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USE OF CENSUS DATA
IN
URBAN
TRANSPORTATION
PLANNING

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USE OF CENSUS DATA
IN
URBAN
TRANSPORTATION.
PLANNING

Report of a conference held July 9-10, 1970

subject areas

55 traffic measurements
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CONTENTS

CONFERENCE SUMMARY

The papers contained in this Special Report emanate from a 2-day conference held at the National Academy of Sciences on July 9 and 10, 1970, and attended by more than 160 representatives from the governmental, industrial, and academic communities.

The primary purpose of the conference was to discuss the types and nature of data that will become available from the 1970 decennial census and relate the uses of these data to the transportation planning process. Base data in many urban areas are now a decade old, and the 1970 information will provide a means of updating and checking the forecasts made. Therefore, providing a working knowledge of what data will be available, what can be made available, and how such information can be used was a major purpose of the conference.

The 4 conference sessions included formal papers, panel discussions, and general discussions of the following topics: continuing transportation planning data requirements, nature and use of census data for transportation planning; practical applications, and limitations, problem areas, and needed programs and research.

CONTINUING TRANSPORTATION PLANNING DATA REQUIREMENTS

Hamburg distinguished between the preparation of the long-range transportation plans and several other functions that are essential to transportation planning and in particular to the continuing transportation planning process. Important differences in data requirements are stated by Hamburg as follows: (a) Greater geographic precision will be required, and block or even block-face data will be utilized if available; (b) greater network detail will be required; (c) temporal detail will be required; (d) data on travel (trips per person, trip purpose, trip length, and so on) will be required but in quantities appropriate to model parameter calibration rather than zonal interchange estimates; and (e) system performance will need to be measured with respect to particular socioeconomic groups in subregions, and these kinds of data must be put into the process.

Taeuber discussed the information that will be made available by the Bureau of the Census and focused on the related questions of when, how, for what areas, and in what form. Generally, he described the current situation as it relates to the broad scope of census data, many of which are of direct concern to transportation planning.

Sosslau and McDonnell stated that an examination of transportation inventories indicates that census data have been valuable to past as well as current transportation planning activities. Of the 4 major transportation inventory items—economic activity and population, land use, travel characteristics, and transportation facilities—census data are most applicable in the area of economic activity and population. They further pointed out that data and services of the Bureau of the Census have not been applied in inventories of travel characteristics and transportation facilities. The authors listed the following 3 products from the census that are applicable to transportation planning: (a) population and housing data that include existing dwelling units by type and character, number of units in group quarters, family size, economic status of family, number of workers by occupation, and number of students by age and school level;

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(b) data from the journey-to-work survey that can be summed by work place to provide an estimate of employment, to develop information on income of workers, mode of travel to work, industry, and occupation, and to serve as a bench mark for work trips in checking forecasts and travel models; and (c) geographic base files, address coding guides covering SMSA's, that consist of a coded list of block faces giving the street name and census block and tract number of each block face and that can be used for coding addresses in base surveys and secondary source information, for locating highway inventory information, for developing traffic assignment network, and for aggregating and displaying data.

NATURE AND USE OF CENSUS DATA FOR TRANSPORTATION PLANNING

Voight stated that the products of the 1970 census will be the most extensive ever provided by the Bureau of the Census. The bureau has made a concentrated effort to meet the demands for social and economic characteristics of the population and the homes they live in at the finest levels of geographic detail that will still permit the tabulation of meaningful data. He said also that an effort has been made to provide for maximum flexibility in tabulating summaries to permit the recombination of these into administrative or operational areas of significance to local organizations.

Daly outlined the content of the questionnaire on work trips that was used for 15 percent of the households. The questionnaire included 2 questions addressed to each person who worked (full time or part time): "Where did he work last week?" and "How did he get to work last week?" The address of the place of work and zip code were requested for the place of work. Daly further discussed the data of work trips contained in machine-readable form on the computer tapes, and also the data on work trips that will be summarized in the course of the regular census publication program.

Farnsworth discussed the address coding guide (ACG) and dual independent map encoding (DIME) as constituting an invaluable resource for transportation planning, city planning, and administration. These files provide computer-usable data tied directly to the highway and road networks and to all significant census and local geographic codes.

Robertson described the genesis of a standardized set of tabulations of the 1970 journey-to-work statistics. He discussed the need for better data in the urban transportation planning process and the degree to which specially manipulated census data can meet that need. He defined the standard package of tabulations developed in terms of its contents and purpose.

PRACTICAL APPLICATIONS

Paaswell postulated that it is possible through proper studies of trip-determining parameters to isloate views of particular interest for special (micro) study. The group considered in his study are the black residents of Buffalo, New York. Paaswell pointed out that contour maps combined with trip-making curves can show areas of potential neglect in large-scale planning and that isolation of these areas for intense study and the gathering of trip-making data peculiar to the specific area are the preliminary steps to be taken in a more traditional transportation analysis.

Zitter emphasized the ways in which data and programs of the Bureau of the Census can be useful in small-area population and employment projections. Zitter primarily limited his discussion to relatively large geographic areas such as states and SMSA's. The bureau, according to Zitter, in recognition of the need for a comprehensive set of estimates that cover all counties and SMSA's in the counties and that are consistent, comparable, and of relatively high quality, has undertaken a new program working with the states to generate such estimates. In this program, referred to as the Federal-State Cooperative Program for Local Population Estimates, the states will prepare estimates of population by a set of recommended preferred procedures, standardized largely for data input and application mutually agreed to by the states and the bureau.

Zitter also stated that, although there is a strong association between employment and population projections, these elements have been treated separately. Employment

projections are a function of the Office of Business Economics in the U.S. Department of Commerce and focus on income and employment for 165 economic areas. The National Planning Association develops employment projections for metropolitan areas. Both of these groups, according to Zitter, see population projection as a function of job opportunities, and most of their attention has been given to employment projections and only the roughest and simplest of techniques have been used to translate them to population. The Bureau of the Census has started to investigate the economic-demographic approach to small-area projections in order to bridge the gap between employment and population. Census data on gross and net migration are receiving much attention in the analysis and, according to Zitter, holds the key to improved and consistent small-area projections.

Worrall discussed the potential use of census data in land use modeling, travel forecasting, impact analysis, and data maintenance and updating. Worrall described the EMPIRIC activities-allocation model that is currently being applied by the Metropolitan Washington Council of Governments. In the area of travel forecasting, Worrall stated that the 1970 census material provides a valuable basis for generating both a zonal and district-level table of origins and destinations of work trips, and that this table when supplemented by information on equivalent zonal or district-level travel times may be used directly as input to a trip-distribution analysis. According to Worrall, the journey-to-work data provide a convenient and inexpensive means for updating many existing data sets and can in themselves serve as an effective base for the design of future facilities. Transportation impact analysis according to Worrall, will be of the most critical areas of analysis during the next decade. Census data can provide at best an initial base for the evaluation of questions related to household education, population relocation, accessibility to employment, incidence of impact on specific demographic and income groups, and potential effects of a new system on existing market areas and overall regional growth.

Shunk discussed the feasibility of using census work-trip data for transportation planning purposes. He said that the use of census work-trip data for transportation planning appears from tests to date to be quite appropriate and accurate, but that further tests may be desirable. Shunk outlined the main tenets of his approach.

LIMITATIONS, PROBLEM AREAS, AND NEEDED
PROGRAMS AND RESEARCH

Brand stressed the need for policy-sensitive forecasts and for disaggregate models, i.e., models of consumer decisions (travel decisions) that are behavioral in nature. He pointed out that disaggregation brings with it the possibility of some real advantages of economies in data collection and simpler travel models, but that the case of existing census data in these models has real limitations because of the strict census disclosure rules. Disaggregate models need information on the individual and his address, but with such information the name of the respondent can be traced. Because of the disclosure rules, this is the primary limitation of census travel data with respect to their use in travel forecasting. Brand proposed that the Bureau of the Census might be requested to add the necessary modeling information to the individual trip record. This would consist primarily of adding the transportation price and service information on all available choices to the trip-maker between his origin and destination. This information concerned with individual or household characteristics and his trips would form one trip record. Brand further stated that approximately 500 to 1,000 trip records, randomly selected over a region, would probably suffice to estimate a behavioral work-trip demand model. He suggested, however, that before the Bureau is requested to do this an investigation of the relative costs of a sample survey by conventional home interview and travel inventory means should be performed.

Pisarski emphasized 3 points: (a) the potential use of census data in analyzing the impact of transportation changes; (b) the necessity to transpose the data from a population to a transportation universe because there is now a mismatch of these universes in terms of geography, definition, and structure; and (c) the need to strengthen and improve the 1972 Census of Transportation as an effective instrument for transportation planning at the urban and state levels.

Wickstrom pointed out that the 1970 census data will provide a rich source of data for transit planning purposes including the journey-to-work data and the population data that will assist in identifying areas where transit service is needed to serve the young, the old, and others who have no alternative means of transportation. He further stated that, by matching levels of transit use to measures of transit service, areas where improved service has high potential can be determined. Census data can also be used for routing studies and for determining worker parking needs and relating these to the supply of parking now available.

Barraclough pointed out that, although the 1970 census fills more needs for planning purposes than the 1960 census data did, there are still many important data gaps. The gaps may be considered in terms of types of data, geographic coverage, level of detail, and updating data. Data gaps occur in the comprehensive land use activities information. Use of census data on nonresidential activities (censuses of business and manufactures) is impractical because geocoding is too coarse and data are unavailable at different points in time. Barraclough pointed out that enormous costs and disbenefits are incurred because the census metropolitan data are fragmented into a number of censuses taken at different points in time with different geocoding procedures. He stated that, perhaps, a higher cost-benefit ratio would result if all of these various censuses were handled concurrently, every 5 years.

The DIME or geographic base files that will be available provide a framework for network data on link volumes, speeds, and number of lanes to be added. Some means of providing vehicle-miles of travel data must be found. The biggest limitation with the DIME geographic files is that they will cover only metropolitan areas. Barraclough called for greater communication between the user of data (transportation planners) and the suppliers (the Bureau of the Census).

DATA REQUIREMENTS FOR
CONTINUING TRANSPORTATION PLANNING

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Continuing transportation planning needs some definition, or at least some bounding statements, if we expect to make any headway with regard to outlining its data requirements. There are at least 10 specific areas or functions that properly fall in the continuing transportation planning process. We do not claim that this list is complete, nor do I suggest that many of the functions included imply data requirements different from those of the original transportation planning, whose major purpose was the preparation of a long-range transportation plan. The functions or objectives of the continuing transportation planning process are as follows:

1. Update the long-range regional transportation plan;
2. Program or assist in the programming of the elements of the long-range plan;
3. Locate or assist in the geographic location of elements of the long-range plan;
4. Design or assist in the design of elements of the long-range plan;
5. Design and evaluate or assist in the design and evaluation of transportation facilities and improvements not included in the long-range plan but necessary to the efficient functioning of the plan;
6. Coordinate and integrate the transportation system with other urban systems including joint design of improvements and new facilities;
7. Monitor the performance of the transportation system;
8. Enlarge the frame of transportation planning to better deal with such special transportation problems as airports, terminals, and goods-movement systems;
9. Provide transportation information services to other operating agencies; and
10. Continue basic transportation research.

We have used the term "long-range transportation plan." In another report (1), we defined strategic transportation planning "...as the process of determining a recommended long-range level of investment in transportation, the division of investment among major modes of travel (i.e., among expressways, major streets, and transit), the location of corridors for expressways and rail rapid transit facilities (or in smaller urban areas the locations of major streets), and the general timing and sequence of investments." In considering the needs of the continuing transportation planning process, we assume that this defined process has provided the region with a long-range plan.

The preparation of this long-range plan included in most, if not all, cases a simulation of the performance of the system of transportation facilities that constitute the plan under conditions of travel demand expected at a point 20 to 30 years in the future. Although this testing of the transportation plan under expected future conditions is common to urban transportation studies, the simulation technique, associated methods, and data requirements are not. Therefore, the specific data requirements for updating the long-range transportation plan cannot be detailed for all studies. Certain characteristics, however, are common and some general statements may be made in this regard.

First, the demand for travel is typically related to the expected future arrangement of urban activities in the region. This future population and land use base should, therefore, be periodically reviewed and modified on the basis of actual development

data, changes in development plans, announcement of new plans, both public and private, and analysis of trends based on the most recent data available. The integration of 1970 census data in this review process is an obvious and vital step.

Second, the simulation process includes continuation or extrapolated values of variables such as trip length, trips per person, and interactance model coefficients (e.g., travel time factors in the gravity model). These values should be reviewed and updated. However, the usual basis for calculating these values, the home interview origin and destination study, can be very expensive, especially when used to estimate interzonal travel. Because future travel among zones is usually simulated, it should only be necessary to take a sample of a size sufficient for calibrating parameters of the simulation model. However, even the selection of a small sample can be expensive and time-consuming; without an adequate sample frame, it can be biased. The existence of a complete file of households organized by block face within the Bureau of the Census provides an excellent opportunity for carefully designed small samples of households in urban areas.

This discussion suggests that the data required for updating the long-range transportation plan differ from the data required in the original surveys basically in terms of quantity, sample size and source, and use of secondary data including the 1970 Census of Population and Housing. However, this is definitely not the case for most of the remaining 9 functions listed as essential to the continuing transportation planning process.

The reason for this lies in the very nature of the functions themselves. The long-range transportation planning process was concerned with defining travel corridors some 20 to 30 years in the future. Generally, route locations are described only as falling somewhere within a 3-mile corridor. When we are concerned with problems of route location, and concerned we must be if we are to implement the plan, this generally must be left behind. Nor is route location the only place where specificity of geography distinguishes long-range transportation planning from the continuing phase.

The simulation process typically used in regional traffic assignments suffers to a significant degree from the aggregation of travel data to zone centroids. This aggregation, necessary for the symbolic representation of an entire region of a hundred square miles or more, results in a loss of detail in terms of geographic consequences of traffic. The local street system typically must be excluded. Also, loadings are distorted wherever zones are larger than the area enclosed by the network itself. Moreover, when we concern ourselves with the impact that proposed transportation improvements will have at the neighborhood level, we need smaller geographic units than zones 320 acres or more in size. The need for detailed geographic descriptions is especially acute when we attempt to consider the impact that changes in land use will have on transportation facilities.

Specification of patterns of settlement and average densities may suffice for selecting among alternative corridor plans. But, when we consider putting in a 20-story office building on a specific site or developing a site as a shopping center, we cannot, or should not, ignore the traffic consequences of that development on the adjacent street system. It appears that these traffic consequences dissipate quite quickly as we move away from the site. The scale of regional networks and regional zone systems often would conceal this impact. Such representation would probably require block or block face loadings and link definitions. Certainly, for a zone 4 square miles in area, loading trips at its centroid would be inadequate.

In addition to geographic specificity, there is the detail at which transportation networks themselves are to be represented. In the long-range transportation planning process, transportation networks are represented by links to which are ascribed characteristics of speed, length, and capacity. For purposes of estimating travel on major facilities in travel corridors, these network representations appear to provide adequate answers. However, when we turn to problems involving ramp design, turning movements, and volumes on local and connector streets, most assignment results require creative interpretation, to say the least. It is with such problems that we are concerned in implementation, route location, neighborhood impact, TOPICS, and so on. Thus, the data needs with respect to network facilities will be expected to become

more detailed and to call for characteristics such as signal timing, intersection control, parking restrictions, number of lanes, turning movements at intersections, lane usage or sharing at intersections, presence of turn bays and median separators, speed limit or legal speed, inclusion of all facilities, reversible lanes, and peak-hour differences, if any, for any of these characteristics. The specification of such greater network detail presumes that there is the ability to employ the data in a useful way. There are, we hasten to add, at least 2 assignment programs that will accept substantially the network detail suggested.

We have described the need for greater geographic detail in the description of travel, activities, and networks. We have also described the need for more detailed information in order to represent the functioning of transportation networks at a finer level of geographic detail. There is still another dimension that we believe requires a more detailed treatment for continued transportation planning processes than that usually given to it at the regional level. That dimension is time of day. Time of day, peak hour in particular, is closely associated with problems of traffic congestion and problems of design-hour calculations. Time of day is indispensable to studies of staggering of work hours.

The definition of capacity used in many traffic assignment simulation programs represents a kind of 24-hour capacity that assumes a peak-hour proportion (not to mention a directional split, turn assumptions, and proportion of commercial vehicles). This capacity, when used with a capacity restraint algorithm, appears to give reasonable splits of traffic between expressway and major street facilities. However, these capacity definitions and restraint mechanisms intuitively are most inappropriate to use at the smaller scale required in many of the continuing transportation planning functions.

The last dimension that we wish to discuss is one that is applicable to both long- and short-range transportation planning although it has received but limited attention to date. This is the socioeconomic status of the population within the region. Most studies have incorporated some measure of automobile ownership or income in the estimation of future travel demand. However, in the calculation of the costs and benefits associated with the acquisition and use of the future transportation system, there has been little or no investigation of impact by socioeconomic class. Thus, while a particular plan may be the best plan in terms of its performance measured in goal achievement at a regional level, it may be attacked as being deficient at a subregional level or in terms of a particular socioeconomic group. Alternative plans may perform less admirably at the regional level but will avoid criticism by any particular subregional or socioeconomic group. Of course, one could argue that higher costs are a waste and represent a needless subsidy. Without discussing the relative merits of using the transportation system as a basis for income redistribution or meeting special interest groups, it seems reasonable to at least investigate the impact that the proposed plan has on particular groups and subregions.

We have attempted in this paper to distinguish between preparation of the long-range transportation plan and several other functions that are essential to transportation planning and especially to the continuing transportation planning process. In general we believe that there will be the following important differences in data requirements:

1. Greater geographic precision will be required (block or even block face data will be utilized if available);
2. Greater network detail will be required;
3. Temporal detail will be required;
4. Data on travel (trips per person, trip purpose, trip length, and so on) will be required but in quantities appropriate to calibration of model parameters rather than to estimations of zonal interchanges; and
5. System performance will need to be measured with respect to particular socioeconomic groups in subregions, and, therefore, data for this must be put into the process.

Other papers in this Special Report will deal with specific applications of census data to the continuing transportation planning process. At this time, we will suggest

only the obvious connections. The 1970 census data will include data on work travel, which, in spite of its definitional differences when contrasted to work travel obtained in the home interview survey, will be of real value in the continuing transportation program. The ACG/DIME geographic framework will be of invaluable assistance in dealing with the problems of geographic detail described earlier. Moreover, this file may prove to be a very useful frame for assembling data on detailed transportation networks. This file is the key to assembling data on the socioeconomic characteristics of the population of the region in the appropriate geographic format. Finally, this file in conjunction with census enumeration of households provides a basis for the fast and efficient development of small samples of households for purposes of calibration of transportation models in the updating process.

A major forward step in the continuing transportation planning process will be achieved with the demonstration that census work-trip data coupled with a detailed traffic assignment technique supplemented by other travel data can be used to demonstrate traffic consequences of particular street-transit or building patterns or both. In any event, we believe that in the seventies we will witness significant improvements in the transportation planning process and that the 1970 census will play an important role in these improvements.

REFERENCE

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WHAT CAN THE BUREAU OF THE CENSUS SUPPLY?

Conrad Taeuber
U. S. Bureau of the Census

It seems useful to broaden the topic question by adding the related questions, When?
How? For what areas? In what form? At what cost? The answers to these questions
are necessarily interrelated. Some items become available earlier than others. The
form in which a user wishes to have the data and the cost involved depend to a large
extent on the number and size of the areas for which data become available. Other
papers will deal in some detail with the specific issues in relation to the journey-to-
work data. My purpose is to describe the situation as it relates to the broad scope of
census data, many of which are of direct concern to all transportation planning.

WHAT?

Before commenting on what will be available, let me underscore an important item
that will not be available. Under no circumstances will the Bureau of the Census make
available lists of names and addresses, with or without any individual characteristics
relating to a person or to an address. Statistical tables will not be made available if
the characteristics of an individual would be revealed by them. This will have some
effect on those users who expect to deal with the data for the very smallest areas, for
here it may be necessary at times to suppress some of the figures for an area because
the population or number of housing units in the area is so small that the statistical
totals would constitute a possible disclosure. We realize that at times this may seem
to impose limitations on highly desirable uses of the statistics, but preserving confi-
dentiality of the individual census data is more important than avoiding some occasional
incovenience to a serious user.

The inclusion of this topic on the conference program reflects a recognition of the
importance of the volume of data that the census provides. The most widely used sta-
tistic from the census is no doubt that of the head count. Among the questions asked
most frequently are the following: How many people live in each of the communities
that are served? How has this number grown or declined? Is further growth or decline
indicated in the age composition of the people who are living there now? Another matter
of early concern is the location of the population in big cities, in suburban areas, in
smaller cities or towns, on farms, or in the open country areas outside the limits of
any town or city. The distribution of the population as homeowners and renters and
the size and nature of the dwelling units that they occupy are matters of considerable
interest. So is the growing use of trailers.

The size of families and the number of large and small families may be of consider-
able importance, as may also be the growth in the number and proportion of one-person
households. The income levels of the residents of an area are important for the de-
velopment of antipoverty and welfare programs as well as for the possibility of de-
veloping new markets. The older couples who no longer have to provide for the care
and rearing of children may represent a group to which particular attention is devoted.
This may also be true of the growing number of senior citizens in the population. Na-
tional origins of the population and the persistence of cultural patterns brought from
overseas or from some other part of the United States are often of importance. The

level of education of the people in an area and the possibility that the area continually exports its best educated youth to other areas are also of importance. The presence of persons with certain occupational skills may suggest the possibility of some industrial development or the need for new efforts at vocational training.

The age, size, and character of the housing and the facilities and equipment in the homes may indicate significant needs for the expansion of public or private utilities and services. There is much interest in the volume and the characteristics of new construction in cities and suburban areas, the rapid increase of multiunit structures in suburban areas, and the changes in value of homes for buying or renting. Businessmen are interested in the amount, size, cost, location, and equipment of vacant units. Differences in these and similar measures, such as between rural and urban areas, small and large cities, central cities and suburban areas, are all important matters for anyone concerned with providing essential services in each area.

The pattern of settlement of a community, the contrasts in density among various areas, and the proportion of units in single-family and multifamily structures have an important bearing on the generation of traffic. The presence of automobiles, the number of families with two or more workers, and the presence of children of school age are all matters that affect traffic patterns as well as the need for a variety of community services.

The list of important information can be extended considerably. The census is an inventory of the Nation at a particular point in time. This inventory can be compared with a similar inventory taken 10 years earlier, and trends can be discerned from such a comparison as well as from an analysis of the detailed data as of the census date. The number of children of preschool age is a useful indicator of the needs for schoolrooms and teachers in the near future; the number of middle-aged adults is an indicator of the future growth in the number of senior citizens. The fact is that much important information is directly available in the standard tabulations and that more can be secured if more cross tabulations are prepared. Imagination and money are really the major limitations on the amount of information that can be extracted from the census data.

The suggestion has been made at times that the Bureau of the Census should take a list of names and addresses and match it to census records, giving the sponsor a tabulation of the relevant characteristics of the cases that could be identified for comparison with census tabulations for the general population. Although such work can be arranged within the strict requirements of the confidentiality of census information, the Bureau is not prepared to undertake such projects. Experience has shown that the results of such analyses are likely to lack statistical reliability because of the difficulty of securing an adequate degree of matching. The address coding guide, which has been developed for many metropolitan areas, provides a means of determining in what geographic area any particular address falls; it gives the address ranges for every block side in the area covered. Thus, any address in the proper format can be readily allocated to the area to which it belongs. A local agency can then tabulate the characteristics of its own cases in relation to census areas such as tracts, and statistical comparisons can then be made on the basis of the data for common areas.

FOR WHAT AREAS?

The special contribution of the census is that it reaches into every part of the United States; it is the one governmental activity that involves every person throughout the country. It provides some results for every city or town or village, for every county or township or other subdivision, and for every state. Within all of the standard metropolitan statistical areas (SMSA's), census tracts have been established; each tract has an average population of about 4,000 to 5,000 persons. For cities of 50,000 and more, and their adjoining built-up areas, a limited amount of information is provided by city blocks. Arrangements have been made to have statistics provided (at cost) on the basis of city blocks for a number of smaller cities.

A number of general statements can be made about the areas for which census data will be tabulated. The questions that are asked of 100 percent of the population can be

tabulated for areas as small as city blocks. The questions that are asked on a 15 or a 20 percent basis can be tabulated for areas as small as census tracts and cities of similar size. The questions that are asked of the 5 percent sample can be tabulated for places of 10,000 or more. This refers in the main to the relatively simple tabulations. Cross tabulations, especially those involving several variables, would require somewhat larger base populations. In general, the more detailed cross tabulations will be prepared only for larger places, cities, metropolitan areas, and states.

Information will be available for rural and urban areas. In census usage, an urban area includes (a) any incorporated place of 2,500 persons or more and (b) the densely built-up areas adjoining cities of 50,000 and more, whether incorporated or not. The Bureau of the Census has also identified unincorporated settlements of 1,000 persons or more and assigned boundaries to them. If such an unincorporated place has a population of 2,500 or more, it, too, is included as urban territory. Areas that are not classified as urban are regarded as rural. Rural includes incorporated places of fewer than 2,500 persons and unincorporated places of 1,000 to 2,500 people living on farms and others living in the open country, in the developments located along highways and having no recognized boundaries, and in small clusters on the outskirts of many cities of fewer than 50,000 persons. Urban places and urban areas are recognized in many of the tabulations. Typically the rural population is divided into 2 groups, the farm and the non-farm. The farm population includes all persons living on farms, whether they are actively engaged in agriculture or not.

The fact that we have developed a system whereby each address in the urbanized area can be coded to the appropriate block side has led to an expectation that statistics might be made available for individual block sides. This is not the case. The only purpose to be served with the identification to block sides or block faces is to provide a capability of preparing tabulations for areas other than those recognized in the standard tabulations. Block sides could be combined into areas within a specified distance for shopping centers, school districts, health districts, or other areas. The standard tabulations could be prepared for such ad hoc areas at cost. Such tabulations can be prepared only at the Bureau of the Census because the summary tapes to be made publicly available will not contain the block-side identification.

The Bureau plans to prepare some tabulations by zip code areas, approximating the areas as necessary. These tabulations are not to be published but will be available on a special-order basis in the form of printouts or summary tapes. It is planned to use the 5-digit codes in the city delivery areas of major metropolitan areas and 3-digit codes elsewhere.

IN WHAT FORM?

Publication in the form of printed reports will be continued along the lines that were followed in previous censuses. However, in recognition of the fact that many users will prefer to have the data in the form of magnetic tapes, any material that appears in the printed reports will also be available in the form of summary tapes. The summary tapes will actually provide substantially more detailed data than can be included in the printed reports. The summary tapes are likely to be available somewhat earlier than the printed reports. Summary information will also be available in the form of microfilm or microfiche.

Information for some 34,600 census tracts will be published in printed reports, one for each SMSA. Because the tabulations based on the 100 percent questions will be available earlier than those based on the sample questions, tapes or printouts of the 100 percent materials will be made available to the local census tract committees as soon as the tabulations for the area have been completed. They will be free to publish these data on their own, or to make copies for distribution as they see fit. Copies of these printouts may also be secured at cost from the Bureau of the Census. The information contained in these printouts will later be included in the census tract reports.

One other form in which some census information will be made available is through public-use samples. As in 1960, the public-use samples will consist of basic records, without any names and addresses, and with limited geographic information. Information

in these records is coded in such a way that no identification of any individual is possible.

All information to be made available for public use, whether in the form of printed reports or of magnetic tapes, will be carefully screened in order to avoid disclosure of information that the Bureau of the Census is required to hold in confidence. Should there be any possibility of a danger of direct or indirect disclosure, the data will be suppressed or two or more areas will be combined.

Maps are available for all areas for which tabulations will be made available. As a part of the preparatory work for the 1970 census, the Bureau undertook the preparation of metropolitan area maps, compiling these from the variety of maps that were available for each of the areas. For the urbanized areas, these maps are developed to a common scale and with a uniform treatment of the culture shown on the maps. Copies of these maps will be available at cost.

<div align="center">WHEN?</div>

The first preliminary results, in the form of simple head counts, became available on a flow basis in May,1970, and the last of these was issued in September. Beginning in August 1970 and continuing through December, the final official head count figures in a series of advance reports were made available. These, too, were on a flow basis. Before the end of that series, the first state reports were made available; these give data on age, sex, race, and relationship to head of household. The data on housing characteristics, issued at the same time, simply give the count of housing units for each place. The reports giving somewhat more detail will be available between October 1970 and May 1971.

At this point it may be useful to emphasize an important element in the entire census process that has a major effect on when data become available. There were 3 census questionnaires. One of them was to be filled out for 80 percent of the population, one for 15 percent, and the other for 5 percent. The questions that were asked of 80 percent of the population were also included on the 15 and 5 percent questionnaires. In other words, there was a core of questions that everyone was expected to answer. In census jargon we refer to these as the 100 percent questions. When you filled out your questionnaire you may or may not have noticed that these 100 percent questions required no manual coding. All of the responses were to be given in the form of filled-in circles. This was not true of all of the questions on the sample questionnaires. There, some of the answers were to be given in written form, such as state or country of birth, occupation and industry, and place of residence 5 years ago. These require manual coding into a form that the electronic equipment can read. The consequence for timing is that the tabulation of the sample information cannot be started as rapidly as that for the information collected on a 100 percent basis.

As soon as the questionnaires are received at the Jeffersonville, Indiana, processing office, the 100 percent portions are microfilmed. By means of an optical scanner, called FOSDIC (Film Optical Sensing Device for Input to Computer), the entries on the microfilm are converted to entries on magnetic tape, and then the tabulation process starts. In the meantime, manual coding is done on those questionnaires that require it. They are later microfilmed, and then the tabulation of the sample data is started.

The priority given to the 100 percent items is not only a mechanical one. There is an important legal element as well. By law, the official population totals for states must be delivered to the President by December 1. This is necessary in order to ensure the proper flow of actions that will lead to the reapportionment of the seats in the House of Representatives for the elections of November 1972.

Although priority is given to the 100 percent items, the tabulation of the sample items receives early attention. The issuing of reports based on the sample data begins February 1971 and proceeds rapidly until these reports are completed.

There is one exception to the priority of tabulations of the 100 percent data. That relates to the items to be published by city blocks. The block statistics cannot be produced as part of the first run of the 100 percent materials. They require a separate run through the electronic computers. The timing for these reports is January to June

1971. The fact that this will require the printing of a line of data for each of about 1.5 million blocks will give some concept of the size of this particular job.

Timetables at best reflect targets; only after the fact is it possible to judge how closely we have met them. The December 1 date is one that we must meet; the others we expect to meet, but we are not required to do so. Until the field enumeration is completed we are dealing with a series of events that we can control only partially. It is possible to say that that stage of programming and debugging of programs is sufficiently far advanced that we have no misgivings on that score, and the availability of the necessary computer capacity is also assured. We feel confident that we will be able to hire, train, and retain the necessary complement of clerical workers to complete the manual coding on time. Manual coding is expected to require some 200,000 clerk-days in order to handle the coding of 20 items on questionnaires relating to more than 40 million persons. Not all items apply to each of them, but the sheets relating to each of these persons must be scanned in order to identify and code the relevant items.

Unanswerable at this time is the question, "When will the data for the state, city, SMSA, or group of blocks in which a person is particularly interested become available?" The work flow is necessarily such that it is not possible to start with a rigid order of states. Instead, work units will be processed as they become available, which means that the order initially depends on the time when the field collection is completed. It will be some time after that before a definite timetable for each area can be established. Experience in previous censuses suggests that the first states to be completed will be some of the less heavily populated ones and that the states with the larger metropolitan areas may well be last.

One element that affects the timing of access to the census results is that, with the equipment being used, the customer who wishes to have his data on computer tape can have them somewhat earlier than the customer who wishes to have printed reports. This is not a matter of deliberate discrimination against those persons who are dependent on the old-fashioned methods of reading and assembling data. Even though much of the printing will be done by the Government Printing Office with the most advanced electronic printing devices, it will still be possible to supply tape copies earlier than the printed reports, by a matter of a few weeks.

WHAT WILL IT COST?

Predictably the answer to the question of cost is bound to be "That all depends." The user who sends in an order for every summary tape that will be made available from the 1970 census had better prepare himself for a total of 2,054 reels of tape. At the standard price of $60 per reel, the total cost would be $123,240.

However, it is not necessary to secure all the tapes for every area in the United States. One can be selective. If a user wishes to have only the tapes available for Kentucky, he would order only 31 tapes at a cost of $1,860. However, he might wish to have only certain tapes for Kentucky. If his needs are limited to one or another count, he might order only 1, 2, 3, or 4 reels. The tapes will be so arranged that data for only one state appear on any one reel or a given set of reels.

All information relates to a specific area. Insofar as these areas and their boundaries are readily known, there is no problem in relating the data to their appropriate areas. However, if small areas are to be used, it may be necessary to have maps that will aid in locating them. Such maps are available from the Bureau of the Census. The need for maps applies especially to the situations in which tapes relate to enumeration districts or block groups (in those cities in which they serve in place of the standard enumeration districts). Data for enumeration districts are not to be published, but summary data for these small areas will be made available on computer tape or as printouts from such tape. An enumeration district is the basic small area that is used to control the work in the field, and this serves as the work unit in the processing stages as well. Enumeration districts are small areas, generally with a population of about 800 persons. The person who wishes to use enumeration districts as the building blocks for his own geographic entities will need to secure also an appropriate set of maps showing what the boundaries of these districts are. He will also wish to have the

Master Enumeration District List (MEDLIST) that furnishes area and place names corresponding to the numeric identification codes that are used on the tapes. The MEDLIST and the enumeration district maps for a state the size of Kentucky are expected to cost about $400.

It is not expected that the needs of all users will be satisfied through the materials that will be publicly available. The Bureau of the Census expects to be able to prepare special tabulations to meet special needs. The charge for such tabulations will be the actual out-of-pocket cost incurred by the Bureau. These will need to be estimated separately for each job.

It will be possible to secure data and also special compilations of the summary data through access to summary tape processing centers that can be found in all parts of the United States. Many of these are local nonprofit organizations, including some chambers of commerce, university research bureaus, and metropolitan planning organizations. A number of profit-oriented groups and service bureaus also plan to acquire tapes and to perform special compilations from these summary tapes. The Bureau of the Census will be glad to supply a list of organizations that have informed it of their intention to render such services to the public. The summary tapes that will be available to such organizations include only information that can be made publicly available. Under no circumstances will they have records from which any individual or any address can be identified.

CONCLUSION

To give a complete description of the materials that will be available on the basis of the 1970 census requires far more space than is available here. Those who wish to pursue any of the possibilities mentioned or have other inquiries should get in touch with the Bureau of the Census, Washington, D. C., 20233, for suggestions on ways that specific needs can be met.

SUPPLEMENTAL DATA NEEDS

Arthur B. Sosslau, Comsis Corporation, Silver Spring, Maryland; and
James J. McDonnell, Federal Highway Administration

The range of data required for continuing transportation planning is, on the high end, the total requirements for transportation planning and, on the low end, nothing. One can find cases all along this spectrum. This range quite properly indicates that no single statement or recommendation can be made regarding supplemental data needs. Supplemental data needs are here defined as those that are required for continuing transportation planning that are not normally supplied by the Bureau of the Census.

This paper attempts to provide some ideas on what we believe are the types of data required. To generalize about the entire package of data needs, we have defined what is required for continuing transportation planning and have further stratified these into the following 3 categories: (a) what the Bureau of the Census provides in normally collected data and other services; (b) what is generally out of the realm of the bureau's services; and (c) what the bureau can provide in the way of special surveys made for specific transportation study areas.

TRANSPORTATION PLANNING DATA REQUIREMENTS

The transportation planning process relies very heavily on measurable characteristics within an urban or planning area. Inventories are made to obtain information on land use, population, economic activity, transportation facilities and related performance characteristics, and travel patterns and characteristics. In addition, less quantitative types of information are obtained, such as pertinent legislation and financial resources.

The base data collected are expanded, summarized, and processed for analytical purposes to develop trends and relationships for forecasting future conditions. These data form the basis for developing models for land use distribution, trip generation, trip distribution, modal choice, and traffic assignment. Forecasts are made of the items collected for the base year by using various analysis methods and projection techniques. The data required for continuing transportation planning are some subset or modification of the total requirements for transportation planning.

The Federal Highway Administration (FHWA) has defined the following 5 elements as essential to a continuing planning process: surveillance; reappraisal to maintain the planning process as a valid and effective program; service to those responsible for plan implementation; procedural development of new techniques; and annual report of continuing study activities. The element of major concern here is that of surveillance, which has been defined as "the maintenance of land use, socio-economic data, and transportation system characteristics on a current basis...to properly compare and evaluate the existing conditions in relation to the forecasts made in developing the recommended plans and programs and to determine if the assumptions made previously are holding over time."

The FHWA has prepared some expansion to the concepts describing the reappraisal function of the continuing planning process. This is shown in Figures 1, 2, and 3 for routine review (level 1), major review (level 2), and plan reevaluation (level 3). Varying data requirements are inherent in these concepts. For routine review, the basic data

required are dwelling unit, automobile ownership, employment, and vehicle-miles of travel (VMT) information by small area. This is for an annual process to determine if the changes in urban development are in accordance with forecasts. For major reviews, which may result from the routine review or should occur in any event every 5 years, more extensive data are required. Here, special generator studies of areas with intensive development are indicated along with screenline and other traffic counting surveys. A small-sample, home interview survey of trip origins and destinations might be taken to monitor changes in trip-making characteristics. This may be supplemented by a postcard transit survey.

Plan reevaluation is recommended at least every 10 years or when significant changes indicate a full reexamination of the plans previously made. Here a re-study of goals, objectives, analytical techniques, and procedures is recommended. A complete data collection effort similar to that for the base study may be indicated.

CONTINUING TRANSPORTATION PLANNING DATA REQUIREMENTS

As a basis for discussion of supplemental data needs, it may be advantageous to discuss what some transportation studies are considering or are doing with regard to data for continuing planning

Figure 1. Level 1: routine review.

purposes. Guidelines prepared by the FHWA recommend annual estimates of growth considering factors such as population, employment, and automobile ownership. Direct measures of traffic growth through traffic counting programs are recommended as well as transportation system characteristics such as travel time, accident rates, capacity, level of service, additional miles of roadway, and parking supply.

Washington, D. C.

Wickstrom and Pisarski presented plans for updating transportation planning data in the Washington metropolitan area in 1969 at a meeting of URISA in Los Angeles. The surveillance activities described were for travel demand, transportation facilities, and land use and activity. For travel demand, a small-scale, continuing home interview survey is considered to detect changes in makeup, location, and characteristics of population and its associated travel demands and changes in the rate of trip-making within the same socioeconomic group. The survey will also provide data for study of migration, family size, and housing needs. For transportation facility surveillance, a counting program to provide yearly counts is envisioned to develop an annual flow map. Also speed and delay runs will be made of a sample of streets to determine travel time changes. Physical changes that affect travel will be obtained from the District of Columbia Department of Highways and Traffic and incorporated into the street inventory file. Surveillance for the transit system operating characteristics will be undertaken yearly. Special surveys will also be made annually of parking supply, passenger terminals and public transit use. The land use and activity surveillance will keep current
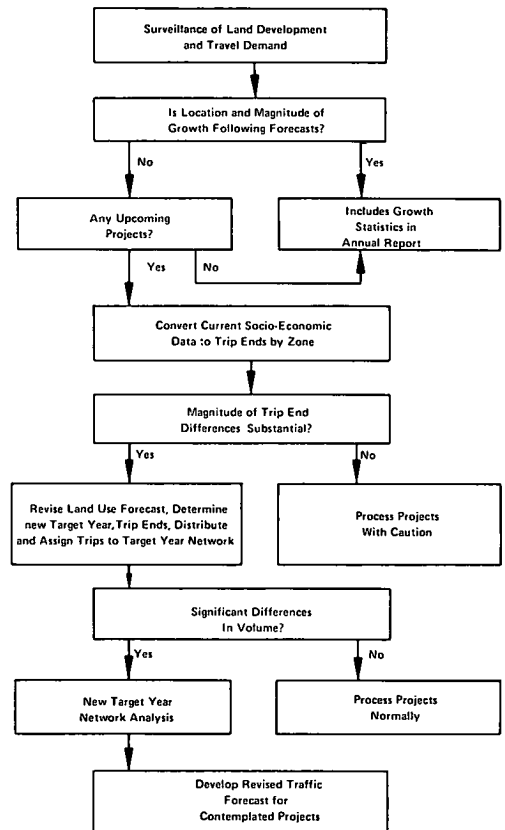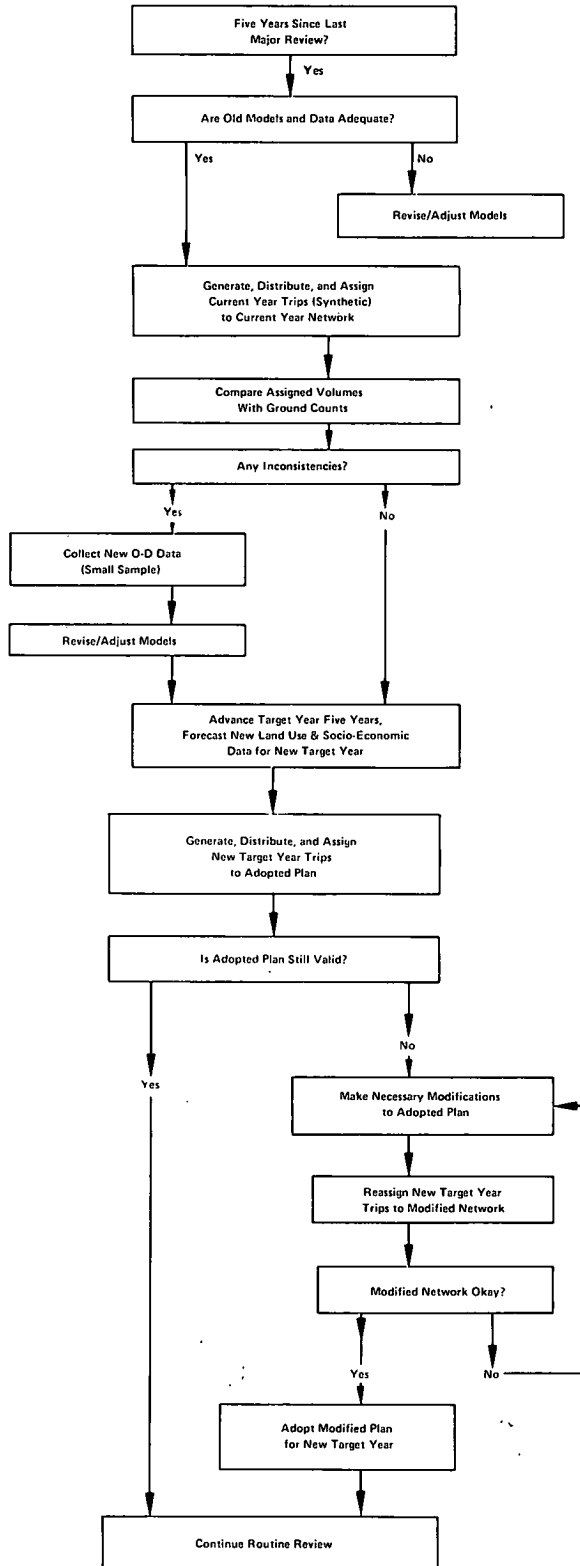
Figure 2. Level 2: major review.

data on the number of dwelling units and relevant household characteristics, employment by type, and land use by type.

Baton Rouge, Louisiana

The change in dwelling units and land use are considered to be the key to the continuing phase. These changes are monitored by processing occupancy permits (required of every new homeowner or business establishment) and building permits. Trip generation in the base transportation study was based on population, passenger cars, blue-collar labor force, white-collar labor force, school enrollment, school attendance, commercial acres, dwelling units, total sales, retail sales, transit index, floor space, and commercial acres. Except for school attendance, these variables are determined from the land use information or from rates. The change in dwelling units by zone and the base population per dwelling unit are used to calculate new populations. Estimates of other population-based variables are obtained by calculating the 1965 relationship between population and the other planning variables and by applying this to the new population estimates.

Figure 3. Level 3: plan reevaluation.

Yearly traffic counts are taken at all external stations to monitor changes in traffic entering or leaving the study area. Control stations are also monitored within the study area. From these, VMT estimates are made for small areas (zones).

The Louisiana Department of Highways has developed an excellent surveillance procedure. The program is based on a recording of building permits, occupancy permits, site plans, and subdivision plats. These documents are transmitted on a continuing basis by the local jurisdictions to the highway department. The highway department has detailed parcel maps on which information regarding construction and occupancy is recorded. New development is added to these maps as the information is received.

The results of this process are used in 2 forms, one graphic and one quantitative. Four maps are used to display the updated land use pattern, the future land use plan, the updated base year transportation system, and the recommended transportation system. The maps, in combination, provide a direct picture of the relationship of current development to the future land use plan and of the extent to which the recommended transportation system is being realized. The magnitude of growth is quantified by maintaining current data on 2 key surveillance elements, dwelling units and employment. This is accomplished by adding employment data from the state employment agency to the development information received from the local areas.

Macon, Georgia

Monitoring in Macon, Georgia, will include traffic growth, changes in land use, basic trip-producing and trip-attracting socioeconomic variables, transit, parking, and street system. Land use information is monitored by using property maps, aerial photos, city directory (cross check for new construction and street addresses), and building permits. A continuous updating of the street inventory is made from information received weekly

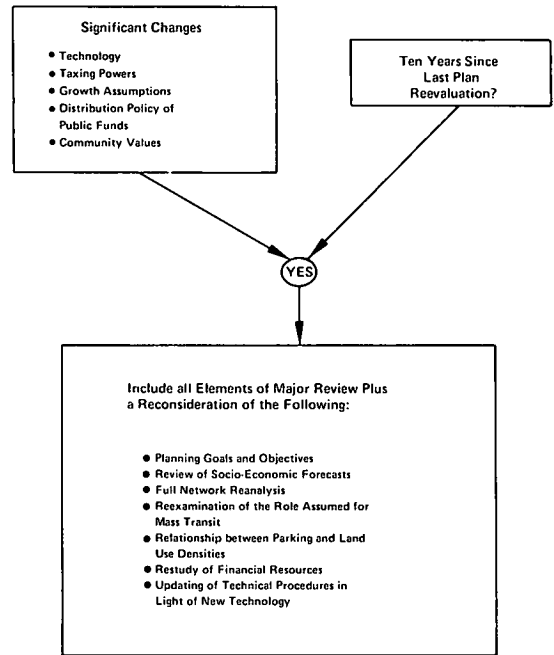from county and city engineers, the Macon City Directory, and field work. A parking inventory will be produced annually, and transit patronage will be monitored by a cordon count around the CBD.

Other Cities

In several studies, land use data are kept current at the parcel level by monitoring building and occupancy permits and integrating these with assessor's records. Many studies plan to use secondary sources, such as state employment agencies, to update and maintain current files on population, employment, automobile ownership, retail sales, and land use. The plans being submitted to the FHWA regarding continuing study make little mention of the use of the 1970 census. This information was contained in a lecture given in the FHWA's urban transportation planning short course by M. L. Marks. Marks suggests the use of data on the primary work trip and on employment by place of work from the journey-to-work survey by the Bureau of the Census. A comprehensive traffic counting program oriented around VMT estimates should be initiated. The primary purpose of the counting program is to monitor changes in travel by functional classification of facilities and by subarea as a means for determining whether the trends forecast by the base study remain valid.

DATA NORMALLY PROVIDED BY THE BUREAU OF THE CENSUS

An examination of the inventories usually required for transportation planning immediately indicate that census data have been used in the past and will be very valuable to continuing study work. Of the 4 major inventory items—economic activity and population, land use, travel characteristics, and transportation facilities—census data are most applicable in the area of economic activity and population. Some uses have been made of census housing data in the land use phases. Generally, data and services provided by the Bureau of the Census have not been applied in inventories of travel characteristics and transportation facilities. This does not, however, preclude use of the bureau's data or its expertise in these areas.

Basically, the census now provides the following 3 products applicable to transportation planning: population and housing data, work-trip and employment data from the journey-to-work survey, and geographic base files. These products are extremely valuable to continuing transportation planning and should find wide use when available for 1970. In the population and housing area, data useful in continuing transportation planning and available from the bureau on a block level that can be aggregated to study specifications include existing dwelling units by type and character, number of units in group quarters, family size, economic status of family (automobiles owned and income), number of workers by occupation and industry, and number of students by age and school level.

The journey-to-work survey provides information that should find use in several applications. The information can be summed by work place to provide an estimate of employment. Because the work place is expected to be coded by block, employment estimates by small areas (zones) can be developed. Information will be available on income of workers, mode of travel to work, industry, and occupation. The journey-to-work data may possibly be correlated to total peak-hour trips and total daily trips and may act as a surrogate for more complete travel surveys. In any case, the survey will serve as a bench mark for work trips in checking of forecasts made and the travel models developed.

In the area of geographic base files, the Bureau of the Census has developed a set of address coding guides covering SMSA's. These guides consist of an ordered list of block faces giving the street name, address, and census block and tract number for each block face. In some areas these guides will be supplemented by the addition of grid coordinates of the ends of each street segment (ACG/DIME). This source will be valuable in geographically coding address-based surveys and secondary source information, such as automobile registrations, as a base for highway inventory information, as a source for developing traffic assignment networks, and as a base for data aggrega-

tion and display. The Census Use Study program begun in New Haven and its extension to SCRIS (Southern California Regional Information System) are using the ACG/DIME concepts in practical transportation applications, and these should provide much useful insight to other urban areas.

DATA GENERALLY NOT PROVIDED BY THE BUREAU OF THE CENSUS

The Bureau of the Census does not provide data obtained in transportation facility inventories. Data obtained in these inventories are used to monitor changes in the system and include traffic counts, travel time by the various modes, capacity added to the transportation system, parking supply and characteristics, and changes in accident rates.

Facility Information

Some items of data that must be collected annually to determine if changes in urban development have affected the transportation system loadings or its performance are as follows:

1. Traffic growth indicated by traffic counts for the entire area by functional classification, for subareas (such as ring and corridor) by functional classification, and for traffic generators;
2. System performance or travel time among subareas by mode;
3. Capacity added by functional class and by subareas as a result of traffic operations improvements and as a result of construction;
4. Speed, volume, and capacity relationships with regard to traffic on arterials by subarea, extent of overcapacity mileage, delay caused by congestion, and peak-hour length by subarea;
5. Parking in the CBD including supply on streets and in garages or lots, cost and its effect on transit usage, and building ordinances regarding parking;
6. Accident rates by subarea, by functional class, and by highway design type;
7. Transit route changes area-wide passengers, equipment, revenues and expenses, route miles, and bus miles;
8. Taxi vehicles and riders;
9. Automobile occupancy at screenlines and on principal arterials;
10. Vehicle classification by functional class and by subarea; and
11. Forecast relationships such as VMT per person, VMT per vehicle, and automobiles per dwelling unit.

The VMT measure in a metropolitan area is a most direct way of determining the demand for facilities. Other indicators such as new dwelling units and new employment are very good surrogate indicators of changing travel demand patterns, but the measurement of area-wide or subarea VMT is the most direct measure. Travel estimates by subarea are required to effectively test whether the various models used in the planning process are reproducing actual travel as measured during a census year. The socioeconomic surveys taken by the census need to be supplemented by a comprehensive traffic counting program that is designed to yield VMT estimates by small area by functional classification.

Traffic counts carefully programmed to yield not only volume data on specific road segments but also aggregate travel demand for portions of a metropolitan area by functional class of facility are some of the most important supplemental data to be collected by an urban transportation study group during a census year. During other years, when the degree of reappraisal may not be so intensive as in a census year, the estimates can be less accurate and less extensive but should still yield sufficient data to make a meaningful annual reappraisal.

Speed-delay runs have been conducted along many transportation arteries over the years. Such work has resulted in profiles of speed and reasons for speed changes. This information has been used to improve operations of arterial streets through signalization and other traffic engineering features. This information has also been used to determine reasonable speeds to assign to street links in traffic assignment networks.

However, comparatively little work has been done in determining overall travel times among major focuses in a metropolitan area. During a census year when much socioeconomic data are being collected by the Bureau of the Census, it is prudent to supplement such data with transportation system performance characteristics.

A specific measure used by the public in evaluating the goodness of the transportation system is the time it takes to travel from one place to another and how this changes over time. The investment of so much money in the improvement of facilities logically causes one to ask whether the travel service provided by the system is improving or worsening. Such questions can be answered by properly planned and scheduled travel time surveys to determine how long it takes to travel from one area to another by mode. Such data should be developed on an annual basis.

Areas that could be considered as a focus for travel time measures would be the CBD, airports, regional shopping centers, minor CBD's, large recreational sites, areas of high residential density, and outlying areas with growth potential. The number of focuses needed for any one urban area depends on size, age, density, and degree of residential and commercial mix.

In order to maintain consistency from one year to another as routes change and the best route mileage either increases or decreases, travel time between the focuses instead of speed should be used. Using this effective measurement makes it possible for improvements in the transportation system to be ascertained readily to determine if the investments in facilities are leading or lagging behind the growth in demand.

Overall travel time measures are very important in determining the overall trend between the base year study and the forecast. Many studies indicate that over the 20-year forecast period effective area-wide speed will change from 20 to 30 mph or more. Now that most studies have progressed 5 or more years toward their initial forecast, a measurement should be taken to determine if the assumptions used are currently valid. Only by testing and probing can plans be evaluated over time. Regional travel time information is one of the necessary ingredients in any continuing program of planning, but it is extremely important that adequate data be collected during census years to supplement the host of socioeconomic data collected at that time.

Origin-Denstination Information

The home interview survey has developed much trip and socioeconomic information over the years and has served as a base of information from which to develop and test proposed transportation systems. A home interview survey should only be undertaken when previous surveys are out of date and models that were developed cannot replicate existing conditions.

Except for some special major generator studies, origin-destination travel information will generally not be a necessary part of the annual surveillance program. The 5-year program generally will not require new origin and destination information unless inconsistencies occur when synthesized trips assigned to networks are compared with ground traffic counts and transit rider counts. For these surveys, selected home interviews may be conducted for model calibration and may only be necessary in newly developed portions of the study area or for areas that have changed in character.

Other possibilities for specialized information include postcard surveys of transit riders and cordon line surveys in special areas or around traffic generators. The home interview might be a less detailed survey than that currently in vogue. Perhaps socioeconomic and trip information, such as number of trips by mode, purpose, and land use, without actual origins and destinations may be all that is required. This would update trip rates by land use types as well as residential generation.

For trip length information a very small O-D type of survey would suffice, if one is necessary. The alternatives for trip length are (a) interviews made on the street to obtain information on single trips from transit riders and automobile occupants, and (b) records of speed and travel time by using a speedometer and time clock mechanism. For every minute of the day, the recording speedometer indicates the speed of the vehicle as well as the time that the vehicle is in motion. The miles that the vehicle travels can also be recorded. One of these instruments on a number of vehicles, included in

a systematic sample and driven during a 7-day period, would provide the number of vehicle trips, the time of day of these trips, the trip length frequency of all the trips, and the miles driven for each trip. The driver would have to indicate when he was driving on a freeway or other type of road so that the average speed of travel by functional class of highway could be determined. Thus, valuable information needed for calibrating most travel forecasting procedures could be obtained without undertaking an arduous address geographic coding process that takes substantial time and slows the planning process in too many instances.

Trip rates for major attractors could be gathered by counting traffic entering and leaving major employment, shopping, and commercial areas. Taxi data could be collected as usual from taxi companies, and such information could be supplemented by installing the recording speedometer, odometer, and time clock.

Small-truck traffic volumes could be estimated from vehicle classification surveys on major arterials and stratified by type of subarea such as the CBD, intermediate areas, and suburban areas. The relationship between occurrences in the base year data and during a census year could be used to extrapolate forward to provide a 20- to 25-year forecast of travel for all vehicles.

Large-truck travel movements are not so uniformly distributed throughout a metropolitan area as small-truck movements. Very little study was made of the movement of goods during most initial studies, and it would seem appropriate to undertake a major survey of goods movement, during the census year especially, and probably to limit the study to goods moved by large trucks. Because such a large proportion of the transportation dollar is spent on moving goods, it would appear that much savings could be made in implementing recommendations developed from a system analysis of the movement of goods in a metropolitan area.

For the 10-year reevaluation, an examination is made of the procedures and models used as the basis for the forecast. In addition, a reconsideration of goals and objectives as well as the roles assumed for the various modes is made. Here, a complete O-D survey may be desirable. The need for such information is determined from the requirements of new techniques developed and changes monitored in trip rates and trip distribution. Again, special types of surveys, such as the modified home interview (without trip origin and destination data), transit postcard, or cordon count surveys, and special generator studies may be all that is needed.

Fiscal Data

Local governments spend substantial funds in road and street improvements every year. As the basis of the financial resources study, which is the major ingredient in developing a short-range priority improvement program, fiscal data need to be collected annually both in the years when the census is taken and in those years when no census is taken. The identification of how much money each jurisdiction is spending on different types of road improvements on the various functional classes of streets and highways is a necessary element in determining the possibility of implementing the plan over the forecast period. Such a study may show that additional funds are required or the level of travel service proposed for the future will not evolve in the time schedule expected.

Timing of Data Collection With Census

To make an annual reappraisal requires that some data be collected every year. It seems reasonable to expect that an extensive coverage of data will be needed in the years when a major reevaluation of the plan will be undertaken or when a reappraisal, testing, and updating of the models will be accomplished. The same types of data should be collected annually but not necessarily of the same scope or degree of detail. For instance, traffic counting on an annual basis should be undertaken so that VMT estimates for fairly large areas result. The 5-year reappraisal or the 10-year plan reevaluation requires data for much smaller areas. For travel time information, the number of focuses for which travel time runs are made on an annual basis may be few compared to the number needed during the reappraisal or reevaluation years.

In general, a continuing process needs information collected on a gross basis annually and collected in such a manner that the base can be expanded and more detailed information collected when the updates are needed. Although collecting comprehensive data every 5 years without collecting anything in the interim may seem prudent, it may cost more over a long period of time because the annual testing and probing of change may result in different decisions being made as to the duration and intensity of some of the data collection efforts on the fifth year.

Because urban planning efforts are being structured around the 5-year and 10-year updates, it would seem reasonable to schedule these to fall on the census years. In 1970, work could be undertaken to forecast information to 1975 and 1995. In 1975, the forecast made in 1970 of 1975 conditions could be tested against actual data collected in 1975. The travel models could be refined or adjusted based on data collected and then used in forecasting 1980 and 2000 conditions. In 1980, when census data are again collected, a major reevaluation of the plan could be undertaken by using the extensive trip and socioeconomic data available at that time.

SPECIAL SURVEYS BY THE BUREAU OF THE CENSUS

In addition to the usual censuses taken on a periodic basis, the Bureau of the Census undertakes special surveys on a contract basis. For example, the Federal Highway Administration contracted with the bureau for a quarterly, 3,000-sample nationwide personal transportation survey to obtain information on households, automobile ownership, travel to work, shopping and school trips, and specific travel on a single travel day. The Bureau of the Census designed the survey form, selected the sample, carried out the interviews, and processed the survey cards. There is the possibility that for special travel surveys the Bureau of the Census can provide similar services to urbanized areas. Interviewers trained for regular censuses may be able to provide services in the home interview area to transportation studies. This approach should be further considered and explored.

The matter of disclosure must be considered in the use of information collected by the Bureau of the Census. Census information cannot be made available if the aggregation of sample data allows recognition of any individual household or sample unit. Although this may appear to be no problem, there have been cases in which a greater aggregation of data has been deemed necessary by the Bureau of Census than was expected or desired by the user. Some discussion and clarification of disclosure policies would be desirable.

CONCLUSION

It should be obvious from the large number of data collection possibilities discussed in this paper that considerable thought must be given to determining the types and quantity of data required for a particular study area. No general recommendations can be made. Each case must be handled individually, and needs must be determined on the basis of the currently available information. The census years may be a good time for developing a new data base.

SOCIOECONOMIC DATA

Robert Voight
U.S. Bureau of the Census

The 1970 Census of Population and Housing will provide many thousands of items of socioeconomic data for a variety of geographic areas of importance to transportation planning. The tabulations yielding this information have already begun and will continue over a period of another 24 months. Two major media will be utilized to present the results of the 1970 census: (a) printed reports containing some 175,000 pages of statistical summaries, and (b) magnetic computer tapes containing nearly 10 times as many data as the printed reports. Microfilm and printouts from the tapes will also be available. A brochure is available that gives a brief description of the various types of statistical output presently planned for the 1970 census (1). Later revisions or addenda to this brochure will be issued to include minor changes in timing and descriptions of additional reports on various subjects as they are finally determined. Announcements and order forms are available from the Bureau of the Census or any U.S. Department of Commerce Field Office. Census reports are also filed in many libraries and are available for examination or purchase at any field office.

SUMMARY TAPES

One series of computer tapes containing statistical summaries of various categories of data will be available, subject to suppression of certain detail where necessary to protect confidentiality, at the cost of preparing the tape (microfilm or printouts). A reel of tape costs about $60. The major portion of the results of the census will be produced in 6 tabulation counts. The first 3 counts will contain summaries for very small areas and will relate to the subject items collected on a 100 percent basis. The second 3 counts will relate to the bulk of the socioeconomic items collected on a sample basis but will also generally include the 100 percent items for purposes of cross-classification. Complete descriptions of these counts and itemized data included in each count are available in a series of brochures titled "Data Access Descriptions." Brochures covering the first 4 counts have been printed. The Data Access Descriptions series also describe the census maps available and other items of interest to potential users of census data. For almost all data, except state, SMSA, or county summaries, it is essential that the user have the census maps to identify the various geographic areas for which data are summarized.

SUMMARY TAPE PROCESSING CENTERS

As a part of the bureau's effort to be more responsive to the specialized needs of users, some 60 Summary Tape Processing Centers have been recognized by the bureau but are not organized or supported by it. Centers develop through local initiative and interest, and their form, purposes, and services are determined by the organizers. They may be at universities, in regional planning organizations, or in profit-making companies. Many will obtain tapes for their immediate states or regions only; several have placed orders for the complete national file of summary tapes. It is anticipated that these centers will provide more immediate service to

potential users of census data by eliminating the inevitable backlog by the bureau. This activity will also enhance the bureau's ability to meet the requests for special tabulations that require the use of basic tapes. These contain data in such small-area detail as to risk identification of the source, even though names and addresses were deleted at the start. They can only be processed by the bureau to delete certain detail, as noted previously, and to ensure the confidentiality of census information.

EARLY DATA

The first responsibility of the Bureau of the Census is to provide final certified state population totals to the President by December 1, 1970. In tabulating the returns to determine these totals in the first count, the bureau will summarize the official population counts in a series of state reports, Series PC(1)A, that will present the totals for counties (by urban-rural residence), SMSA's, urbanized areas, minor civil divisions, all incorporated places, and unincorporated places of 1,000 or more inhabitants. Also statistics on 100 percent housing subjects, Series HC(1)A, will be presented for states, counties, SMSA's (by urban-rural residence), urbanized areas, and places of 1,000 or more. File A of this count will provide some 400 data items for each of some 250,000 enumeration districts or groups of blocks in cities of 50,000 or more across the country; each district or group of blocks contains about 800 to 900 persons. The characteristics include sex by age, race, marital status, household relationship, types of families, and housing value and rent. It also includes occupied and vacant housing units by tenure and race of head of household, plumbing facilities, toilet facilities, persons in occupied units with 1.01 and 1.51 or more persons per room, occupied units by number of persons in unit, tenancy status by race, telephone availability, vacancy status, number of rooms, type of structure, and many other characteristics of interest to transportation planners. File B of this count provides summaries of these characteristics for the state, counties, minor civil divisions, places, and congressional districts.

The second count of 100 percent data is also tabulated to yield 2 files. File A is limited to census tracts and presents population and housing data for specific areas. For the nation as a whole there are about 35,000 census tracts established. File B presents data for some 70,000 individual census areas including places, minor civil divisions, counties, SMSA's, urbanized areas within the state, and combinations of various types of areas. A total of 1,426 population items and 2,159 housing items will be tabulated for each tract in File A and each geographic area in File B. The socio-economic data will include race, age, household relationship, marital status, and type of household by race of head, age of head, and family type. It also includes value and rent by race (white and black), vacancy status, type of structure, plumbing facilities by tenure and race of household head, overcrowding by tenure and race of household head, and other characteristics relating to the economic level of the housing units.

SMALL-AREA DATA

Of particular interest to transportation planners are the data by city blocks. The number of census blocks tabulated in 1970 are about double the number in the previous census. Almost 250 data items will be tabulated for each of the 1,500,000 census blocks delineated in the urbanized area of the 233 SMSA's. In addition to the statistics in the regular block program, the bureau will collect and tabulate, on a contractual basis, statistics for about 125,000 blocks located in more than 900 areas outside urbanized areas. The data for these blocks will also be available both in printed reports and on computer tapes.

Population data to be tabulated for each city block include total population by sex, race, 21 age groups, marital status, and household relationship. Housing items include occupancy-vacancy status; occupied units by tenure by race of household head; type of structure; number of rooms by tenure and race of household head; number of units in multiunit structures by number of units at address; plumbing; toilet; and value of kitchen facilities by occupancy status and race of household head; control rent for renter-occupied units by occupancy status and race of household head; vacancy

characteristics; units with roomers, boarders, or lodgers; and overcrowding by race of household head and by presence of plumbing facilities. Many of these characteristics are significant to land use studies made by transportation planners.

SMALL-AREA SAMPLE DATA

Some of the most significant socioeconomic data of interest to transportation planners are contained in the sample questions asked of every fifth household in the 1970 census. Many of these items, such as migration and place of work, require manual coding; hence, the tabulation of this information will be accomplished from January through October 1971.

These tabulations will be the fourth in the census series and will contain information from the 5 and 15 percent samples; the commonality of some questions in both samples will also, in effect, create a 20 percent sample. The 100 percent items are generally included for the purpose of cross-tabulation. File A of this count will contain census tract summaries; File B will be minor civil division summaries; and File C will include summaries for the state, counties, places, SMSA's, and their component parts. Files A and B will present about 13,000 cells of data for each tract or minor civil division. File C will also present 13,000 data cells for each place, but 30,000 cells for each of the larger geographic areas where the sample items are presented for urban-rural and rural nonfarm and farm residence.

This count provides many of the socioeconomic characteristics of critical importance to many types of planning and analysis in a variety of local programs. It will include information on country of origin of the foreign-born population, citizenship, state of birth, migration, place of work, means of transportation to work, educational attainment and enrollment by type of school, types of families, types of group quarters, disability and employment status of persons 16 to 64 years , age of persons 16 years and older in the labor force by sex, occupation and industry of employed persons by sex for some 40 categories, weeks worked, work status in 1970 and in 1965, family income, income of persons by sex, earnings and occupations of males and females, low-income status of families, family heads and unrelated individuals by sex, labor force status, low-income families receiving income assistance, and value of dwelling or rent paid by low-income families.

Housing characteristics to be tabulated in the fourth count include a number of significant items for transportation analysts. Stories in structures (1 to 3, 4 to 6, 7 to 12, and 13 or more) provide a measure of density for forecasting travel. Also included are number of rooms, presence of basement, units at address, value and rent, duration of vacancy, plumbing facilities, household income, year moved into unit, value-income ratio, asking rent for vacants, sale prices for vacants for sale, automobiles available (0, 1, 2, and 3 or more) for owners and renters, and household appliances owned . A subset of these characteristics will also be tabulated (but not published) for ZIP code areas—at the 3-digit level outside SMSA's and at the 5-digit level for the SMSA's.

LARGE-AREA DATA

A sixth count of 1970 population and housing census items based on the sample will provide a great deal of socioeconomic detail for large geographic areas. Here the full distribution of occupation and industry detail will be displayed for the state, SMSA's, cities of 100,000 and more, and central cities of SMSA's. This count will provide a total of 150,000 cells of population information and 110,000 cells of housing data.

Examples of social characteristics for SMSA's, urbanized areas, and urban places of 10,000 or more that will be published are as follows: percentage of population foreign born, percentage of native population of foreign or mixed parentage, percentage of native population who reside in their state of birth, percentage of total population who moved into their dwelling unit after 1968, percentage of persons 25 years and older who completed 4 years of high school or more and median years of school completed, and percentage of families with own children under six.

Economic characteristics published for these areas include nonworker and worker ratio, percentage of females 14 years and older in labor force, percentage of total married women in labor force and those with own children under six, percentage of males 18 to 24 years in labor force, percentage of males 65 years and older in labor force, percentage unemployed in the civilian labor force, percentage of employed persons in manufacturing industries and in white-collar occupations, percentage of workers working outside county of residence during census week, percentage of workers using public transportation, percentage of those who worked in 1969 who worked 50 to 52 weeks, median income of families, percentage of families with incomes of $3,000 or less, and percentage of families with incomes of $10,000 or more.

A somewhat condensed set of social and economic characteristics will be published for urban places of 2,500 to 10,000 inhabitants and for each county.

A series of reports, Series HC(2), covering most of the 1970 housing census subjects in considerable detail and cross-classifications will be issued between April 1971 and February 1972. There will be one report for each of the 233 SMSA's presenting data for the SMSA as a whole and for the large cities it contains. The series will also include a national summary.

Tables 1, 2, 3, and 4 give summaries of the social and economic characteristics to be made available from the 1970 census.

In 1972 the bureau expects to issue a series of subject reports. Each report will concentrate on a particular social or economic characteristic of the population. Some of these reports will include data for SMSA's and states. Among the characteristics to be covered as currently planned are migration, education, employment and unemployment, occupation and industry, income, and place of work.

DATA SUMMARIES

Analysts and planners who find data compendia useful reference tools will be interested to know that a 1972 County and City Data Book will be issued by the bureau.

TABLE 1

GENERAL POPULATION CHARACTERISTICS, 1970, CONTAINED IN STATE REPORTS, SERIES PC(1)B

Characteristics	State	SMSA's	Urbanized Areas	Places of 10,000 or More	Places of 2,500 to 10,000	Places of 1,000 to 2,500	Counties	Rural Population of Counties	Minor Civil Divisions
Race									
White, Negro, Indian, Japanese, Chinese, Filipino, other	X	X	X	X	X		X	X	
White, Negro, other						X			X
Age[a]									
Single years to 100 years and over	X								
Single years to 21 years and over and 5-year intervals to 85 years and over	X	X	X	X			X		
5-year intervals to 75 years and over					X			X	
Median age, persons under 18 and 65 and over	X	X	X	X	X	X	X	X	X
Relationship to head of household[a]									
For all persons	X	X	X	X	X		X	X	
For persons under 18 years old	X	X	X	X	X	X	X	X	
For persons 65 years old and over	X	X	X	X	X		X	X	
Persons per household	X	X	X	X	X	X	X	X	X
Type of family and presence and number of own children[a]	X	X	X	X			X		
Marital status[a]	X	X	X	X			X		

Note: Complete count data.

[a]Cross-classified by race (total, white, Negro) for the state, SMSA's, UA's, and places of 10,000 or more.

TABLE 2

GENERAL SOCIAL AND ECONOMIC CHARACTERISTICS, 1970, CONTAINED IN STATE REPORTS, SERIES PC(1)C

Characteristics	State	SMSA's, Urbanized Areas, Places of 25,000 or More	Places of 10,000 to 25,000	Places of 2,500 to 10,000	Counties	Rural Farm and Nonfarm Population of Counties	Areas With Negro Population of 1,000 or More: SMSA's, Urbanized Areas, and Places of 25,000 or More	Areas With Negro Population of 1,000 or More: Counties
Age	X					X		
Relationship to head of household	X					X		
Families by number of own children	X							
Nativity and parentage	X	X	X		X			
Country of origin	X	X	X		X			
Mother tongue	X	X	X		X			
State of birth	X	X	X	X	X		X	X
Residence in 1965	X	X	X	X	X		X	X
Year moved into present house	X	X						
Place of work	X	X						
Means of transportation	X	X						
Veteran status	X	X						
School enrollment	X	X	X	X	X	X	X	X
Years of school completed	X	X	X	X	X	X	X	X
Vocational training	X	X						
Children ever born	X	X	X		X	X	X	X
Family composition	X	X	X		X			
Previous marital status	X	X						
Group quarters population by type	X	X	X		X			
Disability	X	X						
Employment status	X	X	X	X	X	X	X	X
Occupation	X	X	X	X	X	X	X	X
Industry	X	X	X	X	X	X	X	X
Weeks worked	X	X						
Class of worker	X	X	X	X	X		X	X
Last occupation of unemployed	X	X	X		X		X	
Work status in 1965	X	X						
Family income	X	X	X	X	X	X	X	X
Income of persons	X	X	X		X		X	X
Median earnings for selected occupations	X	X						
Type of income	X	X	X		X		X	X
Characteristics of families and persons with income below poverty level	X	X	X	X	X	X	X	X

Note: Sample data. For many subjects the amount of detail has been collapsed in moving from large to small areas.

TABLE 3

HOUSING UNITS AND POPULATION CHARACTERISTICS, 1970

Characteristics	Places of 2,500 or More	Blocks Within Census Tracts	Blocks Within Block Numbering Areas or Census Tracts
Total population			
Percent of total population			
Negro			
In group quarters			
0 to 17 years			
62 years and older			
Year-round housing units			
Total			
Lacking some or all plumbing facilities			
Units in 1-unit structures			
Structures of 10 or more units			
Occupied housing units			
Owner			
Total			
Lacking some or all plumbing facilities			
Average number of rooms			
Average value ($)			
Percent Negro			
Renter			
Total			
Lacking some or all plumbing facilities			
Average number of rooms			
Average contract rent ($)			
Percent Negro			
1.01 or more persons per room			
Total			
With all plumbing facilities			
1-person households			
With female head of primary family			
With roomers, boarders, or lodgers			

Note: Data exclude seasonal and vacant migratory housing units.

TABLE 4

PLANNED CONTENT OF HOUSING VOLUME REPORT AND CENSUS TRACT REPORTS

Subject	State	SMSA's and Component Parts	Places of 10,000 to 50,000[a]	Places of 2,500 to 10,000[a]	Places of 1,000 to 2,500[a]	Counties Total[a]	Counties Rural[b]	Counties Occupied Farm[b]	Census Tract	Census Tracts With Negro or Spanish-American Population of 400 or More
100 percent items										
Access	X	X	X						X	
Rooms	X	X	X	X	X	X^c	X^c	X^c	X	X
Units in structure	X	X	X	X	X	X				
Basement	X	X	X							
Population, 1970	X	X	X	X	X	X	X^c	X		
Persons per room	X	X	X	X	X	X	X^c	X^c	X	X
With plumbing	X	X	X	X	X	X	X	X^c	X	X
Race	X	X	X	X	X	X	X	X	X	
Tenure	X	X	X	X	X	X	X^c	X^c	X	X
Vacancy status	X	X	X	X	X	X	X		X	
Duration of vacancy	X	X	X	X			X	X		X
Bathtub or shower	X	X	X	X			X	X	X	
Plumbing facilities	X	X	X	X	X	X^c	X^c	X	X	X
Flush toilet	X	X	X	X			X	X	X	
Water supply	X	X	X	X			X	X^c	X^c	
Complete kitchen facilities	X	X	X	X			X	X	X	X
Value	X	X	X	X	X	X	X		X	X
With plumbing	X	X	X	X			X	X		
Contract rent	X	X	X	X	X	X	X		X	X
With plumbing	X	X	X	X			X	X		
Telephone	X	X	X	X			X	X	X	
Persons	X	X	X	X	X	X	X^c	X^c	X	X
20 percent items										
Year structure built	X	X	X	X			X	X^c	X^c	X	X
Units in structure	X	X	X	X			X	X	X^c	X	X
Gross rent	X	X	X	X			X	X^c		X	X
Heating equipment	X	X	X	X			X	X	X	X	X
15 percent items										
Complete bathrooms	X	X	X	X			X	X	X^c	X	X
Sewage disposal	X		X	X			X	X^c	X^c	X	X
Source of water	X		X	X			X	X^c	X^c	X	X
Air conditioning	X	X	X	X			X	X	X	X	X
Automobiles available	X	X	X	X			X	X	X	X	X
Year moved into unit	X	X	X	X			X	X	X	X	X
5 percent items										
Bedrooms	X	X^d	X^d			X^d	X	X		
Second home	X	X^d	X^d			X^d	X	X		
Clothes dryer	X	X^d	X^d			X^d	X	X		
Clothes washer	X	X^d	X^d			X^d	X	X		
Dishwasher	X	X^d	X^d			X^d	X	X		
Home food freezer	X	X^d	X^d			X^d	X	X		
Cooking fuel	X	X^d	X^d			X^d	X	X		
House heating fuel	X	X^d	X^d			X^d	X	X		
Water heating fuel	X	X^d	X^d			X^d	X	X		
Television (sets)	X	X^d	X^d			X^d	X	X		
Television (UHF-equipped)	X	X^d	X^d			X^d	X	X		
Battery-operated radio	X	X^d	X^d			X^d	X	X		
Elevator in structure	X	X^d	X^d							

[a] Data for units with Negro or Spanish-American head only shown for areas with 400 Negro or Spanish-American inhabitants or more.
[b] Only items shown for units with Negro head are those to which footnote c applies.
[c] Data shown for units with Negro head if 400 Negro inhabitants or more.
[d] Data for units with Negro head only shown for areas with 10,000 Negro inhabitants or more.

These data books provide summaries of a broad spectrum of social and economic data for regions, census divisions, states, counties, SMSA's, and cities of 25,000 or more. The information will also be available on computer tapes and punchcards. Nearly 150 data items will be presented for each city of 25,000 or more including the most recent information available on population, vital statistics, education, employment, income,

housing, banking, manufacturing employment, establishments and payrolls, retail trade establishments and sales by major kinds of business, wholesale trade and selected services, and city government data covering general revenue and expenditure categories, employment, and payrolls. This data book provides a ready means for making comparisons of the characteristics of various cities within a single state or region or of various geographic areas.

SUMMARY

The products of the 1970 census will be the most extensive ever provided by the bureau. There has been a concentrated effort to meet the demands for social and economic characteristics of the population and the homes they live in at the finest levels of geographic detail that will still permit the tabulation of meaningful data. There has been an effort to provide for maximum flexibility of tabulation summaries to permit the recombination of these into administrative or operational areas of significance to local organizations. The bureau will make the data available in a variety of media—publications, computer tapes, printouts, microfilm, and microfiche—so that users may select and purchase the data in the format most suitable for their purposes.

To make the information from future censuses of greater value, we invite criticisms and suggestions for improvements in the data and the data delivery systems based on actual experience with the 1970 census.

REFERENCE

1. Tentative Publication and Computer Tape Program for the 1970 Census. U. S. Bureau of the Census.

WORK-TRIP DATA

Joseph F. Daly
U.S. Bureau of the Census.

There are important aspects of the work-trip data available from the 1970 census:
(a) the content of the questionnaire, (b) the data contained in machine-readable form on
the computer tapes, and (c) the data that will be summarized in the course of the regu-
lar census publication program.

There were 2 types of 1970 census questionnaires: short forms used for obtaining
information from about 80 percent of the households and long forms used for ob-
taining information from the remaining 20 percent. All of the long forms contained
questions on topics such as age, sex, color, household relationship, place of birth,
education, labor force status, occupation and industry, income, and housing charac-
teristics such as tenure and vacancy status, number of rooms, presence of kitchen
and plumbing facilities, and value or rent. Long forms that contained questions bear-
ing on work trips were used for 15 percent of the households. These forms contained
2 questions addressed to each person who worked (full time or part time) during the
week preceding April 1, 1970. The first question was, "Where did he work last week?"
It requested the address of the place of work in terms of state, county, place name,
street name, numeric address, and ZIP code and an indication of whether the location
was inside the limits of the named city, town, or village. The second question was,
"How did he get to work last week?" Space was provided to indicate the principal
means of transportation used on the last day of the reference week. The categories
were driver of private automobile, passenger in private automobile, bus or streetcar,
subway or elevated, railroad, taxicab, walked only, worked at home, and other means.
Some, but by no means all, of the questionnaires bear the address of residence; all of
them should bear serial numbers that permit us to match them with the enumeration
listing books that do contain addresses.

The questionnaires and associated listing books represent the maximum amount of
work-trip data available from the census. Not all of this information is actually re-
corded on the magnetic tapes used for processing the census. In particular, the tape
records do not contain the names of persons or their residential addresses. They do
contain identification codes that permit us to match them with the listing books. They
also contain geographic codes that identify the household location down to the various
tabulation areas used in the regular census publications, including block identification
for those households in block tabulation areas (roughly the urbanized areas of the
country).

The answers to the place-of-work question are also recorded in coded form, coded
at 2 levels. The first level is known as the Universal Area Code (UAC). In the UAC
system there is one specific code for each place of 25,000 or more and one for that
part of each county that is not in a place of 25,000 or more. The tape record for each
worker will have such an area code for his place of work based on the county and place
name recorded on the questionnaire. There are about 5,000 such distinct codes.

In addition to the UAC identification, the work-place addresses of many (if not most)
workers are also coded to the tract and block level. The extent to which this more de-
tailed geographic coding of place of work is done depends on 2 conditions. The first
condition is that the worker must, in general, live and work within an SMSA. In a few

selected cases, we will broaden the detailed coding area to cover several neighboring SMSA's. For example, the detailed coding area containing the San Francisco SMSA will also include Vallejo-Napa and San Jose. The second condition is that the place of work must not only be within the coding area of the residence but must also be within the subarea for which we have prepared address coding guides. This subarea can be thought of as roughly corresponding to the urbanized part of the SMSA or SMSA's that constitute the coding area. For each worker who meets these conditions, a coding clerk will examine the ZIP code and street address on the questionnaire, consult an abbreviated version of the address coding guide for the coding area, and enter on the questionnaire in FOSDIC readable form the street code, numeric address, and ZIP code. If the respondent fails to provide a street and number, but rather gives the name of a building or a business establishment, the coding clerk will use a company name list and, if necessary, a local telephone directory to obtain a street and number address. The tape records for the workers whose place of work address have been thus coded will be matched mechanically to the appropriate address coding guide for the area in question and assigned a tract and block number.

The fact that detailed place-of-work coding will be restricted to persons who live and work within the same coding area was forced on us primarily by the need to limit the number of pages of printed reference materials that a single coding clerk would have to handle. Admittedly, some of us did have visions of setting up an interactive computer-based system like that used for entering or confirming airline reservations so that the coding clerks could key in an address or company name and get back the necessary codes to mark on the questionnaires. But the 1960 data indicated that by making judicious combinations of SMSA's we could expect that not more than 5 percent of the workers living in a particular coding area would actually work in the urbanized part of another coding area; so, we concluded that our efforts could be better spent in coping with some of the other problems connected with the census.

At this time it is too early to tell how successful we will be in coding work addresses to tract and block. However our experience in the Madison pretest, together with a hurried look at a sample of 1970 questionnaires returned by mail, leads us to hope that in most SMSA's about 90 percent of the persons who work in the urbanized part of the coding area of their residence will give answers to the place-of-work question that are complete enough for detailed coding, and that 98 percent or more of these coded answers can be matched to the address coding guide file and thus receive tract and block codes.

Data related to work trips will appear in a number of the regular census tabulations. Here the smallest geographic unit will be the census tract or its equivalent.

1. Tract reports. For each tract of residence in an SMSA, we will show the number of persons reported as working in the central business district of the central city, in the remainder of the central city, in the central county outside the central city, in each other county of the SMSA and outside the SMSA. The number of workers who did not provide a codable work-place address will also be shown.

2. PC state reports. For each place of 10,000 or more and for each county, we will report the number of workers who live in the area, the number classified as working in the county of residence, the number classified as working outside the county of residence, and the number whose place of work could not be coded at the county level.

3. PD state reports. For each SMSA of 100,000 or more, we will show data on age, sex, color, means of transportation, industry and earnings of resident workers who (a) live in central city and work in central city either in central business district or in remainder of central city, work in remainder of SMSA, work outside SMSA, and did not report place of work; and (b) live in remainder of SMSA and work in central city either in central business district or in remainder of central city, work in remainder of SMSA, work outside SMSA, and did not report place of work.

4. Special subject report on journey to work. In this report there are 2 types of tables: (a) Table 1 that is restricted to workers who live in an SMSA or who work in an SMSA and that gives each commutation stream of 50 or more between areas at the UAC level (similar to Table 1 of the 1960 report on journey to work); and (b) Table 2

that is restricted to SMSA's of 250,000 or more and that gives a 1-page stub of socio-economic characteristics of the persons who work in each tract, provided that the tract has 1,000 or more workers. This latter tabulation raises a still unresolved question. It may well happen that the workers in a particular tract are almost all employed by a single enterprise. Publication of a statistical summary showing the number of workers in a tract who fall into each of a limited number of socioeconomic categories does not constitute disclosure in the strict sense because the information was obtained from the individuals and not from the enterprise that employed them. The real question is whether the publication by the government of tables showing that most of the workers in the tract are male or that a substantial number of them have low incomes or so on might be used by someone to attack the employment policy of the dominant employer in the tract. I personally believe that the users of census data are sufficiently well informed about the limitations of such data that they will not leap to any unwarranted conclusions about a particular employer on the basis of such a table. However, because we want to have the census results used for constructive purposes and not merely as fuel for confrontation and because, on the other hand, we do not wish to withhold information that may lead to a better understanding of transportation problems and resources, we will have to consider carefully just what information should be presented.

5. Other summary data. In the course of compiling the tract reports mentioned in item 1, we will have compiled data on number of workers by more detailed place of work and place of residence. The residence categories will be tracts within tracted areas and places of 2,500 or more and minor civil divisions outside of tracted areas. For each county of residence, we have predesignated 20 UAC areas. The summary tabulations for any area of residence will show the number of residents who work in each of the 20 associated UAC areas.

As has been indicated, the basic census record tape for the 15 percent sample will contain residence information at the enumeration district level for all households and at the block level within urbanized areas. The records for workers will show place of work at the UAC level; and for most workers who live in an SMSA and work in an urbanized area, the record will contain the block number and street code of place of work. (In addition, for persons living in an SMSA, there will be cases where the place of work cannot be coded to block but can be coded to ZIP code.) This level of geographic coding should make possible a wide variety of special tabulations. A rather elaborate set of such tabulations by traffic zone is being planned with the support of the U.S. Department of Transportation.

In considering special tabulations, it should be kept in mind that the basic record tapes are confidential and that any tabulations requiring the use of these tapes must be done by the bureau and screened for possible disclosure of the detailed characteristics of any individual. The bureau must, of course, be reimbursed for the cost of its work. It should be further kept in mind that the results are based on a 15 percent sample of the population, so that data for very small subgroups are subject to substantial sampling variability. For example, an estimated total of 1,000 can be expected to have a coefficient of variation of about 7 percent. Roughly speaking, the coefficient of variation will be inversely proportional to the square root of the size of the total being estimated. It is quite possible that in areas where place of residence and place of work are coded to block we may in the next 2 years be able with appropriate support to produce a basic record tape containing fairly accurate map coordinates of residence and work place.

NETWORK DATA, GEOGRAPHIC CODING CAPABILITIES, AND AREA SYSTEMS

George Farnsworth
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I feel strongly that it is past time to discard the notion that the computer is a kind of data factory that merely generates information for the planner to use. On the contrary, the computer must inevitably become a part of the planner's own brain, and he must in turn become part of it. The only possible justification for the tremendous effort now going into the production of census summary tapes and geographic base files is that planners and administrators will use these materials by making them an integral part of their own professional thought processes. This will only happen for those who stop thinking of computers as mysterious and distant oracles tended by a high priesthood of programmers. I stress this point because I am convinced that only those who intimately understand the capabilities and limitations of the machines will be able to make succeesful use of these materials, which are primarily machine oriented.

NETWORK DATA

My house in Los Angeles is high on a hill, and at night, when the smog clears, a panorama of lights spread out below. That is one aspect of network data—a pattern of interconnecting lines. That pattern, however, is the network itself, and the bare net of lines is essentially data free.

The information added to this network in constructing an address coding guide and dual independent map encoding (ACG/DIME) file may be called data for want of a better term, but it is not statistical information. When we speak of census data or transportation data, we are talking of statistical characteristics of groups of people or other units. By network data, on the other hand, I mean specific characteristics of individual elements of the network.

The individual elements of the ACG/DIME network are line segments. The data attached to these segments may be classified into 3 broad interrelated classes: characteristics of the line itself, characteristics of the end points of that line, and information about the areas on each side of the line segment.

Each line segment has a name or other verbal description and a class, such as street, railroad, city limit, or freeway. Other data considered specific to the line itself are its length, ZIP code, and unique sequence number. Additional specific data could be added for transportation planning purposes, such as number of lanes, road surfaces, speed limits, and related information.

Each end of each line segment has an intersection number and a geographic coordinate location and is identified as being on a specific census metropolitan map sheet. All line segments that meet at a particular intersection naturally have one intersection number in common. These numbers are what stitch the line segments together into a network. The 2 ends are further differentiated by order. One is called the from end and the other, the to end. This distinction serves to orient the segment. For streets with addresses, the segments are "aimed" in the direction of increasing house numbers. For other types of segments, the orientation is arbitrary but nonetheless necessary. The end points of segments are a suitable point to attach data such as those on signalization, signs, or separation.

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The regions lying to either side of a segment are first denoted left and right by utilizing the orientation established by the order of the end points. Address ranges are recorded for each side (for streets). In general the address range is of even numbers on one side and of odd numbers on the other side, but this is not required; it sometimes happens that both sides are even or odd or that only one side has house numbers. The 2 sides are further identified by geographic codes that range from state to census tract and block. In addition to the standard bureau codes for state, county, city, congressional district, and so on, local codes are provided for traffic zones, school districts, police precincts, and the like.

The ACG elements of the network data are the segment names, address ranges, ZIP codes, and geographic codes. DIME is the process by which the segment is oriented, the intersection numbers added, and the 2 sides brought together. Coordinates are digitized later for each intersection and added to the file. (Coordinates will be recorded in state plane, latitude-longitude, and map miles.)

Without the features provided by DIME, the ACG elements are simply a free-floating set of block sides not connected into a network and not paired off into opposite sides of the same street. The dual part of DIME results from an interesting property of this type of network. Up to this point, I have been describing the DIME network as a set of line segments connected together at intersections. It is possible, however, to consider the same network as composed of a set of block boundaries connected together at block centers. From this point of view, the line "segment" intersections become the "sides" of the boundaries and the block numbers become the "ends."

Figure 1 shows that the solid lines are the streets forming the basic network and the dashed lines are the "dual" of that network. A segment that is usually regarded as connecting point A to point B with block 101 on one side and block 102 on the other can also be viewed as "connecting" blocks 101 and 102 with A and B as the "sides." This principle of duality is what distinguishes the DIME network from other types of node-link networks.

One importance of the dual network is that it provides the capability of identifying which blocks (or other regions) are neighbors. This allows comparison of the data for one block with those of its adjoining neighbors and would thus permit the construction of a large contiguous set of blocks with homogeneous characteristics. Alternatively one might identify those blocks, tracts, or other areas that are different in some respects from their neighbors.
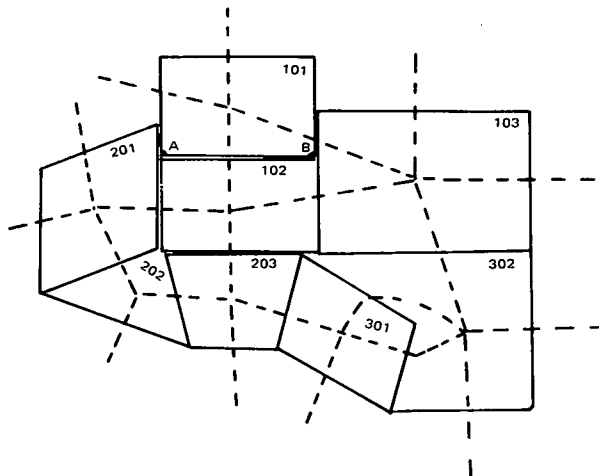

Figure 1.

In addition, of course, duality provides an important and powerful editing feature by ensuring that the clerically created primary network is consistent with its "independently" encoded dual.

To get back temporarily to my starting point, it is now possible for one with real appreciation of the capabilities of the computer and with solid knowledge of his objectives, to manipulate the ACG/DIME network in the same way that anyone can manipulate a map. The ACG/DIME file is in principle a computer-usable map but one that contains much more information than is usually found on maps.

The steam engine did much more than replace muscle power, however; and the computer makes it possible to go far beyond the manipulation ordinarily possible for clerks using maps and statistical tables. This is a perfect example of the "medium" becoming the "message."

It is one thing to imagine asking a clerk to identify a set of contiguous blocks that are homogeneous with respect to some specific demographic characteristic. With a machine, however, it is possible to go far beyond this and ask for a definition of homogeneity that depends on a set of characteristics, giving more weight to some than others and including numerous other criteria.

A draftsman can easily draw a 2-mile radius around a planned facility, but with the geographic base file you and the computer can draw a line indicating the 5-minute driving distance radius and include adjustments for varying speeds, traffic conditions, and other factors. It can be done for a hundred planned facilities at once as easily as for one, and relevant statistical data for the areas can be generated as a by-product.

These and many other applications are possible by using the network data on the census summary tapes and from other data sources. The Southern California Regional Information Study (SCRIS) and many others are working to develop generalized software to aid such manipulations. None of this work, however, will really benefit those who cannot appreciate the power of computing machinery or those who are not capable of seeing how their problems can be aided by such solutions.

The geographic base file, however, is somewhat limited by the fact that it relates to a specific moment in time. SCRIS, therefore, is devoting considerable effort to the development of a continuous maintenance system so that local areas can keep their files current. The system now envisioned is built around the census metropolitan map with intersection numbers. The plan is that all references to existing or new line segments will be on the basis of information available from the map alone, thus avoiding the problem of having to refer to listings for serial numbers or other arbitrary references.

In general, the system will allow changes to all characteristics of existing segments as well as deletions and additions. All added segments and certain changes to existing segments will carry dates to allow historical analysis. A provision for splitting census blocks in a way analogous to that already used for census tracts is expected to allow creation of new blocks while preserving comparability with 1970 block statistics.

SCRIS is now preparing a publication describing the proposed characteristics of the system and outlining methods for using it.

GEOGRAPHIC CODING

Geographic coding (or geocoding) is the process of locating things to particular geographic areas. Normally the things are places or events that enter the process with some very detailed geographic code already present, such as street address, and the geocoding process then consists of assigning various higher level geographic codes such as census block, census tract, and city. Other original location information may, however, be present instead, particularly if the things are not point related, such as school statistics, census data, or high statistics.

To cover such situations, the concept of geographic coding may be expressed as follows: "Given an exhaustive and mutually exclusive set of subsets and an element that fits in only one of the subsets, determine within which subset the element belongs." This excludes problems such as "Which state is US-66 in?" because US-66 is in many states. As long as one of the subsets is defined to be "everything else," it

is possible to handle problems such as "Which street is parcel 17B, lot A on?" even if the particular parcel is not located on any street. This definition also includes problems such as "Is this address on the list of all restaurants?"

In practical applications, 2 particular situations are normally of interest. The most common of these is geographic coding of street addresses. This is discussed further later. Another common situation is geographic coding of points identified with coordinates. This situation arises with points determined by digitizing or surveying and is normally handled by defining the subset geographic areas as polygons and performing point-in-polygon processing.

SCRIS has also done research on this aspect of geographic coding and has developed techniques for using the geographic base file to define census blocks, tracts, or other areas as polygons. A point-in-polygon routine is also available, but we have not yet developed a complete system to the level of ADMATCH, which is used for geocoding of addresses.

As mentioned earlier, the most common geographic coding problem involves locating street addresses within census blocks, census tracts, or other areas. The census use study ADMATCH system, in conjunction with the geographic base file, has proved a very good solution for such situations. ADMATCH has been used by the use study and SCRIS in coding scores of different local address files to ACG/DIME files and census tract street index files. The kinds of files processed have included customer billing lists, survey cases, administrative records, and tax assessment files.

All files processed by ADMATCH have street address as a common characteristic, but in other ways they have been more different than alike. Some have been as short as 80-character card images, while others have been as long as 150 characters. ZIP code, post office name, city code, and no code have all been used as the major match key. Codes assigned to the successful matches have ranged from ZIP code down to block face and coordinate location.

The 2 essential elements of ADMATCH are its ability to unscramble ordinary mailing addresses and its ability to match by means of a weighted score. These together give the ADMATCH system considerable flexibility and a relatively high rate of match.

Address unscrambling consists of finding the essential elements of the address, standardizing them, and inserting them into a fixed format "match key." The unscrambling is accomplished through a scan for all possible abbreviations such as of street directions and street types. Following the scan, a pattern recognition table is used to determine the actual standardized address. In this way an address such as 918 Way St. can be processed and "Way" can be established as the street name rather than a street type. A large number of other examples are illustrated in the ADMATCH Users Manual that accompanies the program. The essential point is that ADMATCH does not require elaborate clerical standardization of either formats or abbreviations.

The ADMATCH programs are written in IBM-360 Assembly Language and will run on a machine as small as a Model 25 under DOS with 32 K bytes of memory. This version is currently being distributed by the Bureau of the Census at the cost of reproduction ($60). A larger and faster version of the system is currently being prepared for use by those with large 360 machines under OS. A version for use on RCA SPECTRA-70 machines is also in the works. On a 360/30 under DOS the system processes some 200,000 addresses per hour, and the OS version on a 360/65 can pass about 1.5 million addresses per hour. Each address must be processed twice; once to unscramble it and once to match it. An intervening sort is also required.

AREA SYSTEMS

I use the phrase "area systems" as a short way to refer to a very large and complex situation. Many rural areas and all urbanized areas are crisscrossed by a very complicated set of boundary lines for a large variety of districts ranging from state boundaries down to individual parcel lines. These districts are used for legal, statistical, administrative, or other purposes; many districts have multiple uses. In Los Angeles County SCRIS staff members have counted more than 200 different types of districts. Almost all of these districts interpenetrate and overlap, and nearly all of them change frequently.

In most cases it is convenient and necessary to establish at least basic census data for the districts, and it is frequently useful to use local data from one type of district for others. Traffic zones, for example, usually have considerable data available from surveys and other sources, but it might often be convenient to tabulate accident data, employment statistics, or tax assessment information for traffic zones. If the accidents are currently totalled by police precincts, the employment data by state tax board districts, and the assessor information by parcel, it may become quite difficult to reconcile these statistics. The central problem of area systems, then, is to reconcile these conflicting and overlapping districts and to establish correspondence between them.

The SCRIS approach to the problem of area systems has centered around use of the ACG/DIME segments as the lowest common denominator on which to build the necessary correspondences. We have devised systems for defining districts either in terms of census tracts and blocks or in terms of their boundaries. A computer program then takes over and assigns the proper district code to each segment within it. Editing tests are performed to check for overlapping of the same type of district, and if the district is specified as exhaustive a check is made for any unassigned areas.

These systems are intended for general use to increase the power of the ACG/DIME materials and to improve the utility of the census data. The manual effort is very moderate and considerable accuracy is ensured through the machine editing. A revision in the ACG/DIME format is planned to allow room for about 20 additional area codes for each side of each segment. When addresses are coded with ADMATCH, then, it would be possible to extract not only the census tract, block, and coordinates but also the traffic zone, school district, police precinct, or other areas.

A fairly simple computer program is also planned to create correspondence tables among the various districts. These tables may also show, for the various correspondences, the percentage of total road distance or total land area included. The table would then indicate, for example, that 20 percent of census tract 1466 is in school district 3 or 100 percent of it is in traffic zone 9738.

SUMMARY

The ACG/DIME files with census and local data constitute an invaluable resource for transportation planning, city planning, and administration. These files provide computer-usable data tied directly to the highway and road network and to all significant census and local geographic codes.

The ACG/DIME files and the morass of census statistics, however, are relatively worthless to the unaided human brain—even when they are printed out or mapped out by a computer. The same information is, of course, equally worthless to the unaided computer. Only when the two work together can real benefits be obtained from these network data files, geographic coding capabilities, and area systems.

JOURNEY-TO-WORK STATISTICS

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Federal Highway Administration

The 1962 Federal-Aid Highway Act required the development of a comprehensive planning process as the basis for determining transportation investments in all urban areas with populations greater than 50,000. Since the passage of that act urban transportation study programs have been established and maintained in the urban areas where required.

The urban transportation planning process that has developed has certain uniformities and similarities from city to city. The process is typified by a systems analysis process including data collection, analysis and model development, forecasting of the location and amount of urban activities and the travel demand they generate, plan development and evaluation, and a continuing phase of update and reevaluation. A full run-through of the analytical and plan-building cycle typically takes as many as 5 years to complete. A general rule-of-thumb for the cost of the process is one dollar per resident of the region.

A great portion of this cost, frequently as much as 50 percent, is consumed by the collection of the necessary data and its processing. Even at that disproportionate scale, the investment has not provided more than bench-mark data that age quickly and are from a sample size inadequate for small area analyses. Further, it has not provided a consistent national urban data base that would permit comparison of cities and city types. This latter point has become increasingly important as the requirement to evaluate relative grant-in-aid requests at the national level has increased.

The interest of the U.S. Department of Transportation, then, in developing a way to assist urban areas with their data requirements stems from the desire to reduce the cost of current data collection and to free funds for expansion of the analytical and plan-development phase of the process. In addition, the census journey-to-work statistics provide more extensive data, frequently at higher quality than previously available and in a nationally consistent format.

DATA REQUIREMENTS FOR THE URBAN TRANSPORTATION PLANNING PROCESS

The kinds of data collected in urban transportation studies can be divided into 2 categories: bench-mark or base year data and continuing process data. The first category is characterized by a base year inventory process, basically cross-sectional in nature, in which major surveys are taken of static and dynamic characteristics of the study area. The latter category keys to the development of time-series data, frequently acquired from operating city agencies and other secondary sources. It focuses on system monitoring statistics.

Base year data collection includes inventories of existing transportation facilities and land usage, sample surveys conducted by field interviewers to acquire characteristics of the population, and dynamic surveys of travel patterns, trip demand, and facility usage. The major component of this process is the residential origin-destination survey. This survey is generally structured in the form of a diary of one day's travel activity by the subject household and also collects accompanying socioeconomic de-

scriptive data. As urban study groups completed the first full cycle through the urban transportation planning process, they have increasingly turned to continuing data collection techniques to develop monitoring and surveillance systems to detect change in the urban condition, specifically with regard to those variables related to transportation such as changes in population and household characteristics, shifts in employment locations, and changes in travel habits or transportation facilities. These data are developed by analysis of the information acquired from operating agencies such as automobile registrations, building permit files, and property assessor records.

THE 1970 CENSUS DATA

The census is a major source of bench-mark data. It is not necessary here to detail the breadth of demographic, economic, and housing data available. It is important to note that almost all of the variables crucial to transportation planning are obtainable in the census, including household characteristics such as family size, median income, automobile ownership, and stage in the life cycle; labor force and employment characteristics; and housing information. The journey-to-work questions that provide for travel mode use and actual work-site locations parallel origin-destination work-trip data very closely.

The advantages of these data are their extremely low cost relative to independent individual surveys in each urban area, their high quality in terms of definitional rigor and control (both in each individual city and throughout the country), and their larger sample size relative to typical urban survey procedure. The disadvantages of these data in the past, as typified by the 1960 census experience, were the fixed geographic aggregates in which the data were available and the slow and costly procedures for obtaining special tabulations for a given city.

Significant innovations in the technology of the 1970 census enhanced the desirability of the journey-to-work data as a transportation planning resource. The major innovation is the geographic coding of the residence and work addresses of respondents to the block level. This is a significant increase in analytical ability particularly in regard to work location statistics. Block level statistics will not be applied themselves, but they can serve as the basic building block in an aggregation process so that census data can be summed to any area system of interest. This is important to transportation planning because of the large amounts of data compiled by urban studies to small areas, called traffic zones. Traffic zones are defined by transportation characteristics and are usually incompatible with census tracts. They vary in size from city to city, but are typically enumeration district size. Census data aggregated to traffic zones will be a powerful new resource for the urban transportation planning process.

This new capability led us to think that a special program to develop standardized tabulations that would be suitable for analysis in each urban area might be feasible. Existing plans for reporting census data on summary tapes and published documents did not meet the specialized needs of urban transportation planning. Specifically, there was the need for additional cross-classified tables at the residence end, summaries at the work-location end, and zone-to-zone trip tables.

THE DEPARTMENT OF TRANSPORTATION STANDARD PACKAGE

The standard package will produce a special summary tape of a defined set of tabulations, generated by computer programs developed by the Bureau of the Census and funded by the Federal Highway Administration. The tabulations themselves were designed in draft form by FHWA personnel, submitted to the states, and sent from them to the urban studies for review and comment. Their comments have been received and incorporated in the final tabulation design.

The basic tabulations can be produced at the traffic-zone level for all urban areas. Those who request tabulations will pay the cost of processing only. These tabulations will provide the zonal data needed by urban studies at a reasonable cost and without the problems usually attendant on a special request. This standard package will accomplish programming time and cost savings and eliminate the delays of the past. It will also accomplish a wider dissemination and usage of this nationally consistent

bench-mark resource. It is designed as a minimum data set, almost a common denominator set, of those tabulations most frequently requested and utilized by urban areas. Those in urban areas who require additional tabulations can proceed through the usual special request process.

The delivery process on these tabulations is as follows: (a) a local agency, if it chooses to participate in the program, makes its request; (b) the request must be accompanied by a conversion file of census block numbers to traffic zones; and (c) the Bureau of the Census produces the summary tape and delivers it to the requester. This program is expected to begin in late 1971 or early 72.

The areas of summarization need not be traffic zones. The programs can develop summaries at any area level defined by block, consistent with disclosure and reliability constraints.

STANDARD PACKAGE CONTENTS

The package contains a trip table and tabulations at the zone of residence, zone of employment, and area-wide level. The trip tables give work trips from all zones to all zones. Tabulations at the zone of residence include summaries of person characteristics, head of household characteristics, household characteristics, and housing characteristics. Tabulations at the zone of employment include summaries of workers by occupation and by industry. Tabulations at the area-wide level include cross-tabulations of household characteristics, housing characteristics, and mode of transportation to work. Detailed formats of these tabulations have been circulated among the state transportation planning agencies and are available from the Federal Highway Administration (1).

PROBLEMS

A significant problem is the time delay in developing the data. 1970 data will be available in 1972. The processing delay is painful to have to accept. It points up the fact that ongoing monitoring systems with shorter time delays between observation and analysis are essential for the future.

There are problems of definition and area compatibility that must be resolved. These include differences at the edges of urban regions as to boundary. For instance, blocks may not extend out as far as the zone system does in some urban areas. Persons outside the SMSA boundary employed inside may not be counted. Further, the typical transportation study definition of a work trip differs from the census definition. In addition, we are dealing only with work trips; trips for other purposes have not been recorded. Because this is a growing segment of total travel, great care will have to be taken in drawing conclusions from the files.

Another set of problems are related to the processing and administration of the data. The geographic coding process has been expensive and difficult. Not all addresses received have been codable because of poorly reported information or inadequate source materials for coding. The pretest experience in Madison, Wisconsin, indicated that 80 to 90 percent of the addresses will be codable. Even with adequately coded addresses, the files are still based on the 15 percent and 20 percent subsamples from the enumeration. These sample sizes are larger than those typically used in transportation surveys, but reliability and disclosure rules will still require suppression of certain data cells.

SPECTRUM OF USES

The potential uses for these data are extensive. The most significant applications will be in their use to supplement or completely replace residential origin-destination surveys. This could be applied against some of the new and broader concerns of the planning process, i.e., environmental aspects, neighborhood impact, and land development.

To effectively replace the origin-destination approach will require that analysis and modeling of urban travel demand be developed by using census data. We know

that work trips generally account for 80 percent of peak-hour travel. Peak-hour travel models utilizing census work trips, therefore, seem entirely feasible. Another range of models relating work trips to total travel are also needed. The relationships here are more tenuous. In general, work trips have been a declining component of total urban travel over time.

Another valuable use of these data will be in their application as a check source and updating resource for existing urban transportation planning data bases. Many urban surveys were conducted in the early sixties. Even with problems of compatibility of definition and coverage, the standard tabulations will be valuable in updating work trip rates per household, work trip lengths, and the like. Some surveys used 1970 as a forecast year. The standard tabulations will provide a means for testing the accuracy of these forecasts and for recalibrating the forecasting models.

Finally, the standard tabulations, if generated for most or all urban areas, will provide the first uniform comprehensive set of urban transportation descriptors. This will be of major value in statewide planning programs, which are growing in use, and in national programs, particularly in evaluation of urban transportation needs on a city-by-city basis.

REFERENCE

1. Urban Transportation Package. Office of Highway Planning, Federal Highway Administration, FHWA Notice HP-22, Feb. 23, 1971.

PLANNING SPECIAL TRANSPORTATION SERVICES

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Within the past 20 years we have created for ourselves a type of dilemma in planning transportation services. On the one hand, we have increased our knowledge about travel through the use of computers, advanced statistical techniques, and increasing budgets. We know with great accuracy trips per capita, automobiles per household, riders per automobile, employment statistics, and hundreds of other numbers that should aid us in defining clearly what individual transportation needs are.

On the other hand, we also find that a large number of urban residents, especially those who are poor and do not have automobiles, are shortchanged in their trip-making ability. Although the Watts riots in Los Angeles were a highly visible example of dis- satisfaction with present systems, experiences in many cities with varied population characteristics, including Baltimore, Nashville, Buffalo, and New York City, have shown that merely the ability to collect or use all of the data has not been enough. In fact, the reasons that so many people in cities have been handicapped in their ability to travel might be found by asking several questions: Are the data for planning satis- factory? Have we been unable to plan correctly? Do we lack the commitment within urban areas to plan and implement the plans correctly?

This paper is especially concerned with answers to the first 2 questions. Special services as used here will apply to transportation requirements that evolve from microstudies in large urban areas. The emphasis will be on deriving planning needs and not on specifying the resulting hardware recommendations.

IDENTIFYING AND DEFINING SPECIAL NEEDS

The term special services might be a misnomer, for what is really meant are trans- portation services tailored to specific needs of a group within a large area. The spe- cific needs in this paper are those of the predominantly black lower and lower-middle classes who live in a geographically identifiable section of a major urban area. (The study analyzed here is based for the most part on data collected for the Buffalo area. The fact that conditions in Buffalo are not unique is amplified by data and analysis pre- sented for Nashville in another report (8) from which additional data for this paper are taken.)

The primary step in a working plan is to identify real goals or needs on a personal basis so that the resident of the area in study can be made to feel that he is a part of that total plan. The next series of steps, of course, is to see if the goals as defined are attainable based on existing or forthcoming resources. It should be pointed out that all goals that are not obtainable cannot also be categorized as unrealistic. For example, a goal of the black ghetto dweller might be to have access to the same num- ber of jobs in 20 minutes of travel time as his white suburban counterpart. This is a real, but presently unattainable, goal in many urban areas; it is not, as would often be categorized, unrealistic.

The Buffalo metropolitan area has many characteristics shared by industrial cities of similar size (population of more than 1 million) in the United States. Although the population of the city itself has stabilized, or actually declined slightly in the past 30

years, the suburban growth has been rapid. This suburban growth is not restricted to housing alone, but also includes industry. This has resulted in a large increase in the job market outside the city limits. The percentage of workers from the Buffalo inner city area working in suburban locations has increased from 18 to 27 percent in the period 1960 to 1968. However, it cannot be stated simply that people are moving where the jobs are. Simultaneously the percentage of the city population that is black has increased steadily, and in the last special census (1966) blacks represented 17.4 percent of the Buffalo city population, an increase of 4 percent above the 1960 census. During that period, total population of the city of Buffalo declined 10 percent. A further brief introduction to the black ghetto area of Buffalo can be made by noting that the median family income is 75 percent of the median city income, and that automobile ownership is half that of the city average. In similar figures for the Nashville model cities area, median income was 57 percent of that for metropolitan Nashville and automobile ownership was 62 percent. The Nashville figures are incorporated here because special services have already been recommended for that city, which is so similar in quantitative analyses to Buffalo.

Further data that will be studied in more detail in a later section indicate that in the black population a significantly fewer number of people hold occupations that can be classified as professional or managerial and that the houses they live in have either lower rental value or lower ownership value. It is the quantification of these general facts that are so well known to us that makes possible real analyses on a microlevel.

If the general goal of the urban black is to better his quality of life (without perhaps a corresponding change in the style of his life), specific goals and their immediate transportation requirements can also be identified. Some of these are given in Table 1.

What is evident from the list given in Table 1 is that generally there is no one form of transportation (other than the automobile) that is ideally suited to all trip needs. Current lack of adequate transportation is one factor in the total ghetto syndrome characterized by high unemployment, lack of adequate competitive markets, poor health care, and to a very large degree lack of cultural and social interchange. However, there is no implication that attainment of an automobile or provision of special services will in themselves raise income, increase culture, provide for better education, or hasten integration. These are social goals, and adequate transportation is only one piece of hardware through which these goals can be realized.

At the most minimal level, the special needs of blacks are those that will raise their standard of living as reflected in statistical values to that of the urban area as a whole.

PLANNING SERVICES BY USING AVAILABLE DATA

Readily available data, such as regular census data regarding income and occupational status or special census data regarding travel characteristics and automobile ownership, can be used in 2 major ways. The first is to identify a region of homogeneity, or similar characteristics, in which patterns of total travel behavior are somewhat predictable. The second is to use the data to develop causative relationships between population characteristics and travel. In a later section a combination of these uses is shown to provide a still more powerful method for isolating areas of special need.

An example of the first use is given in a close look at a one-square mile zone of Buffalo made up of portions of 5 census tracts. This zone, originally defined for use in a previous transportation study, is bisected by a major artery acting on a slight diagonal and is divided into a west portion, W, of predominantly white popu-

TABLE 1

GOAL DELINEATION

General Goal	Transportation Requirement
Better job market	Bus service or special service to dispersed market from ghetto origin
Better health service	Rapid access to hospitals or clinics or mobile clinics
Wider market for necessary or luxury goods	Market type of vehicle service to dispersed shopping areas
Personal business improvement	Small vehicles on a call basis
Social-cultural improvement	Small vehicles on a call basis

TABLE 2

POPULATION CHARACTERISTICS OF A SELECTED STUDY ZONE

Tract	Percent Nonwhite Population	Median Income ($)	Number of Households	Number of Households With No Automobile	Percent Professional-Managerial Workers
W1	0.2	8,000	1,053	318	45.0
W2	0.32	6,821	4,274	1,799	34.6
E1	34.5	4,706	4,169	1,983	13.5
E2	81.0	4,523	5,416	2,569	6.3
E3	1.0	4,591	4,035	1,616	17.1

Note: Population densities (adjusted to areas within zone) are for W, 11,000 persons/sq mi, and for E, 22,000 persons/sq mi.

lation and an east portion, E, of predominantly black population. The census tracts constituting this zone are designated W1, W2, E1, E2, and E3. (The notation is for simplification of use in this paper. The tracts are U.S. Bureau of Census tracts 31, 32, 66b, 67, and 68 for the Buffalo SMSA.) Table 2 gives pertinent tract characteristics to show the ability to develop homogeneous characteristics.

The second use is shown in Figure 1 in which the influence of median income on both total trips and trips by mode is shown for the city of Buffalo as divided into 5 homogeneous areas (1). Clearly, total trips and trips by mode are functions of median income. This in itself is well known and documented (2). What is to be emphasized here is that income data are relatively accessible and somewhat predictable on the basis of census trends, whereas trip-making statistics are generally available only through special studies.

Figure 1 also shows the problem of data aggregation. The filled-in points represent the city as a unit. Each of the other points represents a somewhat homogeneous subzone of the city. Work by Kouyoumdjian (1, 3) indicated that the choice of geographic divisions within the city for use in predicting causal parameters influencing trip-making could have significant effects. He compared trip data by mode from 3 rings originating from the CBD and made up of census tracts with the 5 zones mentioned earlier and with square-mile zones established by the Niagara Frontier Transportation Study. Although the best results in terms of predicting trips by mode as a function of population characteristics occurred uniformly in the 5 zones, selected because of homogeneous characteristics, a high degree of confidence can also be placed in the ring analysis for the innermost zone. When trips were broken into modes, i.e., automobile and bus, it was found that the indicators of automobile trip generation (income, population per zone, automobiles per household, and persons per household) did not yield the same confidence in bus trip generation. However, the best confidence was found in zones of highest population density, which corresponded to the zone of greatest use.

Further study has indicated (4, 5) that in Buffalo a significant number of blacks use, what can be characterized as an important additional mode, the ride. This factor in itself is important in work trips made by blacks, so that any consideration of special services to an area designated as transportation deficient must include methods for measuring trips as automobile rides. For example, of total work trips originating from a zone of predominantly black population ending in both that and adjacent zones, 48 percent were as automobile passenger; whereas of total trips originating from a predominantly white zone one mile from the first mentioned zone, only 17.6 percent were as automobile rider. It is significant to note also that both of these zones are radially within 1.5 miles from the CBD, and both have appreciably the same number of bus route-miles per square mile of area. What the data do not point out are the additional facts that the bus routes are predominantly CBD-oriented while the black blue-collar job market is not and that bus schedules do not adequately cover shift work.

Available data will provide to the planner information on job category on as accurate a basis as desired (census) and industry category and size (census, Polk, or similar survey) from which potential job routes can be established.
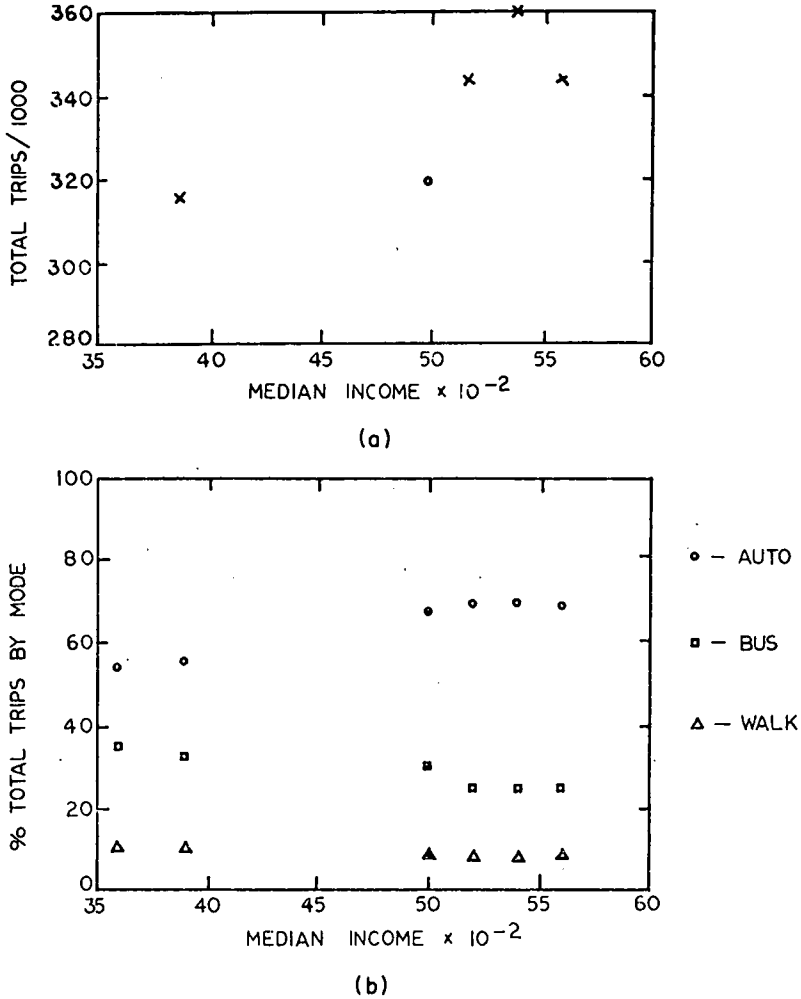
Figure 1. Trip distribution as a function of income for areas of Buffalo.

Because personal characteristics are becoming so important in quantifying need for special services, it becomes necessary to replot the available data in another form, that of continuous or contour maps. Figures 2 through 7 show contours of median income, percentage of households with no automobiles, percentage in area who have to work, percentage of males in professional or managerial positions, rent values, and home ownership values for the city of Buffalo. Isolating areas of low income, low automobile ownership, and low percentage of professional workers would give the planner a strong potential for establishing work-trip patterns. Although not done here, a study of contour development as a function of time would aid in establishing trends in future work-trip patterns, a great assistance in planning both major area and special services. For example, a growing pool of blue-collar workers living in the CBD coupled with a dispersion of blue-collar jobs in suburban areas as quantified in a previous section might be indicative of a large number of potential riders who would not take a CBD-oriented, highly centralized rapid transit system.
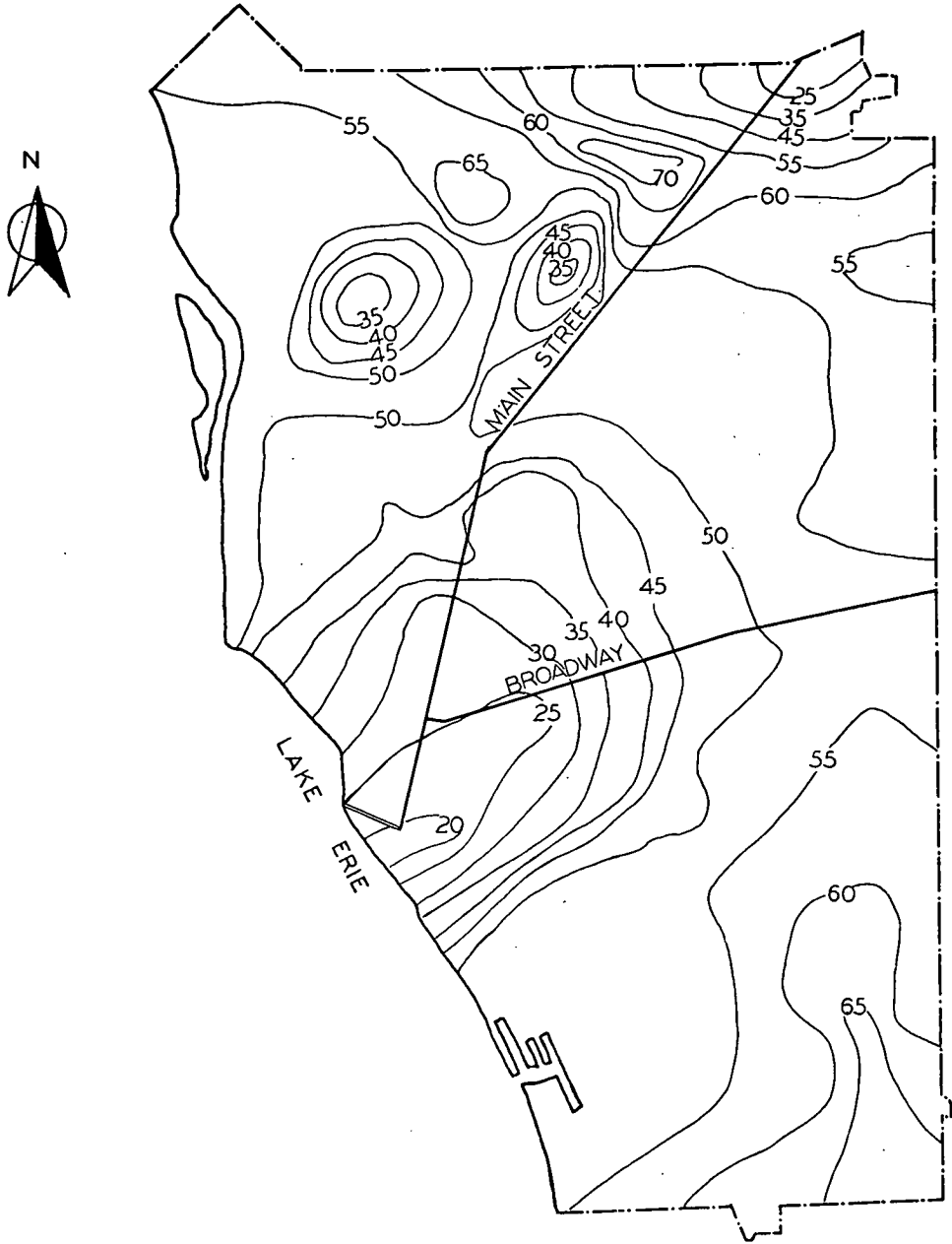
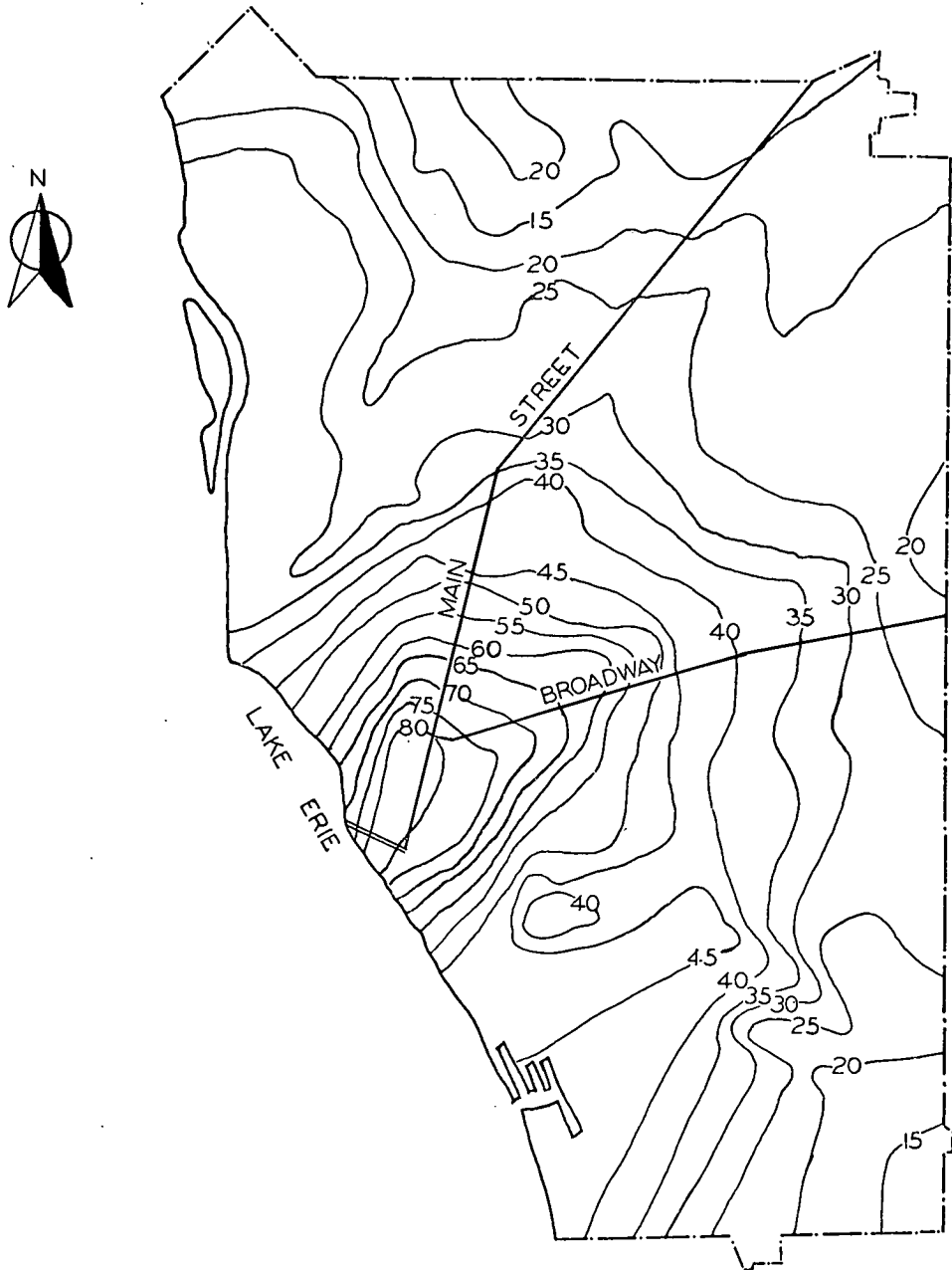Figure 2. Median income in hundreds of dollars.

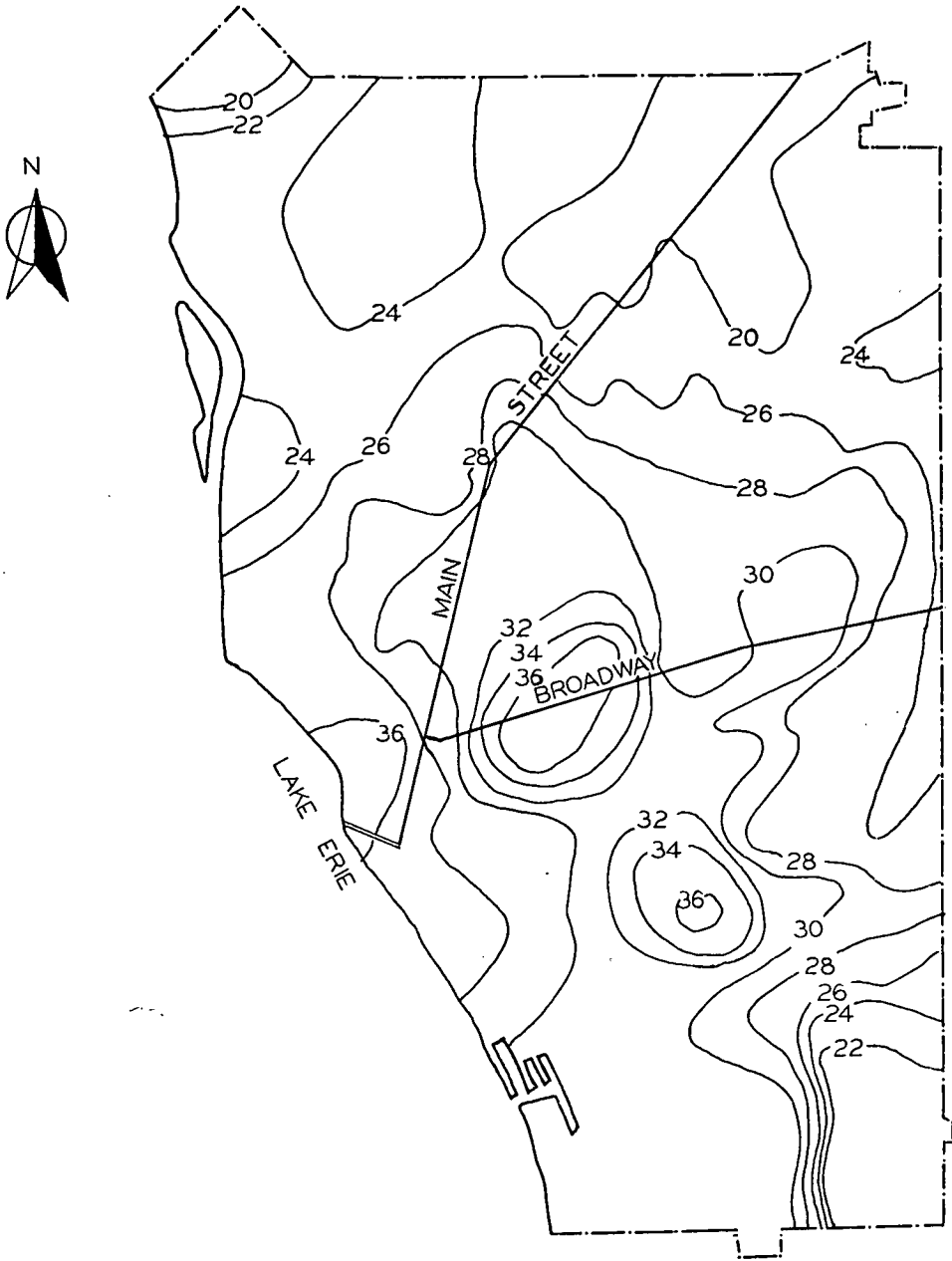Figure 3. Percentage of households with no automobile.
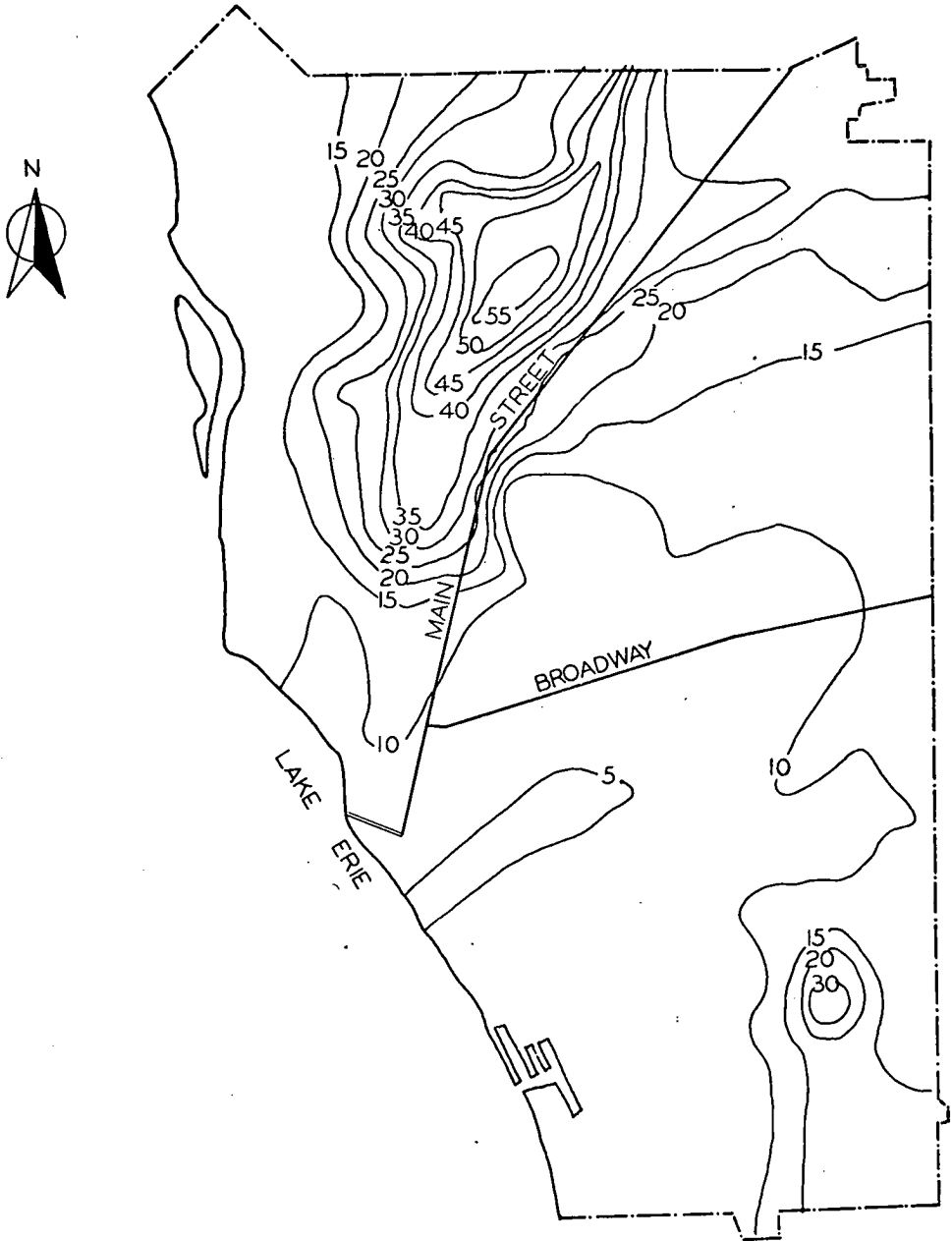
Figure 4. Percentage of work trips by bus.

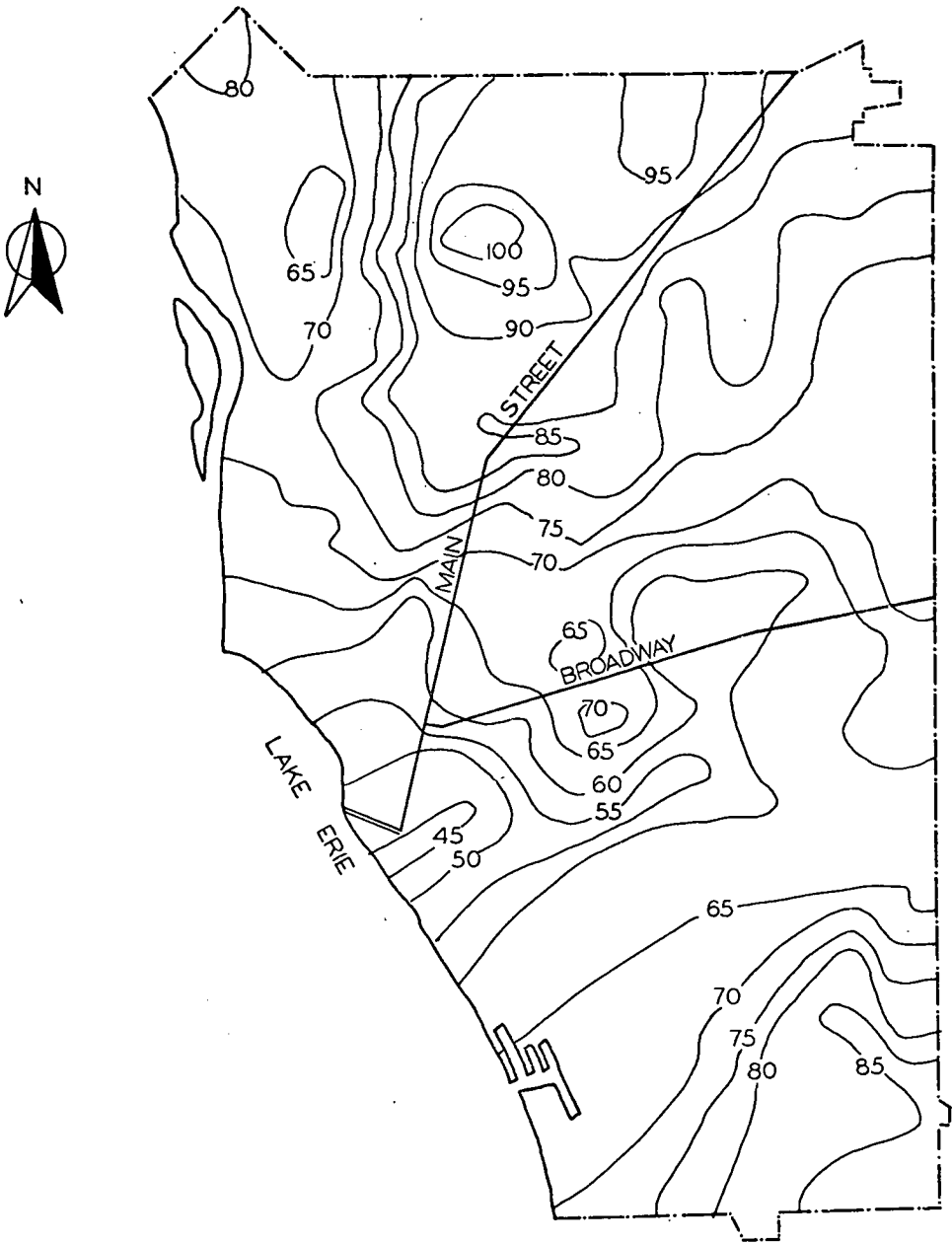Figure 5. Percentage of male workers in the professional and managerial category.
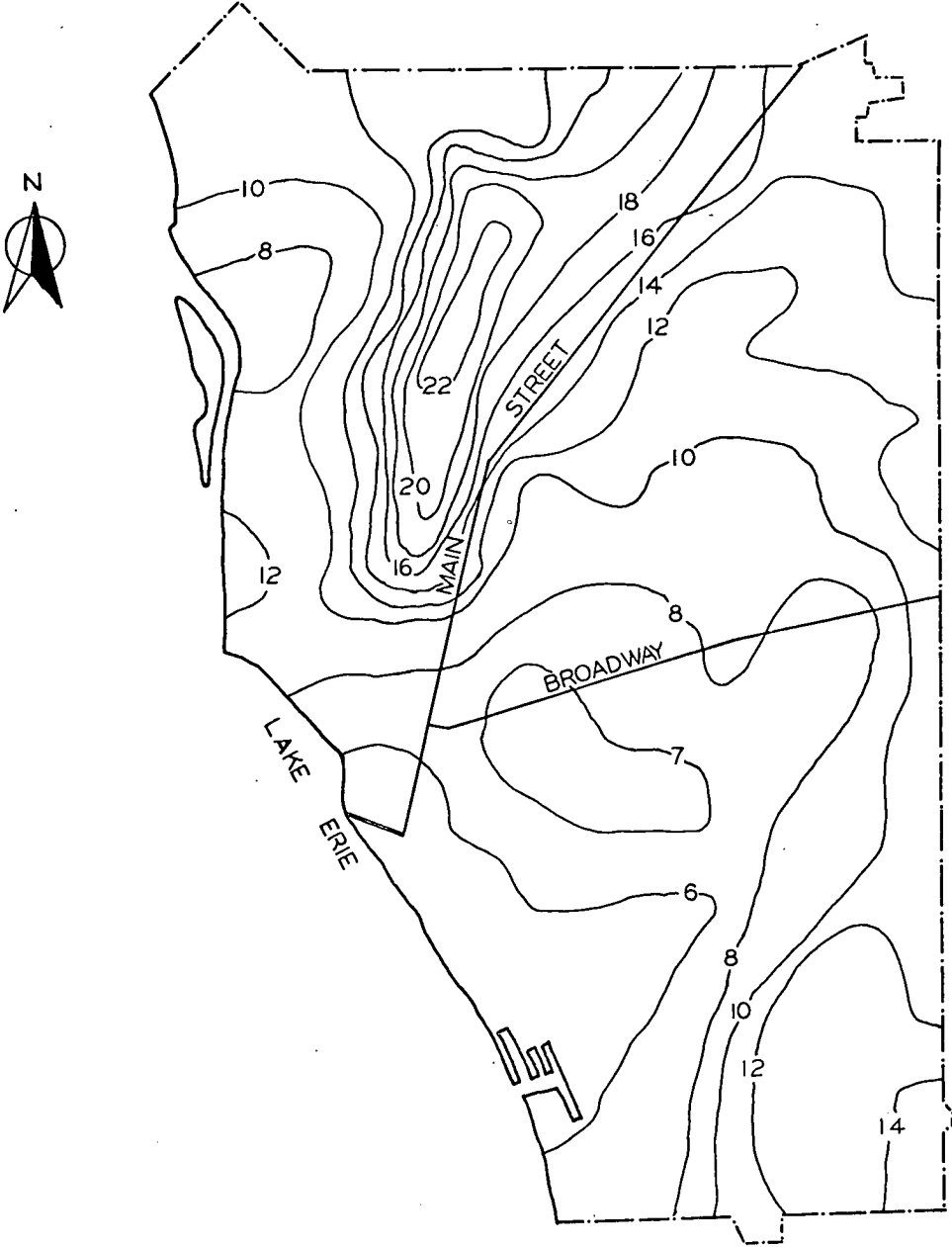
Figure 6. Rent value in dollars.

Figure 7. House value in thousands of dollars.

Development of contours of trip time by mode would indicate either the necessity or the willingness to travel a certain time by mode for a specified trip purpose. In Buffalo the average work trip is 18 minutes by automobile and 30 minutes by bus. More than 2 times as many jobs are accessible in 18 minutes of automobile travel(using the ghetto area as origin) than in the 30 minutes of bus travel. Although more jobs can be made available by longer bus trips, trips longer than 30 minutes are considered unfavorable, especially in an adverse climate. Corresponding figures of travel time by mode for Nashville indicate that 50 percent of the automobile trips reach work in less than 10 minutes and 80 percent in less than 20 minutes. By transit, only 7.6 percent of the total jobs are reached in less than 20 minutes, 58 percent in 40 minutes, and less than 80 percent after 60 minutes. There is no question that a greater balance between transit and automobile trips in terms of travel time must be reached to satisfy one of the major goals of improved employment stated earlier in the paper.

DATA COMBINATION FOR IMPROVED PLANNING

A recurring theme, thus far, has been that a close scrutiny and analysis of available data, combined with supplementary surveys where necessary, can indicate areas of concern for planning special services. At this point a further analysis technique is presented to illustrate how these techniques can be refined to define zones of first analysis for close scrutiny.

Figure 8 shows automobile ownership versus median income for the inner city tracts of Buffalo. (Recall that Figure 1 showed a dependence of both trip volume and trip mode on income.) Further, as the total number of trips per person decreases, the percentage
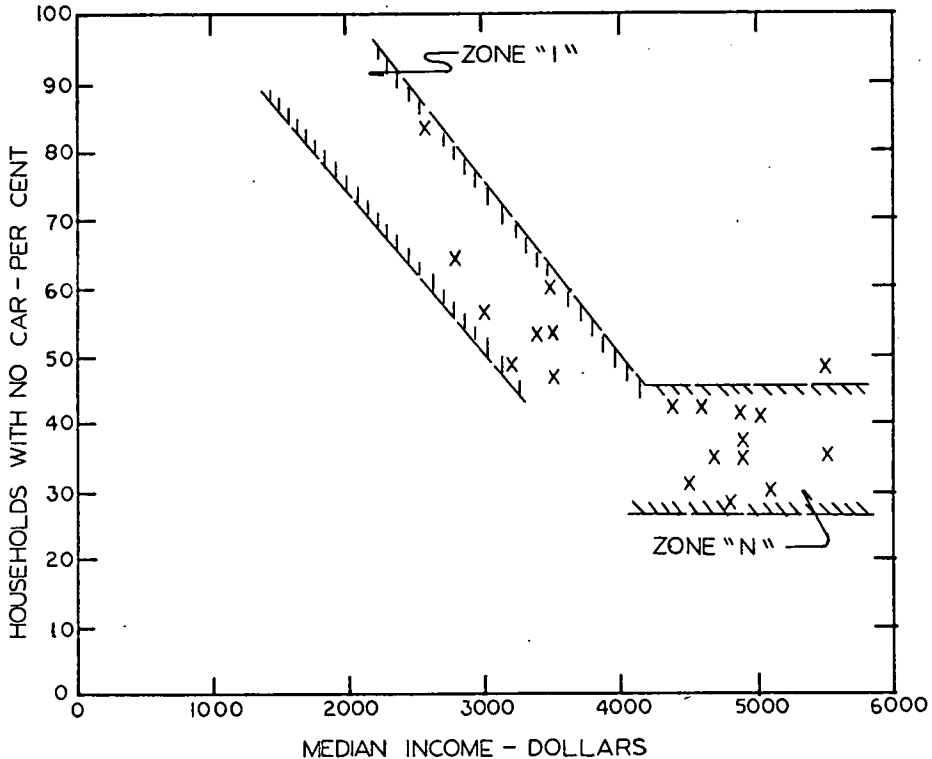

Figure 8. Percentage of households without automobiles versus median income in 1960 census-selected tracts in Buffalo.

of trips per person that are work trips increases. In the study of work trips, contours shown in Figures 2 through 7 and analyzed by the author (5) indicate that in zones of higher income a higher percentage of workers are professional or managerial and that the percentage of professional workers can also be linked to home ownership values. Thus, compilation of population characteristic data serves as a guide not only to the ability to predict mode of work trip but also to the probability of predicting class of work for workers originating from a given area.

A study of data shown in Figure 8 indicates that the data can be divided into 2 zones, I and N. (These indexes indicate the areas where the variable income has an influence on ownership, I, and where it appears independent of ownership, N.) As median income decreases from $4,000 to $2,000, the percentage of households with no automobile shows a significant increase from 40 to 80 percent. At a median income of more than $4,000, there is a greater stabilization of households with no automobile at 35 to 40 percent. This latter figure is somewhat above the national figure of 14 percent for incomes in that range, but in the tracts chosen a larger percentage of the population is elderly and retired and there is a large percentage of people who live within walking distance of work.

Kouyoumdjian (1) has shown that automobile ownership is the most important single variable in determining choice of mode for work trips in the Buffalo area. As the percentage of automobile ownership decreases within a given zone, the likelihood of a search for another mode for the work trip increases. It has also been shown that above a specific income ($4,000) there is little variance in automobile ownership with income.

Another study of trip-making (Fig. 1) has been replotted in schematic form (Fig. 9) to show zones similar to those shown in Figure 8. Here trips per person is seen dependent on income; above an ascertainable income, the number of trips made does not increase appreciably. The use of Figures 8 and 9 together indicate the importance of presenting an accurate description of income data for a large area. These income data can be plotted in contour as is shown in Figure 10, which is a more schematic representation of actual data shown in Figure 2. As these contours represent rather homogeneous areas of income (in this case derived from census tract data), it is possible to locate specific areas in the city within which the incomes are above or below the level

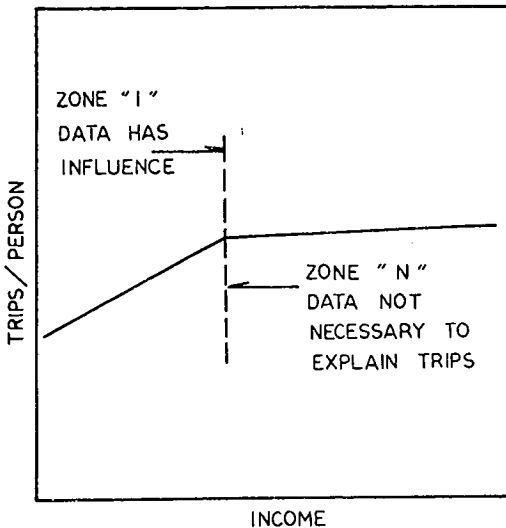Figure 9. Schematic representation of data breakdown for use in planning.

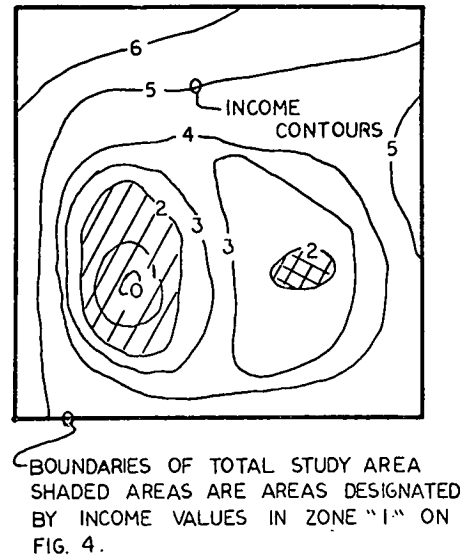BOUNDARIES OF TOTAL STUDY AREA SHADED AREAS ARE AREAS DESIGNATED BY INCOME VALUES IN ZONE "I" ON FIG. 4.

Figure 10. Contour curves used for designating regions of special study.

shown in Figures 9 and 10. It is possible to locate, through income data, areas of probable low automobile ownership or low trip-making. These areas are shown as shaded in Figure 10.

The use of delineating contour areas in planning is given in the following example. An often-used technique of deriving data for origin-destination studies in major area plans is to blanket the given area with a household survey usually ranging from 5 to 15 percent of the households in a random selection, uniformly applied method. Use of trip-generating parameters and income contours would indicate, prior to the survey, areas of special concern as noted earlier. As trips per person do not vary appreciably above a certain income, and as mode of travel is most likely to be by automobile above a certain median income, the actual sample size in areas designated on the contour map as corresponding to N can be decreased without a significant increase in reliability of results.

On the other hand, in areas of low income, low trip-making, and low automobile ownership, the survey numbers might be increased to establish a better reliability in both trip patterns and possible trip desires (latent demand). A 10 percent sample of population might be actually carried out as a 5 to 8 percent sample in high-income areas and as a 15 to 20 percent sample or a higher one in low-income areas, with survey questions appropriate to each of the areas of concern.

One large problem in past studies has been aggregation bias. Large desire lines shown through an area can mask out a more shotgun pattern of trips from that area to other zones. This is especially true in urban areas in which major expressways cut through ghetto areas. The aggregation of desire lines into the familiar pattern of the suburban lines becoming thicker until they block out the CBD and make it almost impossible to notice the desire for CBD-outward movement patterns at inward rush hours. Although the increased use of special surveys in designated areas would not change the desire line pattern, it would give greater and more reliable emphasis to the demand for other than CBD-directed transit. It has already been illustrated that, on a large scale, use of contour maps would help delineate homogeneous areas. The attempt to define homogeneous areas can be refined further in a block-by-block analysis using pertinent census data. Equations for determining homogeneity have been developed previously (5, 6) and are used to determine areas of like housing value or median income and to relate these to job type. In addition, the reliability of trip-generation data comparing large zones with small zones has been tested for 3 continuous square-mile zones in the inner city of Buffalo. By use of analysis of variance techniques, it was demonstrated at the $\alpha = 0.05$ level of acceptance that there is a significant difference in predictions of trips between zones when zones are considered as square-mile uniform areas or as subdivided into 5 or 6 subareas. This, of course, reconfirms previous findings on aggregation but also underlines the fact that aggregation bias can occur in either causative trip-generation models or through smear in gravity models. The aggregation of high automobile ownership with low automobile ownership or high income with low income yields gross averages that are usually detrimental to the low-income class. This averaging could give points on the N zone of the causative curves. The resultant analysis might easily mask the lack of ability of the low-income group to make trips.

DETERMINING SPECIAL SERVICE NEEDS

At this point we have seen that it is possible through a variety of techniques to isolate areas of special concern. It now becomes incumbent on the planner to establish what changes in or to the transportation system are necessary to help improve the quality of life of the ghetto resident.

One example of an existing modal split is given in Table 3, which compares mode of shopping trips for households owning and not owning automobiles. For food shopping, it is much more convenient or inexpensive in terms of bus fare (not food prices) for the households not owning automobiles to walk to shop within the neighborhood rather than to go by bus to a supermarket. On the other hand, of those that own automobiles, a third still choose to walk to shop. This may be a trip by necessity because the worker

TABLE 3

MODE OF FOOD SHOPPING TRIP

Automobile Owned	Trip End	Drive	Ride	Bus	Walk
Yes	In neighborhood	30	1	2	15
	Outside neighborhood	26	2	2	0
No	In neighborhood	2	1	3	33
	Outside neighborhood	2	4	2	2

Note: Data are from a 1968 summer survey by the Department of Civil Engineering, State University of New York at Buffalo and were assessed from a total sample of 32 households in U.S. census tracts 31, 32, and 33 in Buffalo (4).

in a one-automobile family may have the car at the time the trip is made. The inconvenience of using public transit for food shopping was pointed out in personal interviews. Although not adverse to the use of public transit, the shopper would prefer a vehicle that would be easier to enter and store packages in rather than a large bus.

In addition to shopping trips, trips of great importance or those frequently made include trips to church for both social and religious purposes, trips to the hospital, and trips to banks by the elderly on social security day. The latter trips were held extremely important by residents of the Buffalo model cities area. These trips, which are made to a diverse list of destinations, are made with greater difficulty, if at all, by households without automobiles than by those with automobiles. For example, a necessary trip by a mother to take her child to the clinic may never be made because of a variety of hindrances, including inclement weather and lack of cash for fare. Trips considered luxurious, such as trips to parks or theaters outside the rider's neighborhood, may also never be made because of the lack of an automobile. This latent demand is summarized extensively by Hoel et al. (7).

It is possible, through personal survey, to quantify trip modes by frequency, pure time, and trip purpose. This would then permit real hardware alternatives to be established and studied.

The study of the Nashville model cities area (8) pointed out that short-range goals included provision of public transportation service to the model cities residents that would allow them to reach cultural and recreational areas throughout the entire metropolitan area and that the service should be provided "at such reasonable speeds and costs that these factors will not become an impediment or detriment to their use."

An immediate suggestion resulting from studying special needs is to make existing public transit more responsive to intensified small area local needs. (An example of immediate response is the refusal of the Public Service Commission of New York to permit an additional 5-cent increase on the Buffalo public transit system without extensive hearings. All too often these increases have been routine.) This can be done readily through route additions or changes, service home changes, and increased and properly designed information services. Further hardware suggestions such as jitneys or dial-a-bus would evolve through the more exhaustive planning techniques applied to a small area.

CONCLUSIONS

In a time when we are planning for groups that are becoming increasingly articulate in defining their goals, we can no longer be seduced into thinking that data alone will solve all planning problems. It is possible through proper studies of trip-determining parameters to isolate areas of particular interest for special (micro) study. Contour maps combined with trip-making curves can show areas of potential neglect in large-scale planning. Isolation of these areas for intense study, coupled with gathering of trip-making data peculiar to the specific area, are then preliminary steps to be taken in a more traditional transportation analysis. A beneficial concept inherent in micro-area analysis is that it does not have to be limited to poor areas, areas defined as having the greatest transportation neglect. An area with a high concentration of upper income but generally elderly population would be another example of a microarea that

may need special-service planning. Again, the use of contour maps, together with trip purpose and current mode choice, would be useful for such an analysis. The final product is a higher level of true transportation service to all the residents of the metropolitan area.

ACKNOWLEDGMENT

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FORECASTING POPULATION AND EMPLOYMENT

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The focus of this paper is on ways in which the Bureau of the Census data, programs, and related activities can be useful in small-area population and employment projections. It also notes the research under way that is designed to bridge the gap between economic and demographic approaches to projections. These comments are limited to the relatively large geographic areas such as states and standard metropolitan statistical areas (SMSA's). Projections for traffic zones, census tracts, and the like have a literature and methodology of their own and do not fit within the general scope of data and techniques for metropolitan areas. Yet one would not attempt projections with such very fine detail without some SMSA projection to provide the framework and overall control.

SCOPE OF CENSUS PROGRAM

Population Projections

The program of the Bureau of the Census in projecting geographic area population is fairly modest. At the state level, the bureau has published, at irregular intervals, projections of total population by age groups for target dates 15 to 25 years ahead. These projections have been demographic in nature, with separate projections made of each of the components of population change, such as births, deaths, and net migration. Projections for metropolitan areas have not been part of the regular program, although such projections were prepared and published several years ago as part of a special project. These extended only 10 to 15 years into the future. These, too, were demographic projections and were designed to be consistent with previously prepared state projections.

These demographic population projections depend very heavily on census data. Age, sex, and race composition of the population of areas are basic to such projections, and the census provides the initial bench mark. There is also a great need for some basis for projecting net migration, which is the most important component in small-area projections and the one with the largest degree of uncertainty. Census data, directly or indirectly, are the primary inputs. Census-derived net migration rates by age, sex, and race for areas as small as counties are available for the 1950 to 1960 period and are also planned for the 1960 to 1970 period (1).

Although in most projection reports the emphasis is on net migration, computer technology now permits more sophisticated methodology using gross migration data collected in the past few censuses. Particularly useful in this connection are the data covering the 1955 to 1960 period from the 1960 census and the 1965 to 1970 period forthcoming from the 1970 census. The latter will be especially interesting because for the first time plans are being made to provide significant detail on the characteristics of migrants at the county level, both by county of origin and by county of destination (but not county migration streams).

Much gross migration data will be available in the regular census volumes for states and SMSA's (or state economic areas, as in 1960) but the corresponding county detail

will undoubtedly be tabulated only if sufficient resources become available from interested agencies outside of the Bureau of the Census. Our planning at this point is merely to permit us to generate the information at a reasonable cost at a later date. It is too costly to attempt to reconstruct the detailed gross migration data at the county level for the 1955 to 1960 period because no such arrangements were made at the time of the 1960 census processing.

The strong preference and endorsement in favor of gross migration over net migration data for geographic area projection purposes suggested here are not mere whims to introduce complexity for complexity's sake. Past experience in developing demographic projections involving the use of net migration has revealed some illogic in the underlying assumptions. For example, if one assumes that past trends in the migration rate will continue, as is most frequently the case in existing projection methodology, in-migration areas automatically receive more and more net in-migrants, while out-migration areas contribute fewer and fewer out-migrants as the base population in the latter areas becomes smaller as the result of net out-migration. The inconsistency of the situation is quite obvious because, under the circumstances, the net in-migrants and the net out-migrants for the country become heavily unbalanced. The effect of this inconsistency can be quite striking even in the short run when large differentials exist in rates of population growth for areas (2). The problem may not be so readily apparent when a single area is dealt with because the individual planner may not look much beyond his immediate area of concern; but "collective" consideration would reveal problems of a similar nature.

One way to overcome these problems of net migration rates in projections is to use gross migration statistics, that is, to treat in- and out-migration separately. In this procedure, the probability of out-migration is related primarily to the size of the population exposed to risk (by age, sex, and race), whereas in-migration to an area is based on a percentage of the "migration pool," that is, the projected number of out-migrants from all areas of the country who are to be distributed as in-migrants to all areas in the country. Both the 1960 and 1970 gross migration data can be so manipulated.

Population Estimates

Another component of the census program important for developing population projections is our work on population estimation. This program is designed to provide post-censual population estimates, that is, to measure population changes that have taken place since the last census on an area basis. Such estimates, of course, provide updated bench marks for projection purposes. Yet, most projection reports prepared in the past several years that I have seen fail in this respect. Projections undertaken during the next several years may be able to rely solely on the 1970 census as a source. Beyond that, some updating will be necessary to provide realistic bench marks. The program of the Bureau of the Census provides estimates of state and local population for the largest SMSA's on a regular, annual basis. The bureau has developed an extensive methodology for deriving population estimates for geographic areas and conducts continuous research for methods improvement. Yet, except for a one-time special project in the mid-1960's, its program does not provide the extensive estimates needed for small-area projections.

In recognition of the need for a set of estimates that cover all counties and SMSA's in the country and that are comprehensive, consistent, comparable, and of relatively high quality, the bureau has undertaken a new program in cooperation with the states to generate just such estimates. Under this program, generally referred to as the Federal-State Cooperative Program for Local Population Estimates, the states will prepare estimates of population (of counties initially) by a set of recommended and preferred procedures that are standardized largely for data input and application and are mutually agreed to by the states and the bureau. The estimates will be accepted and published by the bureau and be recommended for use for federal programs requiring such estimates. No competing or conflicting estimates will be issued by the bureau.

The best methods to use for such estimates are being determined by tests and evaluation of estimates prepared by alternative methods (and data). Analysis of these

comparative estimates against the 1970 census results will provide the basis for selection of methods to be used by the states in the 1970's. As of mid-1970, the governors of 46 states have agreed to participate officially in the program and have designated an official state agency to work with the bureau in carrying out the technical aspects of the program. This program will provide population estimates on a regular, continuing basis for all (or most) counties in the country in the 1970's. (Estimates for 1968 and 1969 prepared as part of this program have already been published for several states.) A list of the states and their agencies participating in the program is given in Table 1; these agencies will be important sources of updated population estimates. I cannot stress too strongly the potential usefulness of this program for small-area population projections (3, 4).

The need to disseminate information about the availability of estimates through this program was clearly demonstrated to the writer in a recent project involving a review of some 250 published reports from state and local agencies presenting population projections for their areas. The bulk of these reports used the 1960 census as the population bench mark even though the majority of them were prepared in the middle or late 1960's. Significant changes in population and migration patterns have taken place between 1960 and the date of preparation of the projections; yet no attempt was made to incorporate the pattern into the report. Many of the projected population figures were significantly different from the latest current estimates available. It is hoped that in the future technicians will consider it prudent to review their needs for population estimates (and projections) for specific areas with those state agencies associated with us in the cooperative program and officially charged with preparing current estimates.

EMPLOYMENT PROJECTIONS

Although the organizers of this conference saw fit to include employment and population projections as a single, integrated entry, unfortunately this has not been the situation in the real world. Employment projection has not been within the scope of programs of the Bureau of the Census. Rather, the Regional Economics Division of the Office of Business Economics in the U.S. Department of Commerce is engaged in such work. Briefly, this division focuses on projections of income and employment for 165 economic areas—areas that are combinations of complete counties grouped around important cities without regard for state boundaries. The division's model for projecting employment distinguishes between "basic" employment, which is projected by a shift-share technique, and "residentiary" employment, which is developed as a function of total employment in the area. Population is obtained as a derivative of the income and employment projection by a simplistic ratio technique (5, 6, 7).

Employment projections for metropolitan areas are also prepared by the National Planning Association (NPA), a nonprofit private research organization located in Washington, D.C. (8, 9). The SMSA employment projections are developed within a regional and national economic framework. They have some of the same underlying logic as the projections of the Office of Business Economics (OBE) in that they identify and work with several elements of employment—basic industry employment, export component, and residentiary employment—but they are significantly different in the methodological detail and application. Nonetheless, here too population is a derivative of the employment projections but derived by a simple overall employment-population ratio.

Yet this wealth of metropolitan-area projection data on population and employment turns out to be more apparent than real as the consumer struggles with problems of comparability and consistency among the various sets. There are 2 main issues confronting the consumer or analyst when he tries to interpret and integrate these various sets of projections.

1. Lack of common geography. The OBE's economic areas bear no correspondence to states or to SMSA's, the conventional units understood and used by most planners; NPA's SMSA's introduce a flexible definition of metropolitan area boundaries, implicitly assuming that the geographic boundaries of SMSA's will expand with expanding population, but the new boundaries are not defined. The work of the Bureau of the Census relates to SMSA's as defined by the most recent criteria of the Bureau of the Budget.

TABLE 1

FOR STATE-DESIGNATED AGENCIES AGREEING TO WORK TOWARD A FEDERAL-STATE COOPERATIVE PROGRAM
FOR LOCAL POPULATION ESTIMATES

State and Official Agency	State and Official Agency	State and Official Agency
Alabama: Alabama Program Development Office*, 304 Dexter Avenue, Montgomery. 36104; Center for Business and Economic Research, Graduate School of Business, University of Alabama, University 35468	Maryland: Division of Biostatistics, State Department of Health and Mental Hygiene, 301 West Preston Street, Baltimore 21201	Oklahoma: Research and Planning Division, Oklahoma Employment Security Commission, Will Rogers Memorial Office Building, Oklahoma City 73105
Arizona: Unemployment Compensation Division, Employment Security Commission, P. O. Box 6123, Phoenix 85005	Massachusetts: Bureau of Research and Statistics, Department of Commerce and Development, State Office Building, 100 Cambridge Street. Boston 02202	Oregon: Center for Population Research and Census, Portland State College, 614 Montgomery Street, P. O. Box 751, Portland 97207
Arkansas: Industrial Research and Extension Center, University of Arkansas, Little Rock 72203	Michigan: State Bureau of the Budget, Budget Division, Lewis Cass Building, Lansing 48913; Center for Health Statistics. Michigan Department of Public Health, 3500 North Logan Street, Lansing 48913	Pennsylvania: State Planning Board, P. O. Box 191, Harrisburg 17120
California: Population Research Unit, State Department of Finance, 1623 10th Street, Sacramento 95814	Minnesota: Vital Statistics Division. State Department of Health, Minneapolis 55414	Rhode Island: Statewide Planning Program, Suite 300, 36 Kennedy Plaza, Providence 02903
Colorado: State Planning Office, State Capitol, Denver 80203	Mississippi: Department of Sociology and Rural Life, Mississippi State University, Drawer C, State College 39762	South Carolina: Division of Research and Statistical Services, Budget and Control Board, P. O. Box 11333, Columbia 29211
Delaware: State Planning Office, Thomas Collins Building, 530 South DuPont Highway, Dover 19901	Missouri: Administrative Services Section, Office of Comptroller and Budget Director, P. O. Box 809, Jefferson City 65101	South Dakota: Division of Public Health Statistics, State Department of Health, Pierre 57501
Florida: Bureau of Economic and Business Research, College of Business Administration, University of Florida, Gainesville 32601	Montana: Bureau of Business and Economic Research, University of Montana. Missoula 59801	Tennessee: Tennessee State Planning Commission*, Division of State Planning, C2-208, Central Services Building, Nashville 37219; Center for Business and Economic Research, University of Tennessee, Knoxville 37916
Georgia: State Planning Bureau, 116 Mitchell Street, S. W., Atlanta 30303	Nebraska: Nebraska Department of Economic Development*. Division of State and Urban Affairs, P. O. Box 94666, State Capitol. Lincoln 68508; Bureau of Business Research. University of Nebraska, Lincoln 69508	
Hawaii: Department of Planning and Economic Development*. State Capitol, Honolulu 96813; State Department of Health. P. O. Box 3378, Honolulu 96801		Utah: Utah Department of Development Services*, State Capitol, Salt Lake City 84114; Reports and Analysis Section, Utah Department of Employment Security, 174 Social Hall Avenue, Salt Lake City, 84111
Idaho: State Department of Health, Statehouse. Boise 83707	Nevada: Bureau of Business and Economic Research, University of Nevada, Reno 89507	Vermont: Division of Public Health Statistics, State Department of Health, 115 Colchester Avenue, Burlington 05401
Illinois: Division of Health Planning and Resource Development, Department of Public Health, Springfield 62706	New Hampshire: Office of Planning and Research, Department of Resources and Economic Development, State House Annex, Concord 03301	Virginia: Bureau of Population and Economic Research, University of Virginia, Lambeth House, Charlottesville 22903
Indiana: State Board of Health, 1330 West Michigan Street, Indianapolis 46206	New Jersey: Department of Conservation and Economic Development, P. O. Box 1889, Trenton 08625	Washington: Office of Program Planning and Fiscal Management, Population and Enrollment Section, Insurance Building, Olympia 98501
Iowa: Office of State Planning and Programming, State Capitol, Des Moines 50319	New Mexico: Bureau of Business Research, University of New Mexico, 1821 Roma Street, N. E.. Albuquerque 87106	West Virginia: State Planning Division*, Governor's Office of Federal-State Relations, 1703 Washington Street, E., Charleston 25311; Office of Research and Development, Center for Applachian Studies and Development, West Virginia University, Morgantown 26505
Kansas: Division of State Plans Coordination, State Department of Economic Development, State Office Building, Topeka 66612	New York: Office of Planning Coordination*, Room 229. State Capitol. Albany 12201; State Health Department. 84 Holland Avenue. Albany 12208	
Kentucky: Kentucky Program Development Office, Capitol Building, Frankfort 40601		
Louisiana: Division of Business and Economic Research, School of Business Administration. Louisiana Polytechnic Institute, P. O. Box 5796. Tech Station. Ruston 71270	North Carolina: State Planning Division, Department of Administration. Raleigh 27601; Carolina Population Center. University of North Carolina, 123 West Franklin Street. Chapel Hill 27514	Wisconsin: Department of Health and Social Services, P. O. Box 309, Madison 53701; Applied Population Laboratory, University of Wisconsin, Madison 53706
Maine: State Department of Health and Welfare. State House, Augusta 04330	Ohio: Economic Research Division, Ohio Development Department, 65 South Front Street, Columbus 43215	Wyoming: Division of Business and Economic Research, College of Commerce and Industry. University of Wyoming, Box 3925, University Station, Laramie 82070

Note: Participating states as of March 1970. Asterisk denotes coordinating agency as opposed to agency carrying out technical phases of program.

2. Projected trends of population versus employment. Where comparisons can be made for common areas, it seems that the pattern and the trend projected for the future are quite different for the various sets. This is particularly true when one considers using the bureau's population projections with a set of employment projections prepared by one of the other agencies. With regard to the latter, for example, a comparison was made of OBE's population projections and those of the Bureau of the Census. (The bureau had prepared projections for all counties in the country in addition to SMSA's, and it was possible to group counties according to OBE areas.) The results reveal a wide range of differences, although there were many similarities in spite of the extremely different approach. For the 160 areas reviewed, 40 percent of the areas differed by less than 5 percent, and about half differed between 5 and 14 percent. Similar differences in both population and employment exist between census and NPA figures and between OBE and NPA projections.

In general, then, although it is recognized that there is a strong association between employment and population (and migration), projections of these elements have been treated separately. OBE and NPA specifically state that they see population projection as a function for job opportunities and have given most of their attention to the employment projections, with only the roughest and simplest of techniques used to translate them to population. The Bureau of the Census, on the other hand, has limited itself to the population component, relying solely on demographic analysis and not attempting to develop the underlying economic basis. Thus, available "official" population projections for SMSA's cannot be used with the available employment projections without considerable constraint.

Recognizing this unsatisfactory status of small-area projection, the Bureau of the Census has started to investigate the economic-demographic approach to small-area projection in order to bridge the gap between employment and population. Research is being concentrated on regression analysis of migration and employment (and components thereof). Census data on gross and net migration are receiving much attention in the analysis; I think they hold the key to improved and consistent small-area projections. In effect, if the research is successful, the bureau might look to others to provide acceptable economic projections and use the results of its research to project migration and population consistent with the projected employment. If suitable economic projections are not forthcoming, the bureau will consider developing its own as a means of providing more meaningful small-area population projections.

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CENSUS DATA, LAND USE, AND
TRANSPORTATION MODELING

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The focus of this paper is on 4 specific topics: land use modeling, travel forecasting, impact analysis, and data maintenance and updating. The first 3 topics deal with selected applications of census materials to particular kinds of modeling activities. The fourth is concerned with the separate, but related, problem of the maintenance and updating of these materials over time.

LAND USE MODELING

All land use models have the common objective of estimating the most probable future distribution of urban activity, defined usually in terms of population and employment, in a form suitable for input to detailed transportation and land use planning studies. Nearly all of the models constructed to date can build, either directly or indirectly, on census inputs.

Consider for example, the EMPIRIC activities-allocation model, currently being applied by the Metropolitan Washington Council of Governments. The model is designed to perform 2 main functions:

1. To generate small-area (e.g., district-level) forecasts of the future distribution of population, employment, and land use for input to subsequent trip-generation and modal-split analysis, and
2. To provide a base for evaluating the impact of alternative planning-policy decisions on urban growth and development (e.g., the effect on growth of alternative transportation plans).

Figure 1 shows the role of the model within the overall framework of the comprehensive planning process. The model consists mathematically of a set of simultaneous, linear equations that relate predicted changes in the district-level distribution of population to similar changes in employment for the base year and the future distribution
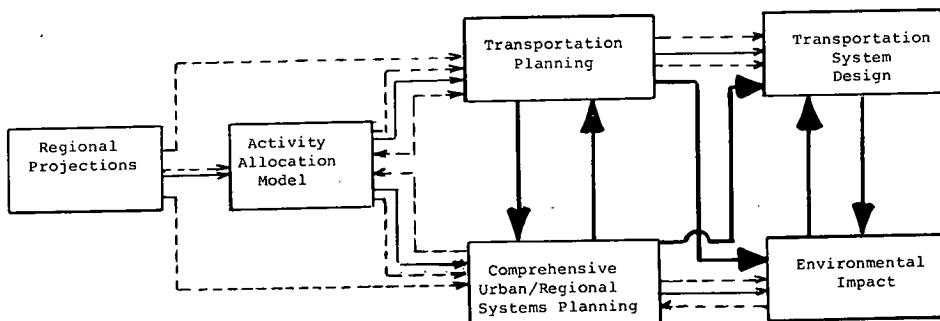

Figure 1. Role of an activity-allocation model in comprehensive regional and transportation planning.
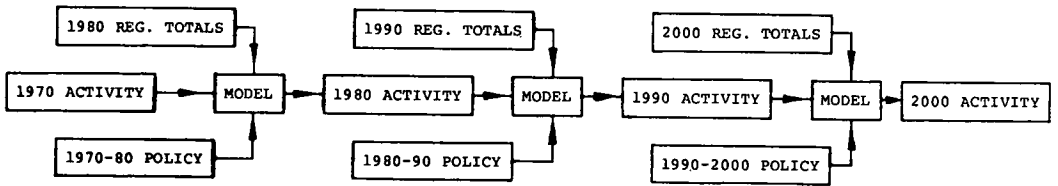
Figure 2. Forecast procedure.

and also relates these changes to alternative planning policy decisions. Activities are defined in the model in terms of classified, district-level population and employment counts. Alternative policies that may be included in the model include investments in future transit, highway, and public-utility systems; subregional growth and zoning controls; open-space policies; and location of major commercial or governmental developments.

The model is calibrated (Fig. 2) by using data collected for 2 separate points in time. It is then applied recursively to generate a succession of forecast distributions of population and employment for different points in time. Each of these forecasts is conditional on the pursuit of a particular set of planning policies and on the attainment of a given total level of regional population and employment. The model can be used both as a straightforward forecasting tool and also as a mechanism for evaluating the probable consequences (in terms of regional growth) of alternative planning policies (Fig. 3).

The model requires 2 separate sets of input data. For model calibration, information is required on the spatial distribution of land use, population, and employment, plus the values of each policy variable, for the start and end of the calibration period. For forecasting, equivalent data are required on each activity for the initial year of the forecast period, together with the predicted changes in each policy variable and the estimated future region-wide activity totals at the end of the forecast period.

In the case of the Washington model, this implies the following specific data inputs:

1. Activity data (in compatible form for 2 separate points in time, e.g., 1960 and 1970, and for each district) for population by age (4 to 6 classes), by household income (4 to 6 classes), and by household size (4 to 6 classes); for em-
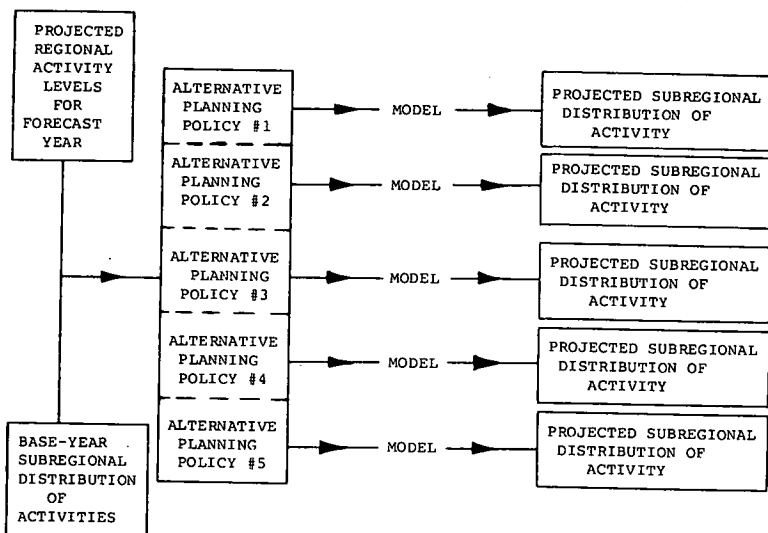

Figure 3. Policy evaluation of 5 alternatives in a single forecast period.

ployment by number of industrial, retail and consumer service, office-federal government, office-nonfederal government, and other employees; and for land use by total area in residential, industrial, consumer-service, office-federal government, office-nonfederal government, institutional, recreational, vacant and agricultural, and restricted, i.e., not available for development, uses (restricted use averages are also required for each forecast period);

2. Policy data for the 2 calibration years, 1960 and 1970, plus each forecast year, 1980, 1990, 2000, and so on, including district-level highway and transit travel-time matrices, district-level water-service measures, district-level sewerage-service measures, location and size of major commercial-governmental developments, zoning controls and open-space requirements, and acreages in restricted uses; and

3. Regional control totals for each activity, broken down as in item 1, together with equivalent region-wide forecasts for each forecast year.

Two, and possibly three, of these pieces of input data can be generated directly from census sources. The first and most obvious of these is the set of data relating to district-level population. Compatible breakdowns of population by age, household size, and household income are available as standard output from the census, for both 1960 and 1970, and for a variety of geographic units. For model-building purposes, tract-level tabulations will, in most cases, be satisfactory. Where district and tract boundaries do not coincide, the DIME system of the Bureau of the Census provides a convenient means for aggregating 1970 block-level statistics to the district level. This latter capability, however, applies only to 1970 data.

1970 employment data may similarly be derived directly from the 1970 census by making use of the proposed special tabulations of employment by place of work. Again, the DIME capability permits the aggregation of these data according to both study districts or census tracts. However, such employment information is obtainable only from the 1970 census and not from the 1960 or prior censuses. Small-area employment data for periods prior to 1970 must be obtained from other sources (e.g., first-work-trip data from an existing home interview study or data derived directly from state employment records).

The third potential application of census data to a model of the type discussed here is less clear. Transportation policies are expressed within the model in terms of changes in district-level highway and transit accessibilities. These in turn are derived from the calibration of a conventional, district-level gravity model. The detailed coding of home-to-work data in the 1970 census, coupled again with the special home-to-work tabulations proposed by the Federal Highway Administration, makes it possible to calibrate a gravity model based only on census inputs supplemented by network information. The resultant friction factors and travel-time matrices can then be used as input to the accessibility measures, which themselves are used as policy variables in the land use model.

EMPIRIC is, of course, only one of a variety of different land use models that might conceivably make use of census inputs. Its utilization of census data, as illustrated here, is broadly representative of the potential use that may be made of the data by other models. In each case, the major census products of interest are standard population and employment estimates. The model must have the capability of matching these data to a variety of different areal systems and separately determined planning-policy and land-area inputs. In this connection, the DIME capability incorporated in the 1970 census is of particular importance.

In the case of growth rather than cross-sectional models that require data for 2 separate points in time, there are obvious advantages in matching the time periods for model calibration and forecasting with those of the census. This necessarily implies (neglecting the possibility of a quinquennial census) a time interval for model building of 10 years. In instances where this is considered to be too large, it is clearly necessary to supplement census-based data with information from other sources. (This point will be taken up again later.)

TRAVEL FORECASTING

In the case of travel forecasting, a number of relatively straightforward applications of 1970 census products may be identified. These range from trip-generation and automobile-ownership analysis to students of work-trip modal split and trip-distribution.

Potential census inputs to trip generation analysis to a large extent parallel those outlined earlier for land use models. Again, census data provide a base for estimating and updating the values of district-level or zonal-level population and employment variables, which themselves serve as the independent variables in conventional trip-generation equations. In addition, the detailed journey-to-work data and work-place coding incorporated in the 1970 census also make it possible to perform a basic trip-generation analysis using only census data as input. This latter analysis, though restricted solely to work trips, may be broken down in some detail according to the characteristics of both the origin and the destination zone and also by mode.

It is also possible, again through special tabulations of the type proposed by the Federal Highway Administration, to use selected samples of census data for detailed household trip-making and trip-generation analysis. These, in turn, may be fed into a disaggregate trip-generation model. Similarly, the data may also be used as a basis for a modal-split (again, only for the work trip) and automobile-ownership analysis. A number of automobile-ownership models have already been successfully developed by using only census data as input.

In this context, however, the most important provision of the 1970 census materials is an extremely valuable basis for generating both a zonal-level and a district-level table of work-trip origins and destinations. This table, when supplemented by information on equivalent district-level or zonal-level travel times may be used directly as input to a trip-distribution analysis.

Considerable volumes of data have been assembled and considerable amounts of money have been spent during the past 2 decades on the collection of information for transportation planning. The utility of data from such large-scale transportation data-collection exercises is now seriously in question, partly because of their sheer expense and partly because of some doubt as to whether data in the quantities conventionally assembled by urban transportation planning studies are either necessary or useful. The journey-to-work data included in the census provide both a convenient and an inexpensive means for updating many existing data sets and can serve as an effective base for the design of future facilities. The fullest possible use should be made of this information before an agency engages in further original data collection.

TRANSPORTATION IMPACT ANALYSIS

Perhaps the most critical area of transportation analysis during the next decade is going to be that of identifying and evaluating the impact of alternative transportation plans and policies on the areas and populations that they are designed to serve. Census data can play an extremely important role in such analysis.

This may range from the simple characterization of the social and economic structure of the areas through which a new freeway or transit system is designed to pass to a detailed analysis of the incidence of transportation impacts on particular groups of the population or the identification of particular planning needs. An example of the latter might, for example, be the isolation of low-income, low-accessibility areas that require immediate transit system improvement. Alternatively, attention might be focused on the spatial distribution of job opportunities or the particular transportation needs of school children or elderly persons. All of these may build directly on census products.

In the case of impact analysis, census data provide at least an initial base for the evaluation of questions relating to household relocation, population relocation, accessibility to employment, incidence of impact on specific demographic and income groups, and potential effects of a new system on existing market areas and overall regional growth.

DATA MAINTENANCE AND UPDATING

My comments have focused on the application of census data to 3 particular areas of analysis. The fourth and final topic that I would like to consider briefly concerns not the use of census data but rather its maintenance and updating over time. Reference has already been made to some of the potential problems posed by the decennial nature of basic census materials. This in no sense negates the utility of the basic census products, nor does it ignore the utility of many of the regular intercensual activities of the Bureau of the Census. Three basic points should be made concerning the maintenance and updating of standard census data. These involve questions of update frequency, areal systems, and data sources.

In terms of transportation planning, it would appear that an average updating period of approximately 5 years is desirable for both population and employment data and also, if possible, for basic trip information. Although more frequent updating may appear to be desirable for particular instances, it is doubtful that the cost of this could be justified on a systematic basis. This in turn suggests a need for a regular program of data updating based to the extent possible on standard census methods and definitions.

Similarly, the DIME system and its related ACG and ADMATCH components must be continually updated over time if their utility is to be maintained. This requires an explicit allocation of resources by an agency employing the DIME system to its maintenance and updating, preferably on an annual basis.

All updated materials should be assembled at the same level and in the same format used to summarize the original census information. This implies, in most cases, either the block or census tract level, depending on the information in question and the geographic location.

The question of data sources for updating is perhaps the most critical single problem associated with the maintenance of a "current" data base. A variety of both secondary (i.e., existing) and primary (i.e., original surveys) sources may be considered.

Secondary sources that may be used for updating purposes include school enrollment, tax assessor and building department records, and, in some instances, state employment security information. The major problems likely to arise in this context are those of geographic specificity and potential incompatibility of definition. These secondary sources may, in many cases, be supplemented at a relatively small cost by small sample surveys designed to update those items of census data as a sampling frame and also by data from the regular data-collection activities of other local agencies. One interesting example is that of the Landmark Corporation in the tidewater area in Virginia. The corporation, primarily as a service to the local business community, conducts an annual sample survey of the basic demographic characteristics of the regional population and of market preferences and consumer behavior. The information is summarized and tabulated for a variety of geographic units including aggregations of census tracts. Such surveys, when complemented by the regular intercensual activities of the Bureau of the Census and the performance of selected special studies by individual agencies (for example, the collection of small samples of trip data by a transportation planning agency), provide a relatively solid base for updating base-year information and maintaining census-based data files in a reasonable current state.

SUMMARY

I have touched briefly on 4 particular topics concerning the potential applicability of census data to land use and transportation modeling. In no sense have I exhausted the subject, nor have I pursued any one of the topics as far as it deserves. My intent has been simply to illustrate the broad applicability of census data to the activities of the transportation and land use planner and to suggest some ways in which he may usefully take advantage of an extremely rich and valuable data source.

AN APPROACH USING WORK-TRIP DATA

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There was some thought that this paper would present a technique for using census work-trip data for transportation planning. I wish that were so. Unfortunately, except for some research we did 3 or 4 years ago (1), little concrete effort has been expended to date to advance this approach to a technique. I have heard some rumors from time to time that it might soon be utilized functionally but have not heard of any actual situations. I think that the approach is probably as well suited for use with census data as with major generator data, as was originally intended. So perhaps with the availability of 1970 census information, some testing will be carried out.

I would like to review this approach because I am confident that it can be used in smaller urban areas where travel patterns are not too complex and that it also has considerable merit for use in larger urban areas, although for such cases much care and special handling must be exercised in order to consider significant travel patterns that might otherwise be neglected. I will start with a review of the information that will be available from the census, then discuss the uses for which I feel it is appropriate, and conclude with how it can be implemented.

The principal census data of interest here are the journey-to-work data. These data will be assembled by asking the location of the principal employment of all workers in 15 percent of the households in the country. This year, by virtue of a special appropriation, the employment place data are available to the street address location rather than to the political jurisdiction as was the case in 1960. This detail of location will permit coding of employment location according to the census block, effectively providing tract-to-tract work-trip interchange data for the 15 percent sample. This is a considerably greater sample than would be available in most urban studies, except Cleveland for instance.

The impact of this is obvious; the census is providing a large-sample, work-trip table that can be used for urban transportation planning. The question may be asked, What good is a single-purpose trip table? That is the key question for this technique, and I will go into it shortly. Suffice it to say for now that there is considerable feeling that these data can be exceedingly useful for numerous reasons. This is why the great effort was put forth to obtain work-place location information to this level of detail.

The same 15 percent sample of households will be asked their occupation and the industry in which they are employed. These 2 classifications will each be coded to numerous major levels. The respondents will also be asked to indicate their principal means of travel to work according to 9 classes. Twenty percent of the households will be asked to indicate their income level. Thus, significant, critical data on the journey to work, the most important trip group in most urban areas, will be available from the census for all SMSA's of the country. The data will be procured at least every 10 years and perhaps every 5 years. In addition to this special data obtained from 15 percent of the households, data on the characteristics of all households will be obtained. This will include significant production-zone information such as family size, sex, and age stratifications. Other characteristics of households will be obtained as well and may be more particularly useful in some urban areas than in others.

How can these data be used for transportation planning? I have already mentioned that the census will provide data that can be used to generate a work-trip table for several modes. Processing of the census data by programs being sponsored by the Federal Highway Administration will yield trip tables that are compatible with zone systems developed for previous urban work. The result of this processing will be a conventional interchange matrix of zonal work trips.

Earlier I raised a question regarding the holes in the universe of travel. Some time ago we looked at some actual data from the 1964 study in Indianapolis. We compared the travel patterns manifest in assigned traffic for work trips to those for all trip purposes. For individual link volumes on freeways and arterials, the correlations between work-trip and total-trip volumes were very high and quite significant. This test was made to examine a theory that, if a good basic major street system is provided, it will provide travel service for trips of all purposes. The test was not the most rigorous that might be performed, but within the constraints that existed, it provided a good indication that the theory was plausible. What the test did say explicitly was that, by using conventional transportation planning procedures, essentially the same results could be obtained (that is, defining major facilities) by using only work trips as by using a complete trip purpose spectrum.

There may be specific loopholes in this theory but, in general, it is quite well founded and reasonable. Consider the correlations between site development locations, employment concentrations, and major highway locations. Major traffic generating facilities tend to locate in high accessibility corridors in order to maximize their proximity to their particular markets. From an efficiency standpoint, major facilities that carry work traffic in peak hours should be utilized to carry other purpose travel when work traffic is not heavy. In some specific cases, such as large shopping centers, recreation areas, universities, or airports, these major generators are usually easily located and should be amenable to special handling that would provide for sufficient facilities to serve such generators from the otherwise designated highway system.

Another way to handle large traffic generators is to do some type of special generator survey, perhaps using license plate procedures. Indeed, this technique was originally intended to be oriented to special generator surveys that would gather work-trip data at the place of employment and other generator data at the attraction zone. Production zone data would, of course, be available from the census. The approach is equally appropriate for use with census work-trip data because the essence of the theory is the representiveness of work trips and because census work-trip destinations are now available to the tract level of detail in all SMSA's.

It should be obvious that many of the instances that come to mind to disprove this theory are those in larger urban areas. Thus, as the city size becomes larger, the individual, diverse, nonwork travel demands of residents that must be handled become more significant in comparison to the miniscule volumes observed in smaller cities. Indeed, comprehensive studies have already been completed in most of the large cities anyway.

This technique is directed at providing a very inexpensive, yet accurate, tool for use in planning street facilities for smaller urban areas, those that are not covered by the 1962 Federal-Aid Highway Act. The nonwork purposes may be relatively as important in the small cities as those in the large cities; that is, they may represent the same percentage of all travel. Because of the smaller travel universe, however, their actual trip volumes are less important. A lane is a lane, in general, regardless of urban area size. For all intent and purposes, the transportation system in a small town is one that satisfies the travel demand for those two 15-minute peak periods when mainly work travel occurs. This is not the most accurate technique perhaps, but certainly it is very cost effective.

The census obtained address of work place for all urban areas, but the location will be coded in detail only for SMSA's. For urbanized areas in most SMSA's, where address coding guides were available at coding time, the location will be coded to blocks. In other SMSA's the location will be coded to tracts, but block coding could be developed by using address coding guides prepared after the original coding operation. In

other urban areas, locations will be coded only according to uniform area code, essentially the city where the work place is located. More detailed coding could be accomplished, although at considerable expense, by recoding work place location from original forms. This obviously limits the applicability of census work-trip data for smaller urban areas. As a result, major generator surveys may still be most appropriate.

The census data do provide capabilities for updating previously obtained data and forecasts in such larger areas. They can be used to check and adjust the work-trip tables and models prepared previously. Propitious factoring can guide adjustments to the nonwork models in line with general trends in person travel behavior, such as trip length and frequency, observed in the work model updates. With the advent of quinquennial censuses, continuing study organizations may be able to fine-tune their models and forecasts quite often in order to keep abreast of the most recent trends in behavior. This will be very important because of the changes in behavior that respond to alteration in traditional institutional constraints and standards.

I have avoided comments regarding mode of work travel until now in order to emphasize mode-choice impact. Naturally, the previous comments were addressed to use of automobile-driver travel data. The availability of multiple travel-mode designations for work trips provides a data base for analysis of mode choice as well as for automobile occupancy and the rail-bus submode decisions.

For the case of automobile-transit mode choice, work-trip data are the most appropriate data that can be used. Much modal-split work in the past has been principally oriented to work-purpose trips, using factors to estimate the total travel universe. The obvious reason for this is that traditionally transit has depended on work travel so much more than on travel for other purposes. Work trips constitute an overwhelming majority of transit trips. Having tract data on trip ends and interchanges by mode will permit mode-choice modeling from census data alone. The most appropriate production zone characteristics, income and density, will be available from the census. The data on industry at work place will provide stratified employment estimates by zone from the same survey source. I do not think anything further is needed to demonstrate this because the available data readily fit the requirements of the standard procedure.

The numerous stratifications of travel mode will also permit analysis of appropriate submode decisions. The automobile occupancy and rail-bus splits fall directly from further stratification of the principal-mode travel data. In addition, the census will provide data on what has heretofore been rather elusive, the number who walk to work and work at home. The 15 percent sample will provide adequate data to estimate these correction factors to the universe of work-travel data. These home-employment and walk-travel estimates have usually not been available from traditional urban surveys.

One further thing that the census will permit with work-trip data is a means to estimate employment by type in attraction zones. This will be a useful check on employment data from other sources, particularly those that are usually conceded to be in some manner inadequate, such as employment security data. It will also provide gross data for rural areas for use in statewide planning. Such data may not previously have been prepared or even been available.

What type of program can be developed to utilize these data? The biggest problem here will be interfacing with the census. The Bureau of the Census has enough responsibilities to occupy it, so we cannot expect special treatment to satisfy the particular needs of each urban area. It would seem reasonable that these work-trip data may be some of the last prepared for external consumption. Indeed, the work-trip data will be processed with the special FHWA programs only on request. The original coding, of course, is to the work-trip destination block. Once that is available, the user can request a summary according to the traffic zones for his area merely by providing equivalence tables and money. From there on, the procedure is fairly straightforward. Work-trip tables can be built, and travel models can be calibrated. Alternatively, the models developed previously might merely be checked by comparing the work-trip distribution of census trip ends to the census trip table. The normal battery of checks would follow.

The key to the technique suggested here is to develop appropriate expansion factors that will provide total highway or transit trips from those for the work purpose only. These factors can be prepared from survey data from the urban area or from cities of similar character. In general, these factors do not differ significantly among urban areas in a region. Because the estimate desired is really an order-of-magnitude type, slight errors can be tolerated. Substantial sophistication in these derivations may be warranted, however, because of their impact. The factors would then be applied to develop either total ADT or peak-hour tables. These would be assigned to a network and analyzed in the usual manner. As mentioned before, care must be taken to ensure that major nonemployment generators are accounted for because this procedure will not necessarily provide adequately for special cases. Use of peak-hour factors will provide direct design data in many cases for urban areas.

This procedure has some significant advantages and drawbacks. The data are collected uniformly for a single base year in an identical manner for all portions of the country. Thus, consistent procedures for using it can be developed and reapplied economically. The survey will be repeated periodically, every 5 or 10 years, and will provide for periodic checking and updating without further travel surveys such as those that have been taken in the past. The data are very inexpensive for the individual planning agencies, although some burden-sharing will eventually be effected. The sample is larger than samples in most previous urban travel surveys. This is important because the data for other travel purposes will be developed from it. The census data will provide an independent source for checking previous work and independent data for periodic subsequent updating.

The fact that the data are for work trips only can be overcome with careful factoring. The work data will be very reliable because of the larger sample, and therefore errors due to factoring will be less dramatic. The census may, however, be inconsistent with other data sources in ways that can only be detected for individual instances when they are examined.

The singular use of census work-trip data for transportation planning appears from tests to date to be quite appropriate and accurate. Further tests may be desirable, but the thesis of this approach appears strong enough to warrant its practical application.

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IMPROVED TRANSPORTATION MODELING

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Two significant objectives for this conference were stated in remarks made at the conference: (a) to encourage those in transportation studies to devote more effort to the job of planning and less to data collection; and (b) to acquaint those attending with what is and what is not included in the 1970 census data.

LIMITATIONS AND PROBLEM AREAS

In the past 15 years, we have spent hundreds of millions of dollars on urban transportation studies. Although our thinking about large highway and transit investment decisions has become somewhat more rigorous and systematic, I respectfully say that most of the work has not shown much. For example, a recent study at the University of Pennsylvania conducted for the Federal Highway Administration (1) concluded that the urban transportation studies found very little variation in transportation requirements (varying travel flows and needs for facilities) with varying alternative land use and transportation plans. We may ask, What is the purpose of a transportation study if not to find the best plan from among many?

There are real difficulties with the urban transportation study process. Much of the difficulty is directly traceable to the predictive models used in it. Data for predictive models, whether from the census or elsewhere, are only as useful as the models in which they are used.

The present forecasts made are quite insensitive to many of the changing values in society. Even in the more restricted area of travel forecasting, the process is insensitive to changes in technology, price, or service. In short, it is insensitive to change. It is legitimate to ask whether we are acquiring the proper kind of information on which decisions can be intelligently based.

The problem is to develop the right kinds of predictive models—perhaps different kinds of models—and then examine the data requirements for these models. We should key our information collection on current conditions and our information projection on future conditions to the kinds of decisions that must be made. (This would apply to the collection of census data or any other data. We must withhold judgment on the usefulness of census data already in hand until prior decision and modeling questions have been examined.) These include transportation investment and operating decisions involving large and small changes to the transportation network. We need to forecast the consequences of these changes. Not only are we changing our transportation system but also we are changing our values with regard to what transportation should do for high-density urban communities.

Part of the set of consequences or impacts that need to be forecast are those that concern travel or flows on the transportation system. We need to forecast travel to the required degree of disaggregation or detail of modes, links, time of day, and so on and to the required accuracy for deciding among alternative investments or operating plans. The forecasts are required for a variety of alternative plans characterized by widely varying price, speed, frequency, and convenience of the different modes in the transportation system.

In short, we need models with the required structural properties to make policy-sensitive forecasts. We need models that are relevant to our analyses, i.e., sensitive to change.

There are 2 types of models, with regard to data aggregation levels: (a) Aggregate models for which the observations are the number of trips between zones by mode, purpose, and time period when the zones have certain characteristics (averages or totals) and the transportation system has certain properties; and (b) disaggregate models for which the observations are the trips of the individual or household with certain characteristics and travel choices available to it. Which type of model is most useful, and what does this imply about census data limitations?

I suggest we must choose the latter, disaggregate models, and this puts us in direct conflict with the disclosure rules of the census. We choose the disaggregate approach, because the fundamental requirement for a demand model is that it be behavioral. It should represent decisions (in this case travel decisions) that consumers make when confronted with actual choices. We need to look at the choices that individuals make. We need to know what choices were available, which choice was made, and what characteristics that describe the trip-maker can we use to model his choice. With regard to the latter, we need data on the travelers themselves so we can isolate and model the behavior of groups exhibiting similar travel behavior in response to different transportation system characteristics. That is, the influence of different price and service characteristics of trips can be expected to vary depending on the different types of travelers and their varying utility preferences, and also depending on the nature of the final goods and services consumed or employment obtained—travel being a derived demand, not generally consumed as an end in itself. Thus, we need socioeconomic information on individual travelers at both the origins and destinations of their trips.

Does the census collect the right kinds of socioeconomic data? Yes, the right questions appear on the questionnaire: income, occupation, automobile ownership, type of dwelling unit, and employment. However, the data are sample data, and reports give only averages or totals for small areas. The data, therefore, have the same problems as socioeconomic data reported in sample home interview surveys at the zone level. The problem with such data is not the size of the area—whether zones, enumeration districts, or blocks—or the sampling rate. The problem is relating the information on individual or household trip-making behavior to its own socioeconomic characteristics and the travel choices available to it.

I would suggest, therefore, that sample zonal or block data do not answer important questions such as those that relate to changes in rates of trip-making between different socioeconomic groups or usage of modes by income groups. Nor do the data give us changes over time in these rates as needed for continuing planning. The reason is that there is great variability in socioeconomic groupings within small areas. Much information is lost in the aggregation process. Fleet and Robertson, in an excellent study (2) in Madison, Wisconsin, found 80 percent of the variance in socioeconomic data within traffic zones and only 20 percent between zones. The lost information in the tails of the distribution is often of the greatest interest. It is the information that shows where we have been and where we are headed. For example, information is lost on low-income groups about which the public sector is concerned. Who are big users of public transit? Also information is lost on high-income groups, representing presumably where we are all headed in the future. Information on these groups is generally lost in zonal averages.

Disaggregation brings with it the possibility of some real advantages and economies in data collection and simpler travel models. The use of existing census data in these models, however, has real limitations because of the strict census disclosure rules. That is, disaggregate models need information on the individual and his address (so the census data can be added to, particularly with information on the alternate travel choices). With information on the individual and his address, the name of the respondent can be traced. This is in direct violation of the (unquestioned and admirable) census disclosure rules. I suggest, therefore, that this is the primary limitation of the census travel data with respect to its use in travel forecasting. This limitation may be correctable, and such a correction will be discussed later.

There are 2 other minor problems in census travel data. The first is the reporting of the travel mode to work. The census question asks the "chief (single) means used" to get to work. Ambiguous responses are possible, particularly in the major metropolitan areas where the journey to work involves a great deal of complex travel. The "wrong" single mode could be identified, from the standpoint of the planner and modeler. Also, information is lost on the access mode of multimode trips in larger urban areas. Access to a mode appears to be very important in modeling travel demand. For example, the sensitivity of transit usage to changes in fares appears to be a function of transit service, partly as measured by access or coverage. With good service, not as many riders are lost with a fare increase. Thus, the important policy question of raising fares to cover the cost of service can be evaluated.

A second relatively minor problem in the reporting of census travel data is a possible upward bias in the number of reported work trips and the employment totals calculated by summing work trip destinations. The census question asks the "means used on the last day he worked (last week)." A simple summation of trips, including those from respondents who worked only part of the week, will likely result in an overreporting of trips. For example, a respondent who worked only 3 of 5 days will really have made only three-fifths the number of work trips on a "typical" day as the number attributed to him by a simple summation. Similarly, those who "moonlighted" or made more than 5 journeys to work will have their trips underreported.

This problem may be approximately corrected by using the information on the number of hours worked "last week" (in the census question). This involves making an assumption as to the average number of hours per day worked by the trip-maker. With this assumption, trips from trip-makers having nonstandard workweeks can be factored by the number of days worked to arrive at a more appropriate number of reported trips.

NEEDED PROGRAMS AND RESEARCH

The Disclosure Problem

The disclosure problem was cited previously as the primary limitation of census travel data with respect to its use in travel forecasting. Getting around the problem will require respecting the confidentiality of the data and the ability only of the Bureau of the Census to work with the data at the tally-sheet level. The bureau itself, therefore, might be requested to add the necessary modeling information to the individual trip record. This would consist primarily of adding the transportation price and service information on all available choices to the trip-maker between his origin and destination. This information, combined with the individual or household characteristics, and his trips would form one trip record. The individual addresses at the origin and destination could be destroyed, although some small area designation of the origin and destination must be preserved. Approximately 500 to 1,000 trip records, randomly selected over a region, would probably suffice to estimate a behavioral work-trip demand model.

Before the bureau is urged to do this work, however, an investigation should be made of the relative costs of such a program versus the costs of collecting and coding 500 to 1,000 similar household trip reports by conventional home interview and travel inventory means. It is quite possible that conducting new limited surveys, tailored to the particular needs of a travel forecast, would be easier, quicker, and cheaper in the long run than having the Bureau of the Census do the work.

External Effects of Major Facilities

The external effects of major transportation facilities, such as expressways and railways, are currently receiving much attention. These are effects such as traffic noise, air and visual pollution, and barriers. Federal law since 1968 requires making public certain findings on the economic, social, and environmental impacts of highways financed with federal aid. The methodology for measuring and evaluating the impacts of external effects of transportation facilities is in its infancy.

An important program of research would utilize census data to measure the response to various measured and hypothesized external effects of expressways and rapid transit lines. Specifically, the geographic coordinates of the expressways or some other facility could be specified, and the movement history and other characteristics of residents at given distance intervals from various segments of the facilities of interest could be machine tabulated. The results would be compared with each other and with control populations located some distance away from the transportation facilities. Important data on the external effects of major facilities on traversed urban environments would be forthcoming. The tabulations would not have to be restricted to expressways, but could include all types of transportation facilities, large and small, so that comparative analyses could be made. The data could also include 1960 census data, although tabulating the latter data would be far more difficult. The additional results in terms of 1960-1970 changes in socioeconomic changes might be worth the effort, however.

Allocation of Transit Subsidies

Several other important programs involving the use of census data in transportation planning come to mind. For example, one could investigate the question of who subsidizes and who is being subsidized by deficit-run transit service by tabulating the number of transit riders by income and (small area) location. This could be combined with information on the costs of running transit service by part of a region and the existing payments of transit deficits by parts of the region. Useful information on existing income transfers and equity solutions would be generated by such an analysis.

Keying Information Collection to Decision-Making

In general, information collection should be keyed to the types and "value" of decisions that need to be made. Because census data represent such an exhaustive (and existing) data universe, research could draw on the existing data to determine the effectiveness of various kinds and amounts of data in reducing the chances of making wrong transportation investment decisions. The costs of such data if collected separately could be estimated. The results would be valuable in theoretical studies of the transportation planning process, leading to more effective, less costly data collection in transportation planning.

CONCLUSION

In conclusion, we may ask ourselves again, How valuable are census data for transportation planning? As a travel universe, to stare at and provide a base at some point in time, we should, as another author suggested, test its accuracy by simply assigning it in the usual fashion. To be fair, however, we should assign it to networks by using appropriate equilibrium assignment methods, such as DODOTRANS (3).

As input to travel forecasting models, the usefulness of census travel data appears quite limited, unless we can get the Bureau of the Census itself to add the necessary information to the individual trip records. This may be the harder and more costly way to get the necessary relatively few trip records. Also, the bureau may choose to exercise its confidentiality rules by refusing small area identification of trip origins and destinations. This would eliminate the ability to use neighborhood-effect variables in the travel mode. In short, the case for the usefulness of census data in transportation planning is not at all clear. Further thought and investigations are needed.

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USE OF CENSUS DATA FOR
TRANSPORTATION PLANNING

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There are 3 subjects that I would like to review and comment on: (a) use of census data to analyze the impact of transportation changes, (b) problems related to the use of the special transportation tabulations, and (c) planning of the 1972 Census of Transportation.

I would like to sketch briefly some of the potential I see for using census data in analyzing the impact of transportation changes. In the simplest condition, I can see opportunities for assembling block data for those blocks within a potential transportation facility's right-of-way. This would provide insight into the number of persons displaced or affected by the facility and their socioeconomic conditions. In a slightly more sophisticated approach, we would be able to begin the determination of a definition of neighborhood. Studies have been performed to find a definition of neighborhood as input to evaluation criteria of alternative facility locations. They have always been hampered by a lack of small-area data and, more significantly, data whose detail has not been submerged by arbitrary geographic aggregation. This leads to an area of potential research where substantial benefits could accrue, that is, the use of a data surface where area is a dependent variable. Variables such as life cycle and period of residency are collected by the census and frequently in home interview surveys. These could be utilized in neighborhood socioeconomic analysis and definition studies to produce areas defined by like characteristics. Certainly this approach has potential applications beyond impact analysis. The problems and distortions caused by aggregation of data into traffic zones are familiar. The opportunity to work with data aggregated into areal units that have been determined by the data themselves should be of great value.

My second point focuses on the impression that I have that for most transportation planners the major point of contact with the 1970 census will be through the special transportation tabulations. I think these tabulations represent a tremendous increase in the speed and ease with which each urban area will be able to acquire census data. Perhaps, even more significantly, data will be of greater utility than ever before because of much greater geographic detail and control, especially at the work end. The opportunity for intercity comparisons on a common data base is particularly exciting.

There are significant problem areas where research is required to realize the full capabilities of this new data resource. The best overall description of the problems that I can give is the necessity to transpose the orientation of the data from a population universe to a transportation universe. There is now a mismatch of these universes in terms of geography, definition, and structure.

Specifically, there will be problems in many cities because of the difference between coverage within the census area boundary and that within the transportation cordon line or study area boundary. This mismatch is exacerbated by the problems of handling inbound work trips made by nonresidents of the region and not covered by the census data. Then there are the incompatibilities in the definitions of a worker in the census and in the standard transportation survey. There are also variations in the handling of mode choice, particularly "change-mode" trips. These must be over-

come by research and analysis. Finally, there is the problem of relating the work trip to other, more comprehensive transportation measures such as peak-hour travel and total trips. These research requirements are hardly exhaustive, but they as well as others have to be resolved to make these tabulations fully effective. Fortunately, because of the nationwide comparability of the data, such research can be centralized and the products made available to all. The U.S. Department of Transportation has begun to structure a program to provide the needed research. Comments and suggestions will be very valuable to that program.

My final point relates to the historical content of this conference. More than 2 years ago the proposal was advanced for the special transportation-oriented tabulations. It took all of these 2 years and a great deal of effort to bring that idea to fruition. I see a parallel to our situation now and the impending 1972 Census of Transportation. I think it is ironic and unfortunate that in a conference on the uses of census data in transportation planning the transportation census played no role. This is a major potential resource of transportation planning data that has not been tapped. Hoping that the same combination of skills that was so successful in the previous endeavor can succeed again, I would like to propose that a joint working group be created by the Highway Research Board and the U.S. Department of Transportation to work with the Bureau of the Census to propose and implement ways of making the upcoming transportation census as effective an instrument for transportation planning at the urban and state levels as possible. The time is already short. Work must begin.

USE OF CENSUS DATA IN URBAN TRANSIT PLANNING

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   The decline of transit service in urban areas of the United States has been well doc-
umented (1). Recently there has been renewed interest in strengthening transit service
in urban areas (2). The success of such efforts to improve service and increase tran-
sit use depends on the degree to which transit service can satisfy urban travel demands.
A unique opportunity exists to utilize data from the 1970 census to assist in the deter-
mination of travel demand and in the development of improvement programs for tran-
sit service in urban areas.

USE OF DEMOGRAPHIC DATA

   The 1970 Census of Population provides valuable information on the distribution
within the urban area of groups that must depend on transit service: the young, the old,
and the poor. Although poverty may become a less significant obstacle to automobile
ownership in the future, the number of elderly people will continue to grow, as will
the mobility requirements of those too young to drive. For example, while the popula-
tion of the city of New Haven, Connecticut, declined from 152,048 in 1960 to 141,752
in 1967 (the year of a special census-use study), the population sector consisting of the
5-to-17 and the over-65 age groups increased from 45,900 to 46,200. These groups
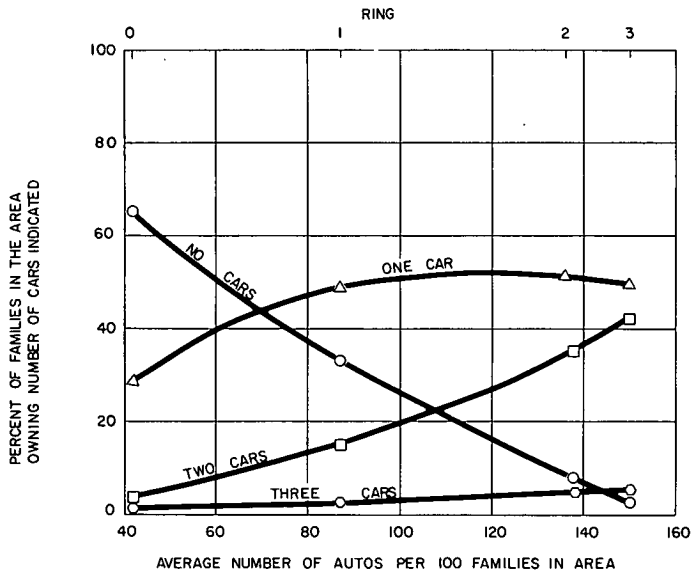represent over 30 percent of the city's population.

Figure 1. Relationship between number of families owning 0, 1, 2, and 3
automobiles and average automobile ownership in Wilmington, Delaware.

By locating the young and old population by tract and comparing the transit service provided (in terms of bus- or seat-miles of service or trips per day per person), areas where improved transit service is needed can be determined. Areas with low-income characteristics can also be identified from census data. A distribution of the number of households by family income can be obtained and compared to transit service.

The proportion of families that do not own an automobile can also be determined from average automobile-ownership data as shown in Figure 1. Census data can pinpoint areas of low automobile ownership where there is high reliance on and need for quality transit service. As shown in Figure 2, transit use per family declines sharply (in Wilmington, Delaware, from 45 percent of all trips to 5 percent) with the purchase of the first automobile. Yet, more transit trips are made on a system-wide basis by families that own automobiles than by those who do not. (Only one-third of all transit trips are made by those persons in households without an automobile in Wilmington.) Still, the majority of all trips made by members of families who do not own an automobile are made without using transit (55 percent in Wilmington); they are made largely as passengers in some other family's automobile. Improvements to transit service can reduce the need for such dependence and reduce automobile use for this serve-passenger purpose
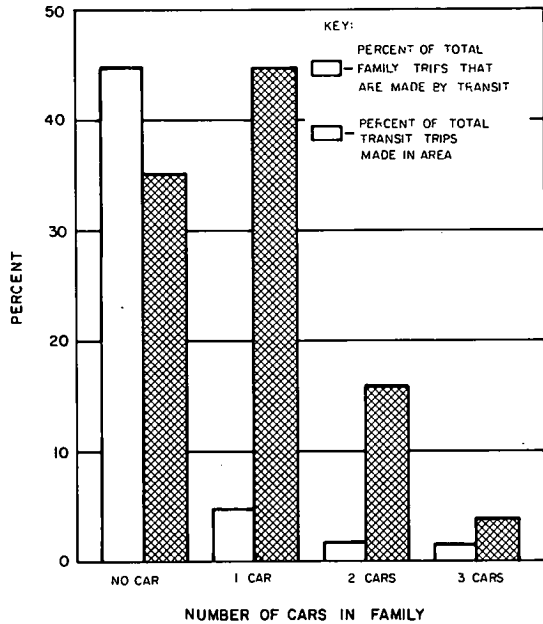

Figure 2. Relationship between transit trip-making and automobile ownership in Wilmington, Delaware.

NATURE AND USE OF JOURNEY-TO-WORK DATA

The 1970 census also collected data from a 15 percent sample of households on employment and mode of travel to work. These data will be coded to block and tabulated at the tract (and in some cases block) level. Special tabulations of these data can be made available at the traffic zone level through a standardized data summarization program developed jointly by the Bureau of the Census and the Federal Highway Administration.

Although work travel in urban areas represents only 20 to 30 percent of all daily travel, it forms a considerably higher proportion of weekday peak-hour travel (60 to 80 percent). In addition, it represents an even greater proportion of travel by transit modes. Data given in Table 1 show that for work travel the utilization of transit is nearly double that of automobile; well over half of all transit trips are made for work purposes.

Another advantage of using 1970 census data for transit planning purposes is related to the fact that transit-use levels have tended to stabilize or decline slowly during

TABLE 1

DAILY PERSON TRIPS FROM HOME BY PURPOSE AND MODE OF TRAVEL IN PHILADELPHIA IN 1960

Purpose	Mode				Total
	Automobile		Transit		
	Num-ber	Per-cent	Num-ber	Per-cent	
Home to work	724	68.3	336	31.7	1,060
Home to other than work	1,774	87.0	266	13.0	2,040
Total	2,498	80.6	602	19.4	3,100

Note: Number of trips in thousands.

the past few years. Thus, 1970 data, which will become available in 1971 or 1972, will still be current for the purposes intended.

USE OF TRANSIT RELATED TO SERVICE LEVELS

Census data can be used to determine the percentage of all work trips made by transit and the number of transit users per 100 workers. These measures can be related to measures of transit service. A study in Wilmington, Delaware, related transit use to the level of transit service provided as determined from an index that combined cost, travel time (versus automobile time), service coverage, and frequency. As shown in Figure 3, those areas that received good transit service had twice the ridership, according to estimates based on parameters of automobile ownership and family size, while areas with poor service had only one-fifth the

Figure 3. Actual versus estimated use of transit in Wilmington, Delaware.

expected use (3). An analysis of transit service levels related to use as determined from census data on mode of travel for the journey-to-work in urban areas can determine where transit service should be increased to attain higher levels of utilization.
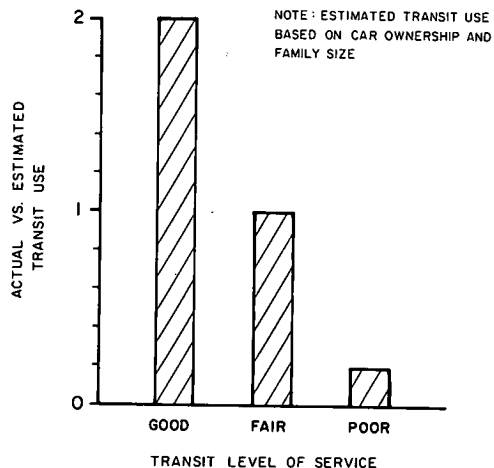
USE OF CENSUS DATA IN TRANSIT ROUTING STUDIES AND FOR CORRIDOR IMPROVEMENTS

Census data on population and employment by tract or block could aid greatly in routing transit service. Maps of existing routes and service frequency can be overlaid on population and employment patterns to see if existing routes should be modified or supplemented. These data should be particularly valuable in routing feeder service to existing or proposed rapid transit stations.

The home-to-work data by mode of travel should also prove most valuable in determining those corridors of commuting movement that are most susceptible to improvement through the provision of express bus service. Possible urban corridor project locations and possible locations for fringe parking facilities can be identified. Total travel as well as existing transit demand in these corridors can be determined.

USE IN ANALYSIS OF WORKER-PARKING REQUIREMENTS AS RELATED TO THE USE OF TRANSIT

An important potential use of census data on journey-to-work travel is in its application to worker-parking requirements. These data include automobile driver and passenger information so that automobile occupancy to work destinations can be determined. In addition, total employment by small area will be available. Together with transit use information, these data can form the basis for evaluating the supply of parking spaces for workers within the downtown area. As shown in Figure 4, a basic relationship exists among these variables.

By comparing automobile use and parking supply expressed in terms of employees per space, the need for improved parking can be pinpointed. This relationship can also be used to achieve a balance between transit and automobile use as related to parking policy. Although improvements to transit, especially in smaller urban areas, will not generally result in a reduction in highway facility requirements in any single corridor, the accumulative effect of such transit improvement can have a marked beneficial effect on downtown parking requirements and on CBD circulation.
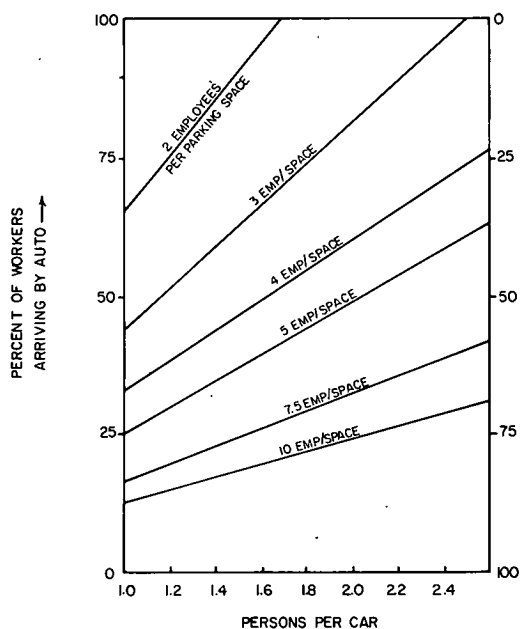
Figure 4. Basic relationship among automobile use, automobile occupancy, and parking requirements for work travel (based on assumption that 8 of 10 employees arrive by automobile or transit and all spaces are used).

SUMMARY

1970 census data will prove a rich data source for transportation planning purposes. The journey-to-work data (coded to small geographic units within the urban area for the first time) are especially applicable to the analysis and improvement of urban transit services. Data from the 1970 population census can also identify areas where transit service is needed to serve the young, the old, and others who have no alternative means of transportation. By relating levels of transit use to measures of transit service, areas where improved service has high potential can be determined. Routing studies can also be undertaken by using census data. Finally, worker parking needs can be determined and related to the supply of parking now available. It would be a wasted opportunity if planners in every urban area did not seize this rich data source and attempt to improve their urban transit systems in a logical, systematic way based on an analysis of the information becoming available.

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LIMITATIONS OF CENSUS DATA FOR
TRANSPORTATION PLANNING AND NEEDED PROGRAMS

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At a meeting of the HRB Committee on Transportation Information Systems and Data Requirements, we discussed the limitations of the census data for transportation planning purposes. We also discussed problem areas and needed programs and research. I will summarize the major points that were presented at this meeting.

There are 3 important gaps in the fitting of census data to transportation planning requirements: a data gap, a communications gap, and a tools and methods gap.

DATA GAP

The data requirements for the transportation planning process can be viewed as a matrix consisting of 3 dimensions: geographic, data category, and mode. This matrix is shown in Figure 1 (1). The geographic dimension broadly relates to trip length and distinguishes urban, statewide, and national transportation planning. The mode dimension covers the various transportation modes such as highway, rail, air, water, pipeline, and intermodal. The data category dimension covers the 3 basic aspects of the transportation process: the activities sited on the land, the flows of goods and people among the activities, and the channels on transportation networks through which the flows occur.

Census data fill some of the information needs for transportation planning purposes, and the 1970 census data fill more needs than the 1960 census data did; but there are still many very important data gaps. The gaps may be considered in terms of types of data, geographic coverage, level of detail, and updating the data.
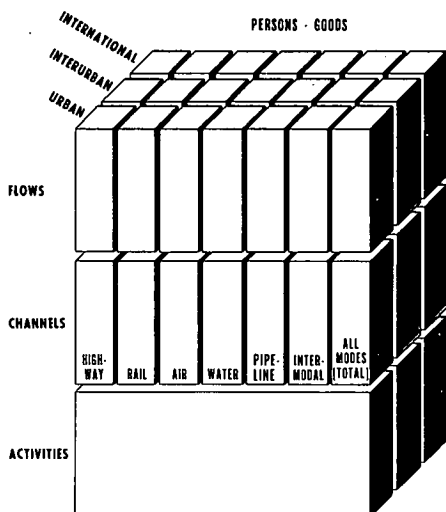

Figure 1. Transportation data structure.

Types of Data

Information on comprehensive land use activities is not available from census data. Population and employment data furnish part of the picture, but information must be added from other sources at great cost for a comprehensive portrayal of activities on the land with intensity measures. It is not practical to use data on nonresidential activities from censuses of business or manufactures for transportation planning purposes because the geocoding is too coarse and these data are available at points in time different from those of data from the population and housing census.

The Bureau of the Census has a logistical problem in taking censuses of population, housing, business, manufactures, transportation, and government, and the program for

taking these censuses at different points in time is the best solution from the point of view of logistics. Unfortunately, this solution does not take proper account of the needs of data users such as transportation planners who wish to have all the data on the various facets of metropolitan activity for the same point in time. Enormous costs and disbenefits are incurred just because the census metropolitan data are fragmented into a number of censuses taken at different points in time with different geocoding procedures. I am sure that a cost-benefit study that considered costs and benefits of both data producers and data users would show that the highest cost-benefit ratio would result if all of the various censuses were conducted concurrently, say, at 5-year intervals.

This would probably make it easier to provide for some of the flows of data that are not adequately provided for now in the census data, notably data on nonwork trips (such as school and shopping trips) and goods movement. The data that are now obtained on goods movement are collected at a very low cost but cannot be used for transportation planning purposes even at statewide or national levels. A wholesale revision of this program is necessary to meet the needs of transportation planners.

The DIME or geographic-base files with coordinates that will be available with the 1970 census data represent the first entry of the Bureau of the Census into the network data field. Actually these files only provide a framework for network data. Data on link volumes, speeds, and numbers of lanes will have to be added. Also, some means must be found for providing vehicle-miles of travel data.

Geographic Coverage

Perhaps the biggest problem of geographic coverage is with these network data. The DIME files will only cover metropolitan areas. They should be extended to cover metropolitan fringes, metropolitan interstices (such as between Washington, D.C., and Baltimore, Maryland), urban areas under 50,000 in population, and rural areas. Only then will we have a comprehensive framework for network data and a uniform national geocoding system suited to transportation requirements at national, statewide, and urban levels.

Level of Detail

The level of detail covered by census data is improving; for example, the 1960 journey-to-work data indicated only the city or county area in which persons worked, whereas the 1970 data will be coded to the block and block-face level. This level of detail in geographic coding is essential for many transportation planning purposes but may be difficult to apply to data on journey-to-work and employment. Many data from other censuses, such as manufacturing, business, and transportation, are not available at levels of geographic detail required for transportation planning. The trend in transportation planning appears to be toward greater rather than less detail, for example, the recent efforts in microassignment.

Updating the Data

The many important changes in the 10-year intervals between decennial censuses of population and housing necessitate costly special surveys. Mid-decade censuses are essential for transportation planning purposes, and transportation planning agencies should support the legislation recently reintroduced into Congress for taking these censuses. There should be consideration of providing for conduct of all of the censuses together at decennial and mid-decade intervals.

Continuing urban transportation planning is an established policy of the U.S. Department of Transportation, but at present there is no method to ensure that continuing data are provided. It seems clear there will be need for some data at intervals more frequent than 5 years. Probably these can be most efficiently provided at the local level, but the Bureau of the Census should have responsibility for annual updating of the geographic base files because these will be used at national and state as well as local levels.

Data requirements for transportation planning change as the process evolves. There is a considerable time lag between the establishment of a data need and the provision for this need through a national program. This fact makes it essential that there be a constant review of data needs and programs for satisfying these needs so that programs are properly responsive to current needs.

COMMUNICATIONS GAP

There seems to be insufficient communication between the transportation planning groups and the Bureau of the Census, chiefly in the areas of required data items, acceptable sampling variability, confidentiality, and the data processing procedures. The bureau knows what data it collects and which of these can be made available, and the transportation planner knows what data items are useful for his purpose and which are not available. It would be better if there were some reversal of these roles. The bureau as a data producer should have a close knowledge of the requirements of data users, and the transportation planner as a data user should know thoroughly what data are being collected and what problems are associated with making these data available.

The standards of sampling variability that are maintained by the Bureau of the Census appear to be high compared with those that the transportation planner is satisfied with. It appears that the bureau is concluding unilaterally that certain data at certain geographic levels should not be made available on the grounds that the sampling variability is too high. The transportation planner, however, is often forced to collect and use data of higher sampling variability. There is need for better communication between the bureau and the transportation planner on this point.

The confidentiality issue also calls for greater communication. It appears that some data cannot be furnished at the required level of detail because this would violate confidentiality restrictions as viewed by the bureau. Many of the data required for public transportation planning may not be available for this reason. It is most important that transportation planners and employees of the bureau define and solve these problems, particularly for those areas that may require special surveys to obtain data similar to those that apparently cannot be made available by the bureau because of confidentiality restrictions.

Finally, there is need to communicate regarding data processing procedures. It is possible that census data could be made more useful for transportation planning purposes at no additional cost if it were processed differently, for example, in the geocoding of work-trip data.

This conference provided a good start toward better communications between the bureau and transportation planning groups, but clearly there is a need for a more frequent interchange of information and this need should be formalized. The HRB Committee on Transportation Information Systems and Data Requirements working alone or with the Committee on Transportation Forecasting could contribute to an improved interchange of information between the Bureau of the Census and the transportation planning groups.

TOOLS AND METHODS GAP

So far we have been talking about improving census data for transportation planning. Some committee members expressed the view that if the 1970 census data were ready tomorrow most transportation planners would be "hip high" in data and would not be able to use it not because of the shortcomings of the data but because the tools and methods have not been developed for most of the transportation planning applications of the data. Others pointed to the need for developing standard methods for adding to the census data to build an integrated body of data suited to transportation planning purposes. They felt that the census data provided a strong foundation on which to build a superstructure of additional data based on standard methods. They saw the need for a methodology that would result in saving of local energies in additional data collection tasks.

The Census Use Study has developed methods of machine geocoding of a file containing street addresses, given a DIME geographic base file (the ADMATCH package). The

geocodes that are assigned in this way include coordinates so that the file can then be used for computer mapping that the Census Use Study has under development (GRIDS).

Also, under Census Use Study auspices, a method has been developed for the Office of Civil Defense in which population is allocated to shelters by using census population data and network data similar to those that will be available from the 1970 census. The same method can be used for other allocation problems, such as allocating population to shopping centers or children to school.

The proposed package of standard tabulations of census work-trip and related data, which is being developed under the leadership of the Federal Highway Administration, provides for rendering census data into a form that is more useful to transportation planners. The Federal Highway Administration has also sponsored research on the relationship between peak-hour traffic and the work-trip data that will be available from the 1970 census.

These are some of the tools and methods that have been developed to date for use of the 1970 census data, and there are probably others. These represent only a start on the total necessary for a full use of the census data by transportation planning organizations. For public transportation planning, a standard package could be developed that accepts as input the work-trip data in the standard form available from the Bureau of the Census and provides as output answers as to where there is or is not potential for public transportation services and the level of service that would probably be sufficient. The potential range of other applications extends from microassignment and detailed impact studies to statewide transportation planning.

What appears necessary and urgent is a program to provide for the development of transportation planning applications involving use of the 1970 census data. This program should include a list of these applications, cost estimates, and suggested agencies that should undertake the development of the tools and methods for these applications. The program should also include consideration of methods of supplementing the census data to obtain the full complement of required data.

CONCLUSION

The 1970 census data, compared with the 1960 census data, are much more useful for the transportation planner. There is need, however, for considerable additional data in order to meet the needs for transportation planning at national, statewide, and urban levels. Some of these additional data needs could be provided for by bringing together the separate censuses of business, manufacturing, government, transportation, and population and housing. If these were conducted concurrently, composite and comprehensive metropolitan data would be easier to obtain and ad hoc data collection efforts could be largely avoided. Also, some of the additional data needs could be met by extension of the 1970 census network and geocoding data to additional areas to provide for a comprehensive national system of network and geocoding data.

There is an urgent need to develop a full range of tools and methods for transportation planning applications involving use of the 1970 census data. A first step would be the development of a comprehensive program for this purpose.

There is a need for stronger communication between the Bureau of the Census and transportation planning groups on required data, acceptable sampling variability, confidentiality, and data processing procedures. The HRB Committee on Transportation Information Systems and Data Requirements could be useful in this regard. It could arrange for a series of meetings with the bureau on transportation planning data requirements. The committee could at the same time arrange for a constant review of transportation planning data requirements to keep abreast of changing needs. This is particularly necessary in view of the long lead time usually required to effect the inclusion of new data in national and state programs.

REFERENCE

1. Transportation Information. U.S. Department of Transportation. 1969.

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