these are procedures for:

1. Creating a geographic base file—computerizing the Census Bureau's Metropolitan Map which includes address ranges, street names, block numbers, and intersection coordinates: in short, everything which is on the city map. The base file is the most important part of a system providing information to planners, for it links all of the elements of data to be manipulated and displayed.
2. Tabulating census data—aggregating data in tables or charts, usually according to predefined geographic areas. Detailed information about many individuals is compressed into forms useful to planners and administrators, with emphasis on being able to make tables for nonstandard variables.
3. Matching individual and local data with geographic codes—coding separate data files to a common geographic base, and relating the files to each other with a computer program for flexibility in mapping and tabulating.
4. Mapping by computer—producing maps of the city or districts which reflect aggregations of individual data on a block basis.
5. Expanding the data base—testing means of obtaining more detailed individual data by questionnaire. Two special surveys—for local planning use—were taken and added to the data base.

In conjunction with these five studies, the staff is studying the elements of a hypothetical planning-information system to test current assumptions about census data. For example, ways to use nationally obtained census data in conjunction with local data by combining several computer programs are being explored, and an effort is being made to discover how data can be manipulated and displayed, even though the data may come from several different sources. The Use Study is thus emphasizing the necessity for developing uniform procedures for data handling.

THE GEOGRAPHIC BASE FILE

Any planning programs or procedures which must use maps will depend on the geographic base file. The file is the data repository containing all the area information which the planner will manipulate or display, and is the element which links data on individuals to the computer programs which will create data on groups (4). Because the file is so vital to the accuracy of the planning information, it must be complete, easy to correct, and easy to update. In New Haven, the Census Use Study has used several forms of the geographic base file and continually updates the file's information by checks against the records of local agencies.



NOTE: The procedure for creating a Geographic Base File includes merging both census-tract and block identifiers with local address ranges. These form a single file which can be edited and updated, and to which coordinates may be added. The file then represents a computer-readable version of the entire city map and the addresses on the map.

Figure 2. Geographic base file preparation (DIME).

File Development

An ideal geographic base file is a computerized equivalent of the map, including address ranges, street names, block numbers, and intersection coordinates. As such, it must contain all the information shown on the base map from the Census Bureau's Metropolitan Map Series (5). Further, it must be in a form which permits manipulation by several computer programs without loss of information. Figure 2 shows the steps in file preparation.

To be of use to any urban planner, the file must include all addresses and street records, regardless of whether they refer to people, housing units, or even to vacant lots.

Thus, land-use data for recreational facilities, commercial establishments, and industrial plants must be a part of this geographic base file to benefit most city agencies. (This lesson was learned when information about trip destinations had to be placed in the file; in the Area Travel Survey, the difficulty of coding trip destinations into the downtown area became apparent when a geographic base file restricted to housing information was used.)

To be useful to traffic planners, all of the location characteristics of the streets must be preserved—not only must a street be defined by its direction or by its blocks, but by the addresses which lie on either side of it. The "contiguity" and "adjacency" of addresses must be as accessible to the computer as it might be visually on a map.

Similarly, to be used on a computer, definitions of street and place names must be consistent, so the file can be manipulated without error; and streets which turn corners, but do not change their names, or streets which alter their names but do not change direction, must also be able to be controlled by the file.

By first enabling the base file to cover the entire city-street network—instead of using arbitrary tracts or traffic zones which may cut across street or neighborhood boundaries—the way lies open to then impose any set of boundaries one may desire. By putting in the detail first, more effective and specialized areas can be retrieved from the file.

When, for example, traffic zones are needed by planners, they are first drawn on the city map and then coded into the geographic base file according to the block numbers they affect. Effectively, the traffic zones then become equivalent to groups of blocks for subsequent computer manipulation, because a special file showing the correspondences has been created. This file, called an area dictionary, at present includes the outline of community action program areas, as well as 10 other areas for special use.

Most local data users want a geographic base file they can control and update to keep it current and accurate. Thus, the study has worked on editing and updating procedures to obtain the reliability and consistency needed for address coding. When errors are found, the file must be capable of accepting the necessary corrections while still reflecting previously correct geographic relationships. This is a difficult task; in fact, the geographic base file in use in New Haven could assure adequate geographic coding only after successive verifications against local address files. If the geographic base file is to be an essential part of an operating information system, then that file must change as the city changes.

Use of the Address Coding Guide

The Address Coding Guide, a preliminary geographic base file provided by the Census Bureau, exists on cards, on tape, or as a printer listing for use by virtually any

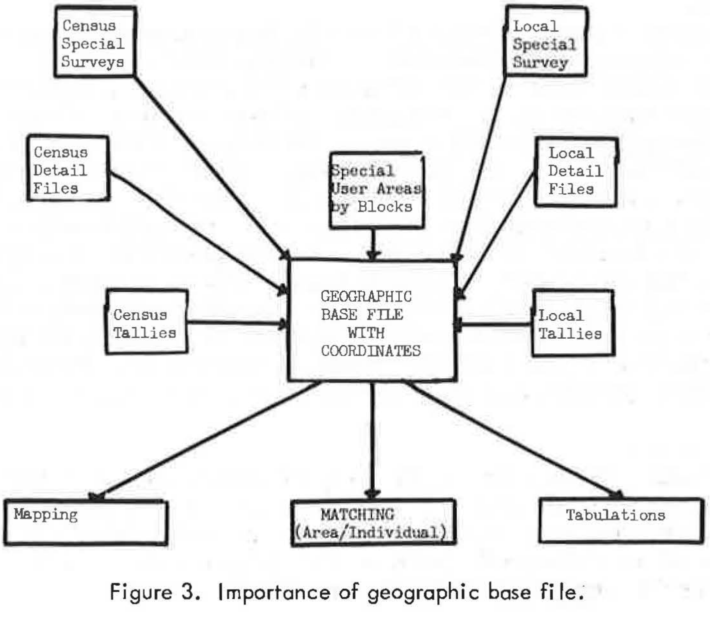


Figure 3. Importance of geographic base file.

local agency. The agency could thus make many tables based on address areas in the city; for example, the local police department plans to use this file for geographic coding of complaint records at the time they are telephoned to the police station.

In order to be able to use the Address Coding Guide, the New Haven staff added editing and mapping features to the file. The resulting structure, called DIME—(dual independent map encoding (6)), is based on the use of computer edits and the concepts of graph theory. The addition of map coordinates facilitates visual editing of the file, by enabling the computer to construct and print out maps based on the address coordinates. Figure 3 illustrates the key position of the geographic base file in the programs and procedures we are developing.

TECHNICAL DATA HANDLING AND PRESENTATION

Tabulating Census Data

Tabulation programs are used by planners to display data in tables or charts, usually according to predefined geographic areas. In this manner, detailed information about individuals is compressed into a form useful to the specific needs of planners and administrators. Obviously, if the tables are to be used most effectively, the categories of data should relate directly to the needs of those who will use the tables, and the tabulation programs must be flexible enough to respond to these specific needs. Therefore, to increase the usefulness of a tabulation, there must be a variety of ways of breaking the basic data into meaningful categories.

Tabulation Data Control—Since most urban data are used in a geographic context, the "area" variable is very significant. In the past, the census tract has been the smallest area for which a large volume of tables were compiled, and the tract—which is an arbitrary area containing approximately 4000 people—has thereby come to be considered the standard small-area dimension for census use. In New Haven, where tabulations covering the whole city have been requested for more than seven different area variables, traffic zones and Community Action Program areas have become secondary standard areas.

In addition, tabulations have been ordered for six different limited areas in the city, including large apartment complexes which act as traffic generators, and clusters of Federally supported housing which have particular land-use characteristics. Most other data users requested tables about either specifically defined nonstandard data areas or about small areas which can be used as building-blocks in constructing larger tabulation areas.

In the past, variables other than area have also been categorized into standard and generally accepted groupings. For example, the population in five-year age groups is a typical census output; but after searching the Census Bureau's published literature, over a dozen different types of age groupings can be discovered. Though this variety might seem to be an impressive aid to users, the number of data categories in the current census tabulation program is, paradoxically, a major source of confusion.

Yet our requests in New Haven will undoubtedly add to this confusion (over six new variations of the age categories have been requested), because planners are not satisfied with standard categories when they have specific questions. It is further disheartening to realize that the number of possible tables that can be generated from census data is so large that the probability of satisfying specific local needs with even several thousand pages of published tabulations is negligible. It is estimated that the number of meaningful alternative tables exceed 30 trillion from the New Haven Census questionnaire alone[1]. These possibilities are a burden not only to the Census Bureau, which must

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[1]The number of tabulations is estimated by considering 100 separate variables with an average of five different category groupings per variable. In this case, a five way cross-tabulation (the income characteristics of small families, with one or more dependents over 65 in certain tracts) yields approximately 500^5 alternative ways to specify the table. If this table is to be done for non-whites, approximately 500^6 alternative ways to specify the table are available.

produce a set of standard tabulations, but also to the local people, who must request specific tables.

Tabulation Requests—The most important characteristic of the tabulations program in New Haven is the large number of variables and categories in the tables. This flexibility will enable us to create tabulation areas along street sides or within a certain distance from a street, special areas for the whole city, or for specific locations in the city. As a result, the characteristics of the population which are affected by a community action program, redevelopment program, or highway construction can be tabulated. Traffic zones, too, can become "standard" areas, and new area units can be created for portions of the city which are currently undefined or which change frequently. Such a project is now being carried out by the New Haven Education Department, which is redistricting high schools by considering the distance students are from schools, and both racial and academic characteristics of the student population.

Other nonstandard categories are being used in New Haven. The Traffic and Parking Department and the Police Department have asked for socioeconomic and family characteristics for the population which is between the ages of 15 and 21 (by single years of age) to be used in traffic and police planning. Extensive nonstandard cross-tabulations have been requested by the YMCA which is considering a driver-training program for children from low-income families. Because they wish to predict enrollment, the YMCA is naturally interested in the age and income of various groups of young people, and whether cars are available in their households.

The Bureau is also planning to produce a new variable based on place-of-work information rather than place-of-residence. Many other special tabulations have been requested and, in most cases, the requests are for tables not previously published by the Census Bureau after a decennial Census.

As a result of our increasing flexibility, the few hundred pages of tabulations which were done in 1960 are being augmented by over 4000 pages of new standard tabulations. And in an attempt to satisfy the local agencies regardless of whether they have a computer available, the Census Bureau will produce many of their tabulations on both computer tapes and microfilm.

Tabulating Techniques

The Census Bureau's Basic Record Tapes of the 1967 Special Pretest in New Haven enable the study to do inexpensive and efficient tabulations on the City of New Haven's IBM 360 and on Yale's IBM 7094 direct-couple system. One tabulating program in use is DATA-TEXT (7); a typical tabulation is shown in Figure 4. Even inexperienced programmers have been using this system quite successfully. Because both the DATA-TEXT program and the CROSS-TAB/360 program were written in assembly language, they are as inexpensive to run as any other tabulation program that we could have used. By using the data for each of the 350,000 individuals in the pretest, and by using general tabulating programs, we plan to produce over 50,000 pages of tables to satisfy the requests that we have received from data users in New Haven. Although more than 50 agencies have requested tabulations, in most cases there is no overlap in tabulation requests. The exceptions are users who, without specifiying their own needs, order exactly what another agency has ordered. Unfortunately, duplicate runs are hard to identify because there already are too many requests to allow us to organize for this purpose. Moreover, in one case of preparing standard tally requests for the Bureau of Public Roads, the needs of local traffic agencies strongly influenced the type of data requested.

A great deal of time has been spent, therefore, trying to organize requests. Using DATA-TEXT, we have been able to form a category file so that new cross-tabulations are made by selecting the variables from the file and then indicating the ways in which they should be cross-tabulated. Despite the ability to create new variables, we have difficulty in organizing information about the tables that have been produced in the past and the tables that have been requested by local data users—and existing publications do not lend themselves to a neat order which would fit in a single booklet.

In our attempt to organize the data resources, the Use Study staff created a chart 6 by 30 ft (72 by 360 items) on which the major tabulation categories and cross-tabulation

CITY PLAN CAP AREAS 8-10

CELL PERCENT BASED ON COLUMN SUM — CONTINGENCY TABLE NO.

SUB-TABLE OF UNITS WITH SUBCAP HC1 ON VAR 27 NUMBER OF HOUSEHOLDS

VAR 32 RACE OF HOUSEHOLD HEAD

VAR 9 NUMBER PERSONS IN UNIT

	WHITE	NEGRO	OTHER	TOTAL	PERCENT
ONE PERSON	75.4 153	66.7 4	100.0 3	160	75.5
TWO	13.8 28	16.7 1		29	13.7
THREE	4.4 9			9	4.2
FOUR	2.5 5	16.7 1		6	2.8
FIVE	2.0 4			4	1.9
SIX	1.5 3			3	1.4
SEVEN PLUS	0.5 1			1	0.5
TOTAL	203	6	3	212	
PERCENT	95.8	2.8	1.4		100.0

Figure 4. Sample DATA-TEXT table.

categories are written. The data that were (a) produced in 1960, (b) planned in New Haven for 1967, and (c) needed by local agencies are displayed on this chart. We find, unfortunately, that even this large chart is inadequate because it cannot list all the precise definitions in the tables, and because ambiguity and redundancy of the information on the chart inhibits its use. The Census Bureau has been attempting to solve these problems by creating standard dictionaries and standard information files for all Census information.

Matching Local Data Files and Individual Census Records

A basic objective of the Census Use Study was to develop methods of relating local data to census data. Relating any two data files—for example, school transfer data (migration) and housing data from the redevelopment agency—is possible only if the street addresses in the local files are coded to a set geographic base. One set of data can be related to another set of data by using the common address for a key. Our definitions of matching, then, is (a) coding separate data files to a common geographic base, and (b) relating these files to each other by a computer program which tests whether the address keys are equivalent.

Matching programs are essential to the planner because they allow him to relate several disparate sources of data. And, if the same geographic base file is used for

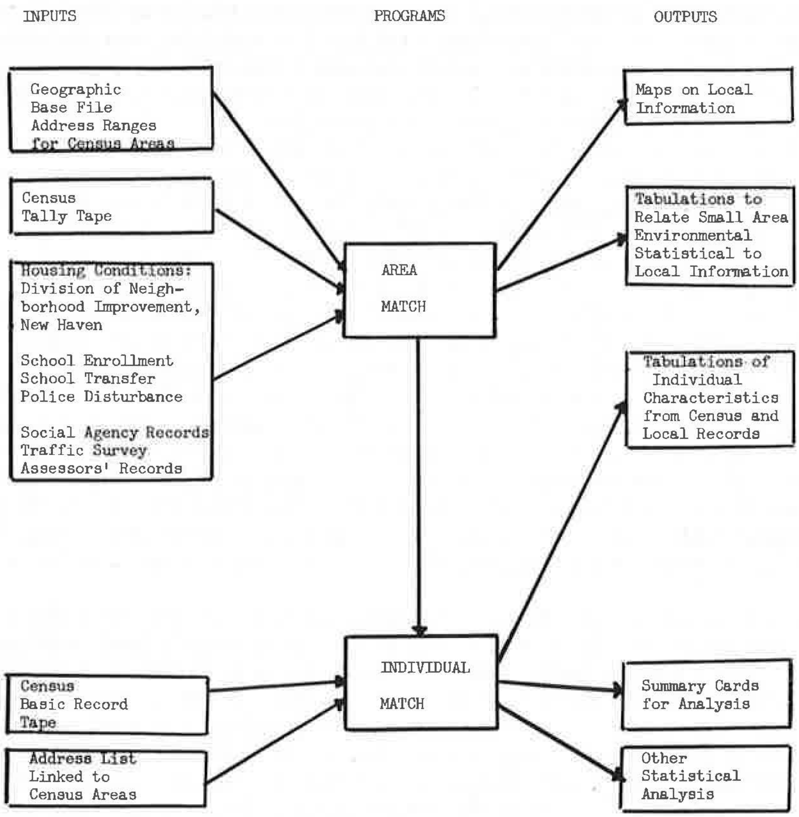

Figure 5. Matching programs.

all matches, with each match performed the accuracy of the file is improved as errors or inconsistencies in the data sources are printed out for correction. Figure 5 shows the types of matching being used in New Haven, illustrating some typical data inputs from local agencies and some possible outputs of interest to planners.

Local Matching Uses—Information from local sources may be matched to census data in two ways: by area (block or block side) matching and by individual (person) matching. The distinction between these matches is important; each has a different definition, different computer programs to accomplish the matching, and different confidentiality implications.

Area matching codes the address in local records to its specific census block. To do this, the geographic base file relates the address to the house-number ranges which identify the appropriately coded census-block or block side. We have had almost a dozen requests for this type of matching in New Haven: one such area match relates crime incidence to census blocks in order to display the incidence of crime and to explore the environment of crime.

Individual matching, on the other hand, relates the characteristics of individuals (age, sex, etc.) in local records with the same individual as recorded to the census. This type of matching will be done for the 1970 supplementary survey questionnaires; for example, the New Haven Travel Survey questionnaire will be related to the individual census sample questionnaire to help determine typical trip destinations, frequencies, and routes. There are thus two anticipated outputs of our matching system. First, the area match can code local addresses to many specific geographic locations—towns, tracts, traffic zones, blocks, enumerated districts, school districts, or other similar areas. Then, any other environmental information about blocks or block faces can be linked to these addresses. An immediate need for this matching was suggested by the Police Department, which wanted to look at the difference between crime patterns in low-income and high-income areas. Second, matched individual characteristics can be aggregated into appropriate categories and printed in tabulations or as maps. Other local data can also be linked with census data at the address level or at the person level to produce tabulations. These procedures permit analysis of the demographic characteristics of selected groups in the population which have been identified in the records of local agencies. For example, the relationship between individual income (determined by the census) to the number of trips taken by these individuals (learned from the Area Travel Survey) will be one of these cross-tabulations.

Problem Areas—Two major constraints in matching projects are the condition of the local records and the use of inappropriate identifiers from local records. In the first instance, we have found that the tape records have in many cases never been used for processing or manipulating the addresses. So, a preliminary phase of preprocessing and editing assumes major importance. In most of the matching that we have tried, none of the records are in appropriate condition to match without extensive editing. In all cases, we find that the extensive errors in punching addresses and in spelling street names represent major problems. The condition of the local files must, therefore, be taken into consideration when the data to be matched are determined. And, the local agency must be responsible for relating the matching needs explicity to the research being done.

Others factors likely to operate as constraints include the fact that the cost and feasibility of matching on a large scale still has not been established, and that procedures for input and/or analysis have not been fully defined, either by the Census Bureau or by local planners. Finally, individual matching needs a reliable screening system to be effective: care in choosing the characteristics to be matched is more essential to success than are the computer programs which actually do the match.

Successful matching techniques will also allow the Bureau to provide statistics on groups of sample subjects from special surveys such as hospital patients and crime areas promptly and at a reasonable cost. (Summary statistics are the only statistics that are ever released from matching projects; no information will be released from any matching study which will ever identify a particular individual or household.)

Matching Techniques—Before the Use Study, most area and individual matching had been done laboriously, by hand. In these earlier attempts to do matching by computer and by hand within the Census Bureau (8), in other government agencies (9), and in private industry (10), major difficulties had been encountered in defining streets and geographic codes. However, because a geographic base file is available in New Haven, we are now able to relate administrative records, community event records, and attitudinal questionnaires to the standard census base by computer.

A new technique for area matching has been developed by a study consultant from Cambridge Computer Associates who has been working for some months in New Haven. His results are encouraging and we expect a fully operational routine within the next few months. The technique for matching includes first the preprocessing of local address files and then the matching of two address files on either an "absolute" or a "probability" basis. In the preprocessing routine, the local records are scanned to locate the key items in the addresses. Then the addresses are put into a fixed, identical format which can be read by the matching routine before the actual matching program is used to attempt an area or address match. Thus, many different types of records can be matched and continual updating of the base file is possible.

Individual matching is a two-stage process. First, an attempt is made to match individuals to the addresses in the geographic base file. Only then is the individual match made on personal characteristics, to limit what would be a search for exactly matching other individuals within an area. In some cases, individual matching must be accomplished by matching on only three out of four characteristics—screening out an exact match on age, for instance, or other personal characteristics which might render the data so specific or so general as to be useless, or very expensive to obtain.

RECORDS (ORIGIN)	TOTAL NUMBER	PREPROCESSOR REJECTS	MATCHING REJECTS	SUCCESSFUL MATCHING	PERCENTAGE OF MATCH
Birth/Death Records (State)	3,646	9	134	3,503	96.1
Division of Neighborhood Improvement Complaint Records (City)	830	2	75	753	90.7
Police Arrest Records (City)	410	5	137 (104 without house numbers)	268	65.4
Police Complaint Records (City)	3,336	2	175	3,159	94.6
Donnally Address List (Census)	29,337	72	492	28,773	98.1
New Haven High School Academic Records (City)	9,434	0	335	9,099	96.4

Figure 6. Area matching accomplished at the Census Use Study.

To prevent frequent keypunch errors from interfering with an otherwise good program, in New Haven major variations in street names and major location names appear in the geographic base file, as well as an approach toward common misspellings of names in the area and individual matching programs. Moreover, because individual characteristics are involved in validating some area matches and for attempting individual matches, age and several other items of individual information are available. If other information such as Army serial numbers or social security numbers are available, this information could also be helpful in matching.

For example, a special serial number is present on both the Area Travel Survey and the Census "25 percent" questionnaire because the special-survey sample address list was generated from the regular census address list. This feature will allow a complete computer check of the individual matching procedure by allowing the serial number match to be verified with the file that results from the address match alone.

Though all matches will of necessity be imperfect, we anticipate that our area matching will be able to code over 95 percent of the records, with the 4 or 5 percent mismatch attributable to ambiguities and misspellings in the local address file. For area matching, the percentages can be increased by hand-correcting the local agency's address file and submitting it to an additional run. Unfortunately, our experience with individual matching is still inconclusive, so representative percentages of accuracy cannot be stated. Our achievements in area matching are summarized in Figure 6.

Mapping Census Data and Local Data by Computer

The planner often has difficulty in evaluating large amounts of printed data even though he may be able quickly to recognize and assimilate the importance of visual patterns. Computer mapping is, therefore, a logical development in data processing for planners and administrators, and we are exploring—with some success—several options available for producing maps by computer. Until machines can make the maps conveniently and cheaply, even standard map production will require research. Even so, mapping procedures which make use of census and local data can be done efficiently when the mapping techniques can be supported by tabulations and matching programs which use a standard geographic base.

Use and Development of Mapping Techniques—Local users have requested several map types, as well as such mapping-related materials as the centers of blocks (needed for traffic-network assignments) and the areas of blocks (used in density calculations).

These two uses require a complete coordinate file for every street in the city.

The types of maps requested have been quite varied—users have required outlines on several blocks, dot maps on a block basis, irregular polygon maps, proportional symbol indicators in the center of blocks, and special area boundaries. Dot maps or maps that use symbols have been requested to display the incidence of fires, traffic accidents, and police complaints. In addition, grid mapping and contour mapping have alsobeen requested to display socioeconomic information and land-use characteristics.

The Census Bureau will use the mapping techniques developed in New Haven for production of a test brochure of a series of maps. These maps will be representations of 30 significant variables in the census data. Several proposals have been discussed to include maps as a standard production item to be published with tabulations in 1970. This standard set of census computer-produced maps would obviously be of value to persons in local areas who are without computers. As such, these maps would certainly represent a useful addition to census publications.

Before any data can be presented on a computer-produced map, they must be assigned numerical coordinates. And, because the smallest unit of area information available from the census is the block side, the intersections (block side terminals) must be given coordinates. Thus, both census data and local data which are keyed to block sides can be displayed on a map. Assigning coordinates to groups of blocks or parcels of area is more difficult, however. First, the approximate location of the parcel centroid is calculated using as a base the address range that the parcel encompasses. In addition, "block boundary coordinates" can be calculated. The ability to manipulate and calculate coordinates is essential for local use of computer-mapping techniques, and the types of maps that can be produced are determined to a large extent by the completeness and precision of the coordinates in the geographic base file.

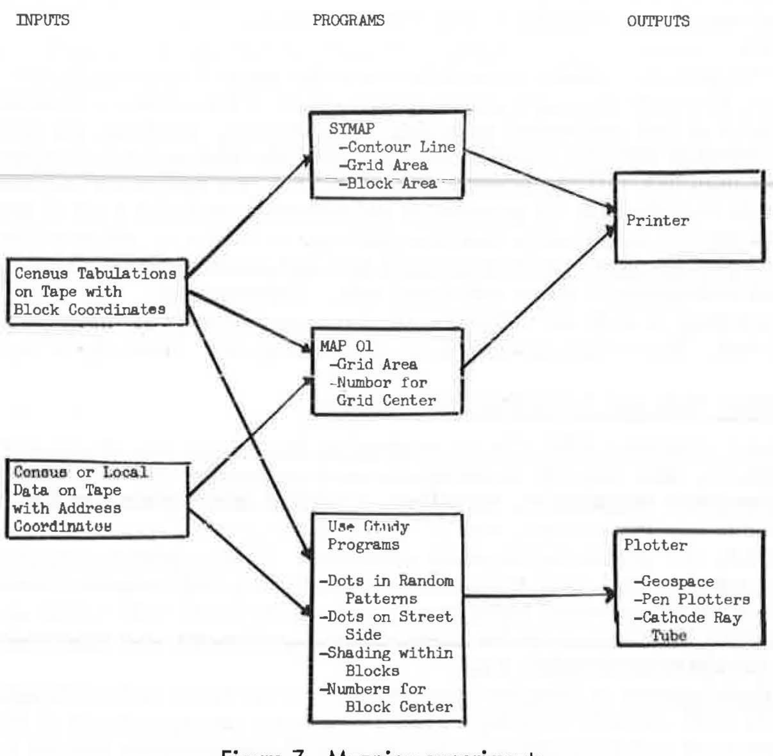

Figure 7. Mapping experiments.

To preserve the maximum degree of flexibility with the data, and to prevent loss of information, the mapping experiments should use the smallest unit of area possible. As a general rule, data assigned to blocks should be displayed, rather than data assigned to larger areas such as tracts. The smaller units allow increased precision when required, and allow controls to be included to eliminate specific details which might threaten confidentiality.

Figure 7 outlines several mapping experiments we have conducted with our data and various computer programs for mapping which are available.

As indicated, our mapping projects use two basic inputs: the Census Tally Tapes and the Basic Record Tape. This variety in inputs allows different approaches to map production to be tested and the cost of each to be evaluated.

Mapping Techniques—The types of computer mapping that can be done in New Haven will be dictated to a large degree by the equipment that is used. Computer-mapping techniques using the pen plotter, printer, geospace plotter, and the cathode-ray tube are being developed in New Haven with available equipment. Calcomp plotters at Yale have been tried with results of excellent graphic quality, and MAP 01 and SYMAP have been tried with the printer—samples of the SYMAP maps are shown in Figure 8 (11). We have also cooperated with the Harvard Laboratory of Computer Graphics on a project to produce maps for potential use in FHA decisions on home loans. Unfortunately, however, the time and cost characteristics of elaborate plotter and printer maps may exclude large-scale map production efforts in most cities.

Experiments (12) with the geospace plotter equipment at IBM's New York Scientific Center have also been undertaken, for it can produce very high quality maps (shown in part in Fig. 9) quickly and at a moderate cost. The study also plans to conduct experiments with Stromberg-Carlson, Control Data, and IBM cathode-ray tube equipment to produce dot maps, if we can make arrangements with various companies and universities to use the equipment. Our preliminary tests indicate that small, inexpensive maps can easily be produced with the use of the cathode-ray tube equipment.

To conclude, in New Haven there is an emphasis on mapping flexibility and the ability to produce large quantities of low-cost maps. Some planners are disturbed by the lack of "human" quality in computer maps; at the same time others feel that the value of the computer is in the production of rough maps which have information impact rather than aesthetic force.

Expanding The Data Base

As valuable as it is, the census data obtained at 10-yr intervals is often lacking in the detail needed by local planners because of the necessarily limited scope of the standard questionnaire. Recognizing this problem, the Census Bureau tested two special, detailed surveys in New Haven which would be compatible with the format of the standard questionnaire. The Bureau selected the sample, mailed out the questionnaires, edited the returns, and coded the data on tapes for use in New Haven.

Area Travel Survey—The New Haven Area Travel Survey sampled 2.5 percent of the population in New Haven. It asked for a daily record of trips for a particular day and was collected on a series of days throughout one full week. Using this survey, it was hoped that home-to-work information could be collected, and used in conjunction with journey-to-work data gathered from the entire New Haven Pretest.

Traffic planners in the Bureau of Public Roads, the State Highway Department and the City of New Haven all hope to use the data from this survey to evaluate how our regular census results can be used for traffic planning, but also to see how this special instrument works in providing fresh data for traffic planning. If the Area Travel Survey methodology proves feasible, the Bureau of Public Roads may arrange for such surveys after 1970.

Family Health Survey—The other special survey, the Family Health Survey, sampled one person in eight in the central city and one in thirty in the suburbs. The questionnaire developed for this survey asks for detailed health information, and the resulting data are expected to be useful not only in defining health needs in the city, but also in helping planners to decide where new community health facilities will be of the most use.

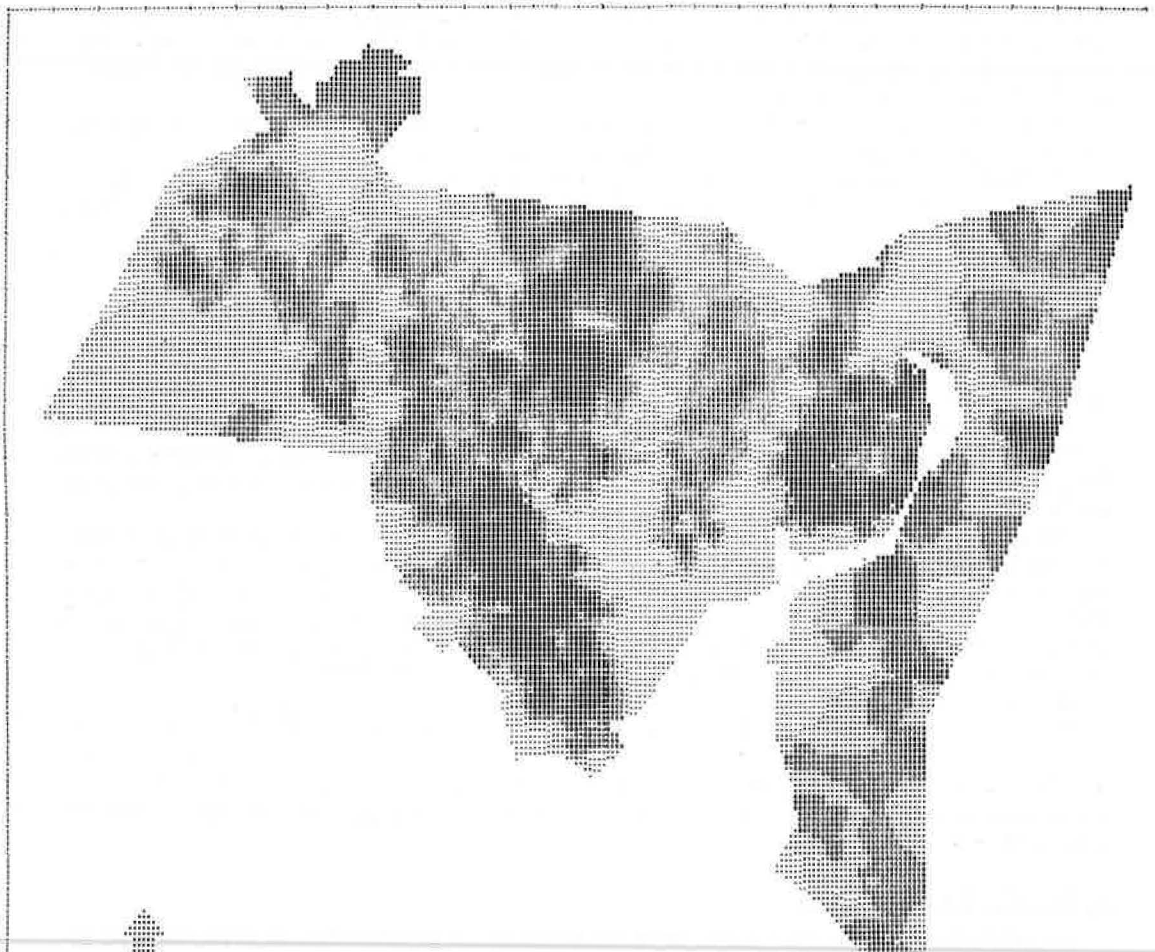

Figure 8. SYMAP sample map—density of pre-school children five years old and younger, number of children per acre.

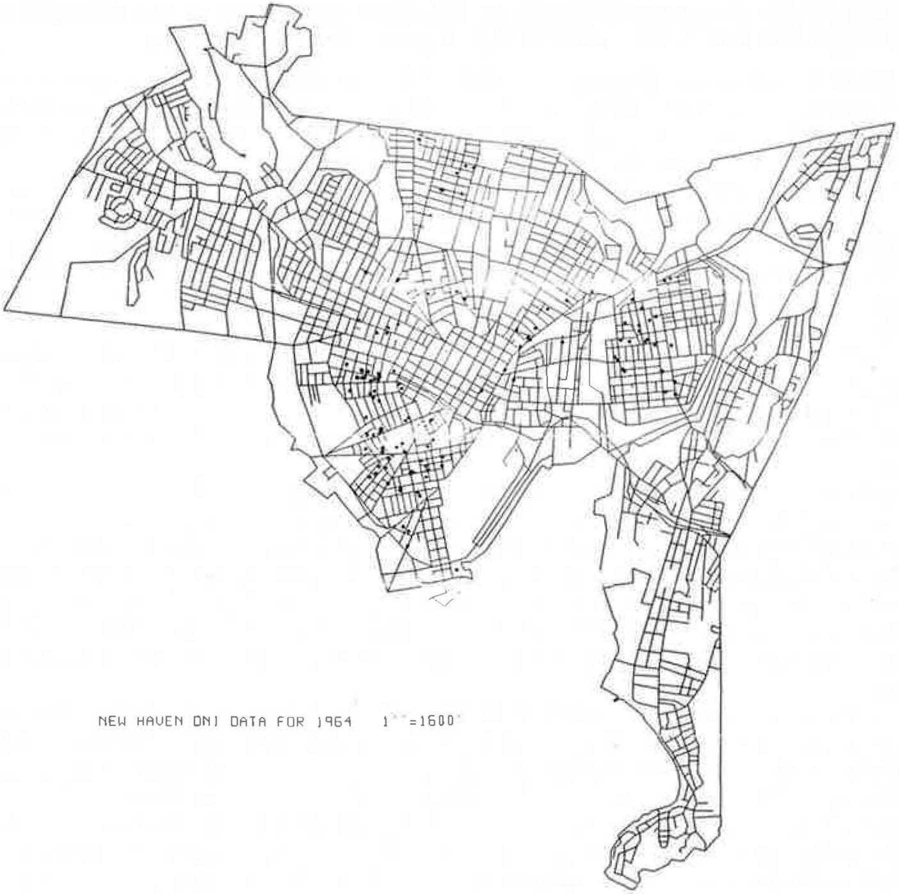

Figure 9. Sample map from geospace plotter.

Other Local Surveys—In addition to the surveys conducted by the Census Bureau, local agencies could run their own investigations, which could be then matched to the Bureau data with only a slight decrease in completeness. The census could still supply the format information necessary to make the sampling capable of being matched, but the local agency would take full responsibility for developing the questions without Census Bureau involvement.

Such a survey is now being conducted by Yale's Department of Sociology, and will yield detailed information on attitudes toward the community in New Haven.

SOME PRELIMINARY CONCLUSIONS

The ideal computer has been described as one which is free, painted on the wall, has unlimited memory, accepts verbal input, and answers verbally. Of course, it should not have to be programmed. The ideal planning-information system for some planners consists of a sheet of published Census data. In fact, for many planners who have many questions and few answers, a sheet of published data may be useful in answering one or two questions—which is, after all, better than nothing. And, since the published material is free and in hand, the planner may think he has an ideal information system.

As a result of our experiments in New Haven, some preliminary conclusions about an information system designed to use census data can be presented. These general statements, while obviously debatable at this time, are based on our attempts to satisfy current needs for small-area data in New Haven. They are as follows:

1. Need for accurate geographic coding—The importance of the geographic base file to all computer programs using census data and local data makes accuracy mandatory. To be of greatest value, not only must the state of past census coding be preserved, but any code changes must be added to keep the file up-to-date.

The use of addresses, whose occupants change constantly, as the key element for linking all data records implies the need for programs and procedures to update the geographic file on a set schedule. Thus, accuracy depends on the creation of an acceptable, time-dependent structure for local information updating. What we have learned from our New Haven experience constantly emphasizes the importance of the geographic base file.

2. Need for flexibility and detail—The New Haven experience can also help us define the flexibility needed to meet user requests: flexibility which will permit us to respond so efficiently to user requests that any special categories—whether of area or subject—would be handled so well that the concept of the special category would cease to exist.

Flexibility of response is required because the areas defined by the user are not fixed, but varying according to the changes in programs, agencies, and time. Thus, for the study to be responsive to any request requires taking changes into account. In addition, to increase the value of the tabulations, the geographic base file must include coordinates, street names, addresses, intersections, and area calculations. Finally, addresses and intersections for industrial, commercial or public buildings should be included along with those for residential units in order to increase the capability for matching.

These detailed inputs are required because local agencies need data of more precision than can be imagined at the Federal level of administrative decision. Therefore, the smallest unit of data—individual record on the basic record tape—must constantly be used to provide tabulations and demographic variables or categories. In addition, our response to these initial requests must be fast enough to permit the data to be useful.

Although the maps and tabulations we have produced are varied, we are still limited by equipment available. It is, furthermore, doubtful whether any single computer system can be designed to be general enough to fit all the needs of local planners at even a single location. Thus, many computer systems (which would not only have to be set up but also interrelated) make the flexibility necessary for tabulations and mapping as much an equipment-design problem as a systems problem. Regardless of what hardware manufacturers tell us, computer equipment available for large-scale data storage, retrieval, and display is not adequate for most urban-planning applications. Our experience in New Haven suggests that this may be true regardless of the equipment's cost; and when costs are considered then the point certainly cannot be disputed.

3. Need for further studies—The first two conclusions stress the importance of being able to relate the programs to manipulate and display data to planning needs. Admittedly, they tend to emphasize the ideal rather than the practical; at any rate, we hope that these suggestions will lead to applications beyond New Haven's needs.

All of the Census Use Study activities have helped define the usefulness of various computer programs for producing small-area data. They have done this by orienting our programs and procedures toward increasing access to census data, and by attempting to maximize the use of census data in local projects. Through these activities in New Haven, we have come to think about planning-information requirements for urban areas in general. But, it is now clear that a great deal of additional exploratory work must be done before an urban information system can be built to satisfy the needs of planners and agency administrators—yet our efforts in New Haven have, we hope, made a significant step in this direction.

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Discussion

MORRIS H. HANSEN, U.S. Bureau of the Census—It may be useful to make some brief comments that relate what we are doing in New Haven that Mr. Leyland has described to what is actually developing in the 1970 Census. Our goal is to provide in the 1970 Census for essentially the same geographic resources that are being developed in New Haven, although the work will not take form in exactly the same way.

We are taking the census in the major metropolitan areas and in certain surrounding parts of the country by mail, and this has many implications that I will not discuss. One of the implications was the necessity, the absolute necessity, for finding a way to assign geographic codes to addresses. A year or so ago, we initiated the creation of an Address Coding Guide (ACG) which would do this, and would also serve other purposes in geographic analysis. This was initiated long before many of the previously mentioned developments took place. The Census could not wait for these things to take place—we had to be ready to take the census in April 1970. When you operate under such requirements you must start with the lead times that are necessary. So the ACG is proceeding, is well on the way, it will serve a number of important and useful purposes, and is being developed with extensive local cooperation. This is another topic of its own.

But with the recent developments on DIME in New Haven, we are now able to say that the introduction of DIME into the system will have important advantages in facilitating geographic analysis and statistical mapping. Our plan is to incorporate these additional features into the census as a second stage. We will do this provided that the resources are available, and we are undertaking to obtain them. We cannot guarantee how far this can go until our appropriations are known, but our plan is to end up by incorporating in the census the DIME system, the system of providing the orientation of street intersections and segments, and blocks, and also associating coordinates with the intersections, and thus make it feasible to achieve the computer analyses and mapping flexibility discussed.

The total system involves creation of the base maps (which we have undertaken and are well along with) and the creation of the ACG. The ACG will permit new types of flexibility in geographic manipulation in the computer, as compared with prior censuses, but will still lack the desired additional power for computer manipulation and mapping that can be obtained by incorporating the DIME system and coordinates.

In summary, assuming the availability of resources which we are expecting to press hard to obtain (but the outcome is still unknown to us) these additional features will be developed and merged with the ACG. We also hope that this system for geographic coding and analysis will become a live and continuously updated one, that the whole system will be put in the public domain, and that local and other public use will provide feedbacks as one of the important factors in keeping it up to date. Problems in getting resources for keeping it up to date are still to be resolved, but we are hopeful that this whole system can be developed and maintained on a current basis.

KEVIN HEANUE, Bureau of Public Roads—Mr. Leyland has presented an excellent summary of the interesting and innovative work of the New Haven Census Use Study. I would like to describe some of the preliminary results of the New Haven Area Travel Survey, the 2½ percent sample travel survey conducted in conjunction with the New Haven Census Use Study and then give you some of my impressions concerning the involvement of the "transportation interests" in the Use Study.

The travel survey was primarily a mail survey conducted using normal Census Bureau procedures. A home-interview control survey was taken in conjunction with the mail survey. About all we can say at this time is that the survey was run in October and that there was approximately a 50 percent mail return. The survey utilized a mail out/mail back procedure with one mail followup two weeks after the first mailing. To date, it has not been possible to make a comparison between the two surveys.

The prime objective in conducting the New Haven Travel Survey is to examine the feasibility of collecting travel information in conjunction with the decennial census, utilizing the mail questionnaire. In addition, there are a series of secondary objectives. For example, there is a direct link between the travel survey questionnaires and the full census returns of the sample households. With proper provisions made to prevent disclosure, researchers will be able to relate the travel characteristics to the full range of census statistics at the household level. It is hoped that procedures can be developed which will allow tailoring of generation analysis to appropriate census statistics.

Now moving from the travel survey to the broader area of the implications of changes and innovations in Census Bureau procedure to transportation planners, I would like to raise a few notes of caution. In the past, we have had the luxury of specifying, coding, and conducting travel surveys. We laid out our survey areas, we zoned them, conducted the survey, and prepared tabulations to our own specifications. In 1970 it will be a new ball game (I am assuming that Congress appropriates funds to undertake detailed coding of place of employment, i.e., journey to work).

The Census Bureau, having developed the flexibility of data aggregation using block faces, is sweeping right by us, compelling us to adapt our procedures to obtain maximum benefits from this leap forward. But, there will be some problems. One difficulty is areal coverage. The 1970 mail census coverage will be limited to the urbanized portions of the SMSA's and more specifically to the areas having home mail delivery. This means that block face geographic coding will be limited to the mail area. Most of us participating in the New Haven effort were disappointed to learn that the detailed coding was possible only in four out of eleven towns within the New Haven SMSA. In the remaining seven towns, the travel data were accumulated to the town level. In areas not on the New England town basis, the problem may be more serious. On the positive side, roughly 85 percent of the total work destinations were included within the urbanized portion of the area.

A second problem is caused by the fact that some people will not report place of employment in sufficient detail or accuracy to permit blockface coding and as a result there may be a disturbing number of destinations coded to the next higher geographic level available, namely municipality or county. On the positive side is the very large sample size (25 percent) that should allow us to overcome many shortcomings of the statistics.

One of the most encouraging results of the New Haven project is the fact that the Census Bureau is ready and eager to serve the transportation planning interests as a group. In New Haven, Public Roads in cooperation with the Connecticut State Highway Department and the New Haven Department of Traffic and Parking has developed a sample set of tabulations which, we hope, will form the basis for a standardized transportation planning data package. The tabulations have been submitted to the Census for review by their confidentiality committee. Upon the official release, this "package" will be widely circulated for comments. We hope to reach a consensus prior to the 1970 Census on a transportation planning data package equivalent to the census tract tabulation program. In this way, each study, instead of going through the laborious process of preparing individual data specifications would just request the standard set of tabulations. Hence, individual requests would be minimized and one set of tabulation programs could serve the needs of many organizations.

The potential of the cooperation among ourselves and with the Census Bureau is enormous. However, as is true with most progress, it will be necessary to resolve some problems and to undertake certain additional work if we are to gain maximum benefits from the Census innovations.

W. L. GARRISON, University of Illinois—For a number of months the Bureau of the Census with the cooperation of other agencies has been experimenting with new methods for acquiring census information and, importantly, new ways to relate that information with the needs of other Federal agencies and with needs of state and local agencies, public and private. This study is generally referred to as the "New Haven Study." But it could have been done in "East Overshoe" or "West Cupcake." What is important about the study, in my judgment, is that it is another step in the continuing process of introducing new information technology into society generally—the process of diffusing innovation. Here the innovation is information technology, and the Census effort represents one of many places where the nation's information capabilities are being adopted for old and new uses.

There appears to be a pattern of the diffusion of new technology. There are three stages.

1. New technology is given a well-defined task where it is more efficient than the technology that it replaced. Often the new technology has very limited applications.
2. The technology is gradually improved, and understandings of the jobs that it can do are improved. Many new jobs are found for it.
3. The technology begins to shape the way tasks are performed, and entirely new tasks are performed. The technology begins to shape our lives and we adjust our lives to it.

This format seems to fit in many instances. The automobile, for example, we first used only in a very limited way—a status replacement for the horse and buggy. But as the automobile was improved it was adopted for more and more uses. Now new tasks have been developed which the automobile performs, and we have adjusted our lives to it. The computer is another example. Its first use was very limited. Recently many jobs have been found for it, and now new systems are being built upon it.

The New Haven Study is an experiment in the application of information system technology. Because of preceding and parallel activities from which one may learn, the New Haven Study has available many guidelines, and there is an opportunity for compression of the trial-and-error period that characterizes much introduction of technology.

Earlier, there was reference to three stages in the introduction of new technology. The New Haven Study, and previous work at the Census, has passed well through the first two steps and has started on the third. Here, and elsewhere in the Census, information technology is now used for tasks previously done using other methods. Now the New Haven Study is exploring new tasks. Handling of the distribution and review of Census forms has been adapted to the new technology, and the new technology is being expanded to mapping and answering of special queries. There is more efficient handling of information across the board. Things are being done that have not been done before, for instance, coding information. Certain questions arise.

1. In the sense of the third stage in the diffusion of technology, what are present estimates of new tasks that will be performed; what tasks will be performed that have not been performed before? Again, new technology provides for straightforward substitution for previous tasks and new tasks are performed with new purposes. What glimpses of future opportunities do we have from the New Haven Study?

2. What time constants will characterize the diffusion of this technology; what will be its geographical spread?

One disturbing feature of new technology is the long period of time that characterizes widespread adoption. Time constants on the order of 20, 30, 40, and 50 years are common in putting new knowledge into widespread use even where massive sums are spent to improve the technology and to accelerate its diffusion. The computer itself is a case in point. We are well into the third decade of computer utilization, yet there remain many obvious gaps in application. A related matter is the pattern of geographical spread. Even where communication levels are high, the diffusion of a new idea or process to all places where it might be applied is relatively slow. Hybrid corn has provided a recent example in this country. The much studied spread of hand tractors in Japan and South Korea provides still another interesting example. If diffusion starts from one center, then one pattern of change unfolds. It it starts from many centers, then another pattern of change unfolds.

Constraints on diffusion over time and space are well understood. The importance of face-to-face telling is very great. Reinforcement plays an important role. Individuals need to be told and retold. Where innovation requires institutional change, resistance to change occurs for adoption of innovation is tied to the slow pace of institutional change. My question is, what are we learning in New Haven that would help us understand the diffusion of new Census ideas and techniques? Can we learn things that we may use to develop strategies for diffusion?

3. How may we establish clients for technology; what is the market for the New Haven product?

In the diffusion of innovation through the private sector a very important role is often played by brokers or others who are highly motivated by financial rewards. Also, individual firms are highly motivated to adopt new technology, in part, because of pressures of survival and, in part, because of new opportunities for profits. In many instances new institutions are created which serve in some way as brokers. They sell the new process, or product, by shaping the needs of firms and individuals so that it meets those demands of their clients. The final question is, who will serve as a broker? How will the new ideas from the Census be sold?

EDGAR M. HORWOOD, Urban Data Center, University of Washington—The purpose of this panel, sponsored by the Highway Research Board's Urban Information Systems and Measurements Committee is to bring to the attention of the urban transportation planning professions the nature and the implications of a bold and forward experiment which is being conducted under the title, New Haven Census Use Test.

The session was designed around a position paper prepared by George P. Leyland, Associate Director of the New Haven Census Use Study, who was called on to discuss the test project in some detail, and in particular to point out its transportation and land-use planning implications. A panel of prominent specialists, including representatives from the Bureau of the Census and experienced observers in the transportation planning field, was asked to respond to the presentation and to raise questions, project ideas and otherwise react to the presentation with a view of sharpening its focus on the question of long-range urban and transportation planning analysis.

For several decades now, urban transportation studies have been conducted on the basis on securing ad hoc data at considerable cost and effort and without significant inputs from either Federal or local government sources as related to the periodic fact finding responsibilities of these respective agencies. To date, the Bureau of the Census' effort to relate residence and place of work has been too grossly defined at the work-end of the trip to be of benefit to the transportation planning process. With all due respect to the census effort, the matter of relating origin and specific work destination as part of the decennial census is an extremely costly affair, and possibly beyond the capability of early attainment as part of the formal census process itself. Transportation and land-use planners have been hopeful, nevertheless, that procedures introduced as part of the census effort would give more refined inputs into the transportation planning process.

While transportation and urban planners have been looking to census for specific data, they have not particularly had their eye on fundamental advances in urban information systems which would permit the integration and assimilation of data not hitherto accessible. A system of the type presented can spatially coordinate data entities so that modes of reporting now made possible by computers would expedite data reporting and information presentation. The system which Leyland describes is identified primarily by the creation of what he terms a "geographic base file." This concept not only permits the matching of entity records in a spatial sense, but permits information retrieval by map imagery through computer assisted graphical output.

Although the paper implies no spectacular results in regard to the New Haven Area Travel Survey, conducted as a part of the New Haven Census Pretest (insofar as results have not yet been fully evaluated), the concept of the geographic base file is so fundamentally new that this relatively short paper can hardly do justice to the vast analytical implications of this file. I believe it presents the framework for an entirely new generation of urban transportation and other planning studies.

The utility of the geographic base file stems not only from its inclusion of the city map via the digitization of the street configuration, but from its capability to relate a street address to a small geographical location in space through automated means. The latter capability would permit us to conduct wholesale destination-type traffic surveys by examining a file of records at the workplace location, where for large industries machine records of home addresses usually exist. This could substitute for the expensive conventional home-interview sample method. It should be possible to examine a far larger sample of trips to large traffic generators and central business districts or industrial sections with comparatively little effort. While the test undertaken by the New Haven Census Use Study group did not conduct destination type surveys, the potential is nevertheless in the system.

Of just as great importance is the capability to summarize data by small area accumulation, such as census blocks or block faces, to aggregate entity values included within an area of arbitrary polygon definition, thus permitting a reasonable matching of data to any system of zones, whether they are determined before or after the given study. Again, the New Haven Census Use Study has not yet ventured into this area, but there is ample precedent in such an extension of the effort as demonstrated by work done elsewhere with similar type systems.

An important aspect of the New Haven Census Use Study is its identification with tests by many types of users and its concept as an experimental approach toward census related information systems technology. The national census is the most extensive urban and regional information system extant, and therefore it behooves us to make the greatest efforts to make it responsive to emerging needs. In the past, the census reacted to user needs and problems mainly through decisions to include or exclude various types of data. These data needs have changed over the years in response to the changing problems themselves. The advent of automation introduces a new factor, however, which requires a new order of research and investigation involving the information system itself as contrasted with the data base. The advent of the mail census and the direct synthesis of information from census tally tapes by users, in lieu of printed tabular information from published census reports, creates a new environment to which Leyland and his associates address themselves.

It is significant that the test itself was financed largely through the efforts of other departments of the Federal Government other than the Department of Commerce itself, which conducts the census. It remains a question as to what efforts local governments will make to interface with technology of this nature.

The only note of concern which I feel obligated to introduce is the fact that this test may have come a little too late within the decennial census planning schedule to permit the results of the test to have a substantial influence on the national decennial census of 1970. It does not appear that the Street Address Guide preparation now being conducted in the metropolitan areas of the nation will be a substitute for the geographic base file which is discussed in the paper. The Street Address Guide is essentially a directory of terminal addresses and their coded relationship to census block and tracts, but without geographic tie-in to the urban street system.

It is probable, nevertheless, that the major aspects of the geographic base file may be developed in the immediate post-census years through the activities of local or regional planning organizations and designed in such a way as to be integrated with the census effort of 1970. The development may thus be a little slower than could have occurred if the New Haven tests had been conducted two or three years ago to give ample advance time for detailed planning and local interface. These facts do not reduce the importance of the experiment.

The foregoing notes have been more expository than reportorial of the paper presented by Leyland, because he was obliged to spend most of his time and effort of the presentation in discussing the nature of the test itself rather than expanding his statements into areas of conjecture, as I have taken the liberty to do. The Census Bureau effort is, in my estimation, an important contribution to the integration of local and national efforts in the development of long-range multi-purpose urban and regional information systems with dimensions characteristic of the age of automation. I submit it is an important venture for examination by all of those concerned with urban and transportation planning studies and analyses.

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