Uses of Census Data for Transportation Analysis*

ARTHUR B. SOSSLAU and JAMES J. McDONNELL

ABSTRACT

Census data can be applied to a wide variety of problems faced by transportation planners. A number of potential applications of census data in the evaluation of current transportation conditions are described.

Transportation planning agencies were surveyed in 1972 to determine the data items most frequently used from the 1970 census. Figure 1 (1) shows the results of that survey as published in a report prepared for FHWA (2).

The range of socioeconomic information contained in the census can readily be seen from the lists in Figure 1. This wealth of data, offered in the Urban Transportation Planning Package (UTPP) and not generally available from any other census product, affords transportation and other urban planners a unique opportunity to relate social, demographic, and economic factors to transportation patterns and trends and thereby to gain insights that are essential to the understanding of current-year conditions, to the evaluation of trends, and to the construction of models for developing future transportation strategies.

For purposes of this Record, transportation planning uses of census data are divided into two categories: model and nonmodel. The uses of census data in nonmodel studying and evaluating of current conditions are described.

TRANSPORTATION PLANNING USES

At least three major categories of uses of census data apply to nonmodel transportation planning and analysis:

1. Establishment of a data base
   a. Socioeconomic variables used in transportation planning at the residence end
   b. Employment characteristics at the employment end
   c. Journey-to-work trip information on a residence-to-workplace basis.
2. Data summary and reporting
   a. Evaluation of trends in characteristics at the residence end and work end in population, housing, and employment characteristics by comparing 1960, 1970, and 1980 census data
   b. Summary, reporting, and analysis of 1980 conditions for journey-to-work trip lengths, major trip movements (distribution), mode use, carpooling, travel times, and so forth
   c. Evaluation of changes in journey-to-work travel such as distribution of trips within the region, changes in mode of travel, vehicle use, and so forth, by comparing 1970 and 1980 census data
3. Travel-related analysis
   a. Analysis of accessibility to community services of segments of the population to assess transportation needs of special users (a PLANPAC program, SAACCESS, is a convenient tool to accomplish this)
   b. Mapping of population-related characteristics that support transit use (items such as car ownership, income, population within 0.25 mile of transit service, etc.) by applying the successive-overlay technique
   c. Utilization of journey-to-work information to indicate parking demand by destination area and area of residence for work travel
   d. Impact analysis of transportation ranging from characterization of the social and economic structure of the areas through which a new system will pass to analysis of the impacts on particular groups in the population
   e. Specialized analysis of population segments to develop targeting programs to encourage and enhance carpooling, vanpooling, transit and bicycle use, and so forth.

Among the most valuable applications of census data is the building of a data base on which current conditions of population, employment, and work trips can be evaluated. Such evaluation is the first step in determining how a region is developing, what

1. *Census Items Most Frequently Used*
   Population & Household Data by block, tract, enumeration, district, etc.
   Age and Sex
   Race
   Income
   Auto Ownership
   Occupation Industry & Class of Worker
   Place of Work
   Mode of Journey-to-Work
   Spanish Origin
   Number of Units at Address
   Value
   Contract Rent
2. *Items Frequently Used*
   Vacancy Status
   Employment Status
   Hours Worked Last Week
   Place of Residence 5 Years Ago
   Tenure
   Second Home
   Disability Presence & Duration
3. *Items Occasionally Used*
   Marital Status
   State or Country of Birth
   Years of School Completed
   Number of Children Ever Born
   Weeks Worked Last Year
   Last Year in Which Worked
   Country of Birth of Parents
   Mother Tongue
   School or College Enrollment
   Veteran Status
   Access to Unit
   Kitchen Facilities
   Rooms
   Flush Toilet
   Bathroom or Shower
   Basement
   Months Vacant
   Heating
   Components of Gross Rent
   Year Structure Built
   Number of Units in Structure/or Trailer
   Farm Residence
   Water Source
   Sewerage Disposal
   Bathrooms
   Number of Stories/Elevator
   Fuel
   Bedrooms
   Air Conditioning
4. *Items Seldom or Not Used*
   Citizenship
   Year of Immigration
   Marital History
   Vocational Training
   Occupation-Industry 5 Years Ago
   Commercial Establishment on Property
   Clothes Washing Machine
   Clothes Dryer
   Dishwasher
   Home Food Freezer
   Television
   Radio

FIGURE 1 Use of 1970 census data items *(1)*.

*From Transportation Planners' Guide to Using the 1980 Census, FHWA, U.S. Department of Transportation, Jan. 1983.

changes are occurring that may affect its transportation system, and where travel-related problems might arise. The data base is also used in most technical activities, such as evaluating changes over time and accomplishing analyses of parking demand, accessibility, and rideshare planning. These are activities that usually do not require models and other forecasting methods. The information required is available directly from census products.

Socioeconomic data used in transportation planning at the residence end include counts of population, housing units, vehicles available, income, and school enrollment. These variables are available at the census tract and or zone level or both from Part I of the UTPP. The data can also be used to examine relationships among variables, such as the number of vehicles available by household, income, and household size. This is available from Part II of the UTPP.

Employment-end information includes counts of total workers, of workers by mode of travel, of workers by sex and occupation, and of persons per vehicle and persons per carpool. This information is available from Parts III and V of the UTPP. As an example of use in transportation planning, such data can be compared with previous counts to assess shifts in nonresidential growth and changes in an area's employment makeup (e.g., shifts from industrial to service economy).

Residence-to-work trip information is available from Part IV of the UTPP at the census tract or zone level and in Part VI at the intercounty level. These data are important in developing an understanding of the geographic distribution of travel, the selection of travel modes, travel duration by mode, and the extent of and potential for ridesharing.

NONTRANSPORTATION PLANNING USES

Census data are also a valuable resource for a number of agencies other than those directly involved in transportation planning, thereby offering the possibility of cost sharing in the purchase of the package. Of special interest is worker information coded to zone or tract at the workplace, which is not available from other census sources. Potential uses by nontransportation agencies are listed in Figure 2 (3).

DESCRIPTIONS OF SELECTED USES

Several applications of census data involve analysis and presentation of the data and do not require forecasting or reliance on modeling procedures. One example is accessibility analysis for various segments of the population. Another is the use of census data to help determine park-and-ride lot locations. Some of the applications of census data for transportation planning are discussed in the following sections.

Transit Planning Through Successive Overlays

Transit agencies generally have not utilized data

DEVELOPMENT PLANNING

- Developing community profile for Overall Economic Development programs
- Analysis of labor force composition and trends
- Analysis of population/employment distribution pattern
- Retail location and marketing studies

EDUCATIONAL PLANNING

- Analysis of future school enrollments by grade
- Redistricting of schools
- Analysis of special educational needs by small areas
- Assessment of bilingual education needs

HOUSING

- Assessment of housing improvement needs
- Analyses of real estate trends and tax revenue forecasting
- Targeting of building code inspections
- Analysis of displacement and other problems occasioned by condominium conversion

HEALTH CARE

- General health care planning
- Analysis of special health program needs as related to socio-economic factors
- Analysis of public health factors
- Identification of areas not adequately served by physicians
- Identification of areas most in need of improved ambulance service

FIGURE 2 Examples of census data uses for activities other than transportation planning *(3)*.

ENERGY CONSERVATION PLANNING

- Identification of target areas for energy conservation assistance in the building sector
- Analysis of local problems and opportunities for energy conservation in space heating, water heating and cooking
- Identification of key corridors for bicycle facility development

LAND-USE PLANNING

- Analysis of socio-economic, demographic, housing, employment, and transportation trends

FIRE PROTECTION AND DISASTER PLANNING

- Analysis of fire and disaster risks by subareas
- Insurance-cost analysis for residences by small areas

PUBLIC WORKS

- Evaluation of projects requiring displacement or relocation of residents
- Improved record-keeping of street inventory data using Census GBF/Dime capabilities
- Assessment of utility needs
- Estimation of right-of-way acquisition costs
- Preparation of Environmental Impact Statements

SOCIAL SERVICE PROGRAMS

- Analysis of service area boundaries and facility locations
- Analysis of client group needs and resources
- Assessment of day care center requirements
- Assessment of playground requirements
- Preparation of funding applications for programs
- Forecasts of future tax revenues

LOCAL GOVERNMENT ADMINISTRATION

- Forecasts of future demand for services
- Identification of target areas and groups to increase voter registration

OTHER

- Assessment of labor market conditions and workers by type activity

FIGURE 2 continued.

sources such as the census in planning route extensions or cutbacks and service increases or decreases. In the current economic and political climate, the need for such data-based planning has grown.

The successive-overlay technique geographically plots selected transit-related variables such as car ownership, income, percentage of elderly or young populations or both, and so on, on individual transparent map sheets that can be overlaid one on the other with a street system as the base (4). In this way potential areas of high transit patronage can be identified for use in evaluating current transit travel (this technique is also available for journey-to-work census data). Another variable of interest that was not available in previous census data is the population of handicapped persons.

In one urban area this technique was used effectively to measure the propensity for transit use in terms of the following variables:

1. Passenger cars per dwelling unit: less than one vehicle, high transit use propensity; one to two vehicles, medium propensity; and more than two vehicles, low propensity;
2. Average income: $0 to $4,000, high propensity; $4,000 to $10,000, medium propensity; more than $10,000, low propensity (these incomes were for 1970);
3. Females aged 16-24 per acre: 0.5 to 1.2, high propensity; 0.3 to 0.5, medium propensity; 0 to 0.3, low propensity;
4. Persons aged 62 or over per acre: 2.0 to 2.82, high propensity; 1.0 to 2.0, medium propensity; less than 1.0, low propensity; and
5. Dwelling units per acre: 4.0 to 6.9, high

propensity; 1.0 to 4.0, medium propensity; 0 to 1.0, low propensity.

These items were plotted individually and an overlay of all items was made as shown in Figure 3 (4). The results defined an area in which a postcard home survey of potential transit riders was then made. As a result of using the overlay technique the survey cost was reduced because a limited area in which the survey was most likely to produce significant results had been targeted.

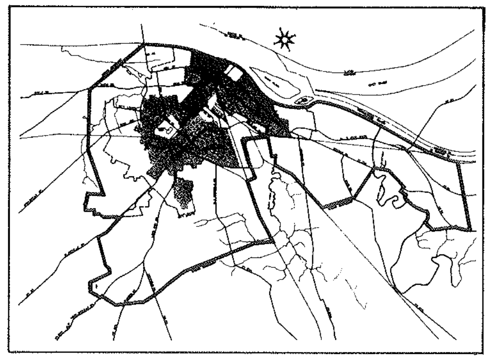
Accessibility and Special Population Segment Analysis (5)

Many community services are keyed to special segments of the population--the elderly, the poor, ethnic and racial groups, and so forth. Other services, although keyed to the general population, may have limited interest for all but target populations, such as programs to encourage carpooling, vanpooling, and bus use.

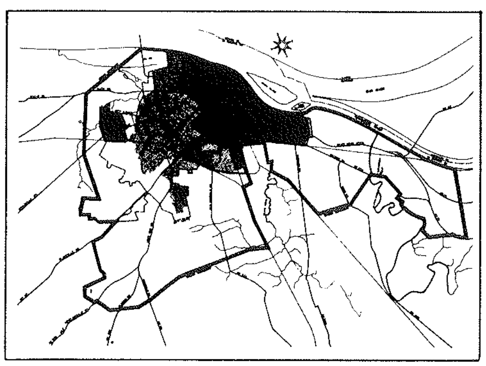
Census data allow stratification and geographic plotting of the population by key variables such as sex, income, and car availability. Accessibility measures may also be developed linking targeted segments of the population to community services such as hospitals, schools, and employment areas. Measures of accessibility by transit and automobile can thus be developed by combining population stratifications from census data with local transportation networks.

Accessibility measurement is also used by planning agencies to assess the social impact of community services on segments of the population. Such measurements are then used to evaluate alternative proposals for transportation improvements. In fact, accessibility measurement has been used to indicate progress toward several goals--land use development objectives, social objectives, and system performance objectives.

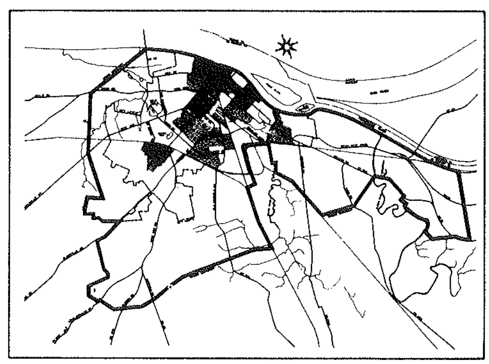
Passenger Cars per Dwelling Unit.



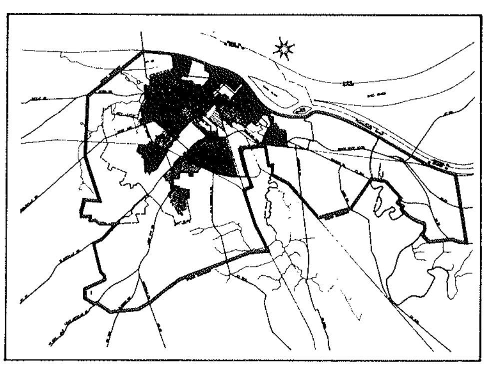
Persons Age 62 or over.



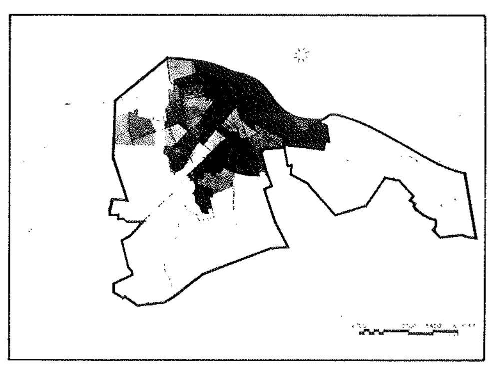
Average Income.



Dwelling Units per Acre.



Females Age 16-24 per Acre.



Composite Overlay of Indices.

FIGURE 3 Sample plots for successive-overlay technique *(4)*.

Charts and graphs are commonly used to display accessibility measurements. Figure 4 (5) shows a graphic technique that compares accessibility of employment opportunities to population subgroups of differing geographical and income stratifications under two alternative plans. Accessibility is measured during the peak hours for the automobile mode. Similar figures could be developed from census data for other groups, other modes, and other activities and for a wide variety of combinations.

In Figure 5 (5) an isochronal map is used to display the accessibility of the low-income group to employment using the same data as those used for Figure 4. The isochronal map adds a dimension missing from Figure 4 by illustrating that although Plan B provides a higher level of accessibility overall, certain areas are more accessible under Plan A.

A third type of display of accessibility measurement is shown in Figure 6 (5). Accumulated percentages of total population are plotted across travel times to major medical facilities separately for travel by transit and by automobile. Census data can be used to further distribute these variables by sex, income, automobile availability, and so on.

Computer software is available for accessibility analysis. It produces a combination of graphic and tabular reports to display accessibility by a highway or transit system or both. The program is called Special Area Accessibility Model (SAACCESS) and is part of the PLANPAC system of programs. A standard set of reports is produced for each facility or group of facilities using SAACCESS. These include

1. A plot of cumulative percentages of the population versus travel time,
2. A histogram of percentage of the population versus travel time,
3. A tabulation of actual population with the percentage of population and the accumulated percentage of population accessible at each travel-time increment, and
4. A listing for each zone of the closest facility among a number of major community facilities and its travel time.

Locating Park-and-Ride Lots

Census data on work trips by mode can be assigned to the highway or transit network of an area or both for graphic display or they can be displayed as in the examples in Figures 4-6. These offer good visual summaries of conditions as they existed in 1980, and the successive-overlay procedure can indicate those areas that have the potential for increased

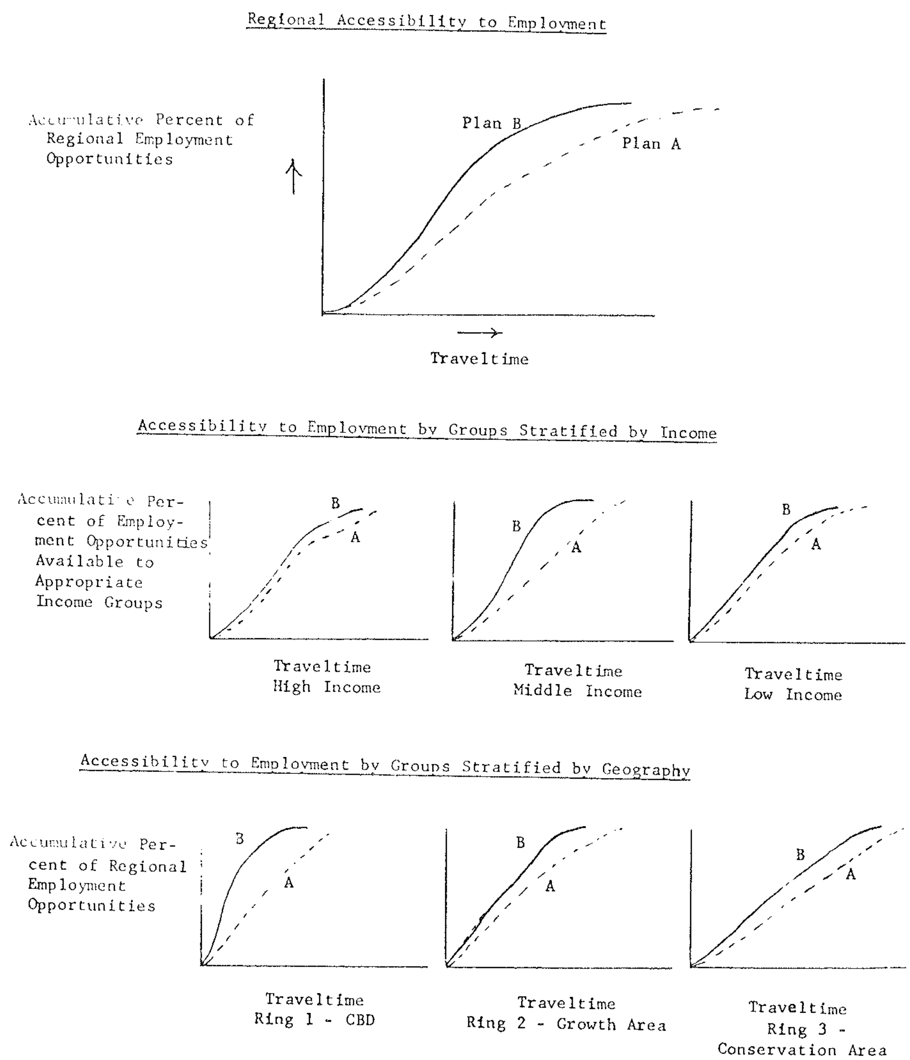


FIGURE 4 Accessibility to employment by automobile during peak hours *(5)*.

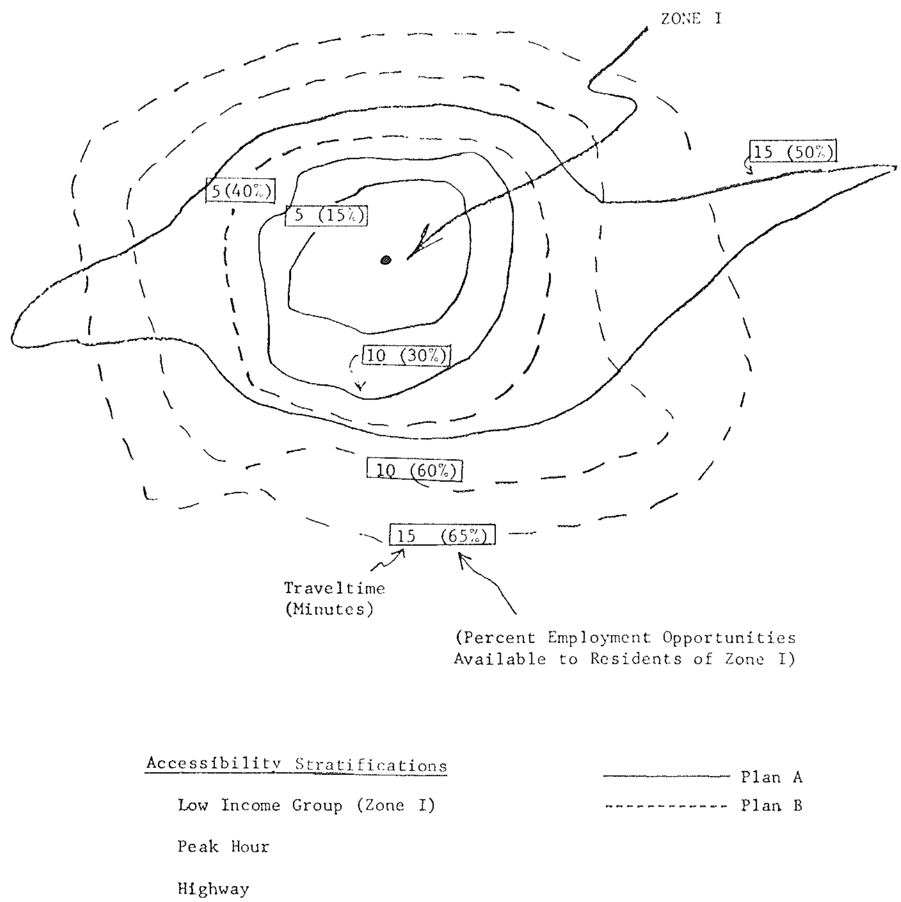


FIGURE 5 Accessibility for low-income group (Zone I) to employment opportunities via highway during peak hours *(5)*.

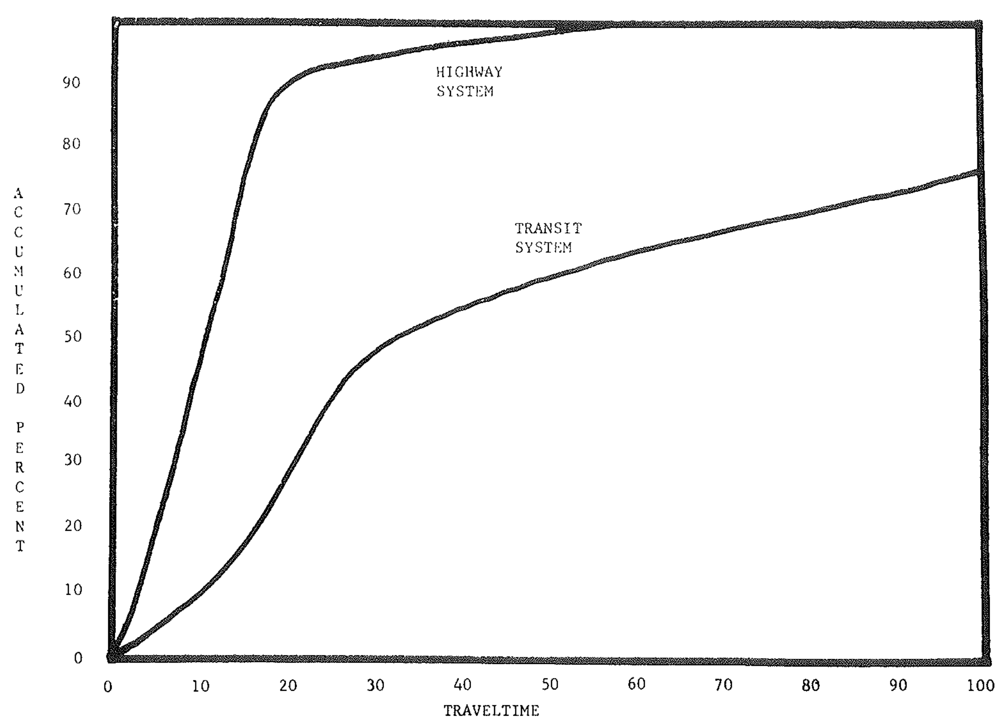


FIGURE 6 Accumulated percentage of total population versus travel time for major medical facilities *(5)*.

ridesharing or transit patronage. However, these types of analysis and display do not reveal the potential transportation savings that would result from provision of park-and-ride lots.

Selection of potential park-and-ride sites for further study can best be achieved by assigning journey-to-work vehicle trips to a transportation network and examining the link volumes that result. Destination areas with large numbers of workers are then selected and trips from all origins to the selected destinations are assigned. (The selected destinations can be combinations of downtown zones that include approximately 1 mile² each, but destinations outside the central business district (CBD) that have large concentrations of employment should also be examined as sources of park-and-ride use.)

Difficulty arises because traffic assignment programs traditionally assign trips from a single origin to all destinations. To do the reverse, assigning trips from all origins to a selected destination, would prove costly. To overcome this problem, the journey-to-work trip table derived from the census can be reversed so that the workplace appears as the trip origin and the residence appears as the destination. Concentrations of these trips on individual links of the network indicate potential locations for park-and-ride lots.

The Urban Transportation Planning System (UTPS) programs of interest are UMATRIX and UROAD. UMATRIX is used to reverse the trip table. UROAD assigns trips from selected origins to all destinations.

Bus Routing and Circulation Analysis

Journey-to-work trip tables contained in Part IV of the UTPP provide information useful for analysis and evaluation of bus routing and circulation.

Figure 7(a) shows an example of what might be a current CBD routing of a bus from an outlying market area. The information in Part IV of the UTPP allows identification of transit trips from the market area to each zone within the central area. CBD zones with high proportions of journey-to-work destinations from the market area are then identified. Generally they are zones with an aggregate of 70 percent of all CBD destinations from the market area. Depending on local conditions, those zones might be selected that have at least a given percentage of total destinations (15 percent in the example shown in Figure 7). Using block-group information at the

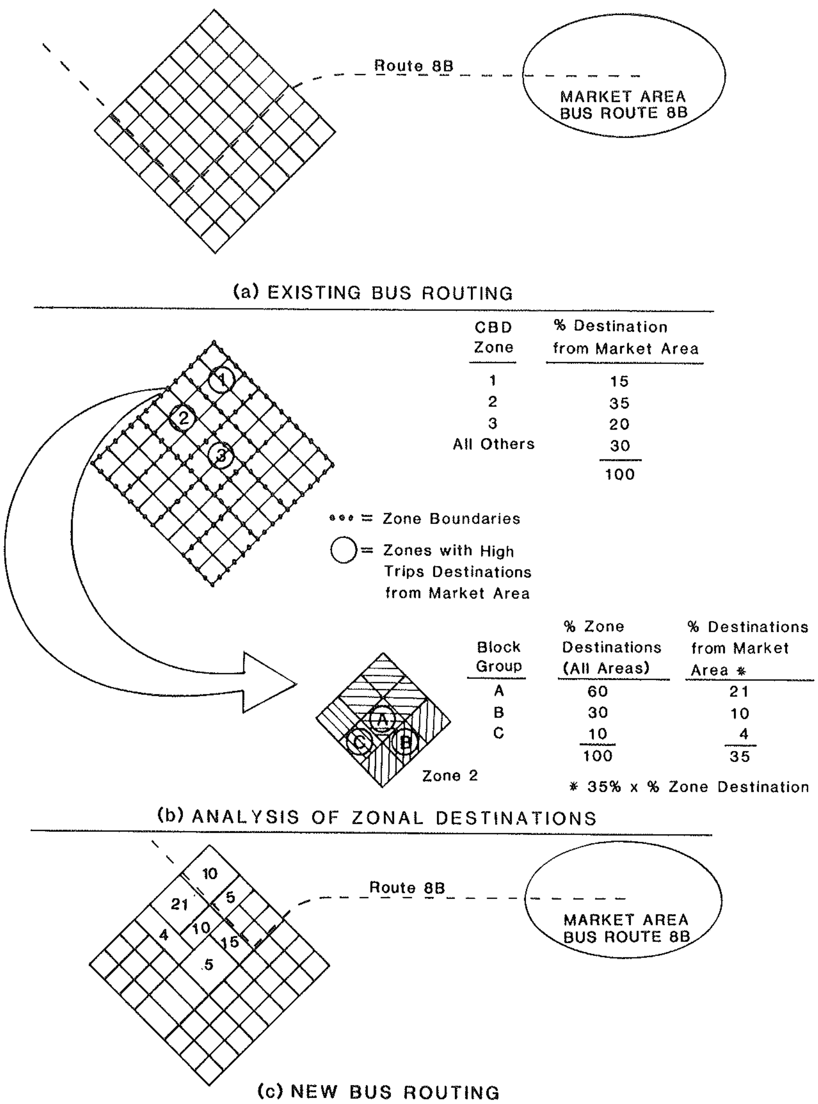


FIGURE 7 Downtown bus circulation analysis.

workplace from Part V of the UTPP, zonal destinations can be further subdivided for a more detailed geographical display, as in Figure 7(b). The existing bus route can then be matched to these destinations to determine how current service might be improved, as in Figure 7(c).

Similar analysis can be done to determine optimum bus routing to a location outside a central area, such as a major industrial park or other region of high employment. Such a case is represented in Figure 8. A bus route through the CBD into an outlying area is show in Figure 8(a). Transit work-trip destinations (from Part IV of the UTPP) in the region outside the central area are plotted by zone. This is done for the origin market area for each route to be examined. The existing routing is then compared with the distribution of destinations to determine whether route changes are advisable. For this type of analysis, zones are generally appropriate areas of aggregation, although in some instances subdivision of destinations by block groups as described for Figure 7 might also be appropriate.

The transit system might already serve the destination concentrations thus plotted by use of transfers in the downtown, but more direct through routing is generally desirable, as shown in Figure 8(b), and is likely to attract greater patronage.

High-Occupancy-Vehicle Lane Evaluation

Use of high-occupancy vehicles (HOVs) is often encouraged by reserving a special highway lane that allows faster travel than is possible for other traffic. In designing an HOV lane, one problem often encountered is determining where on the facility the special lane should start. Low traffic volume on the special lane might result if it is not placed at the proper location.

Journey-to-work information from the census is most useful in making this decision. The trip table in Part IV of the UTPP can indicate those residence-to-work movements that are most likely to use the roadway being considered for an HOV lane. The trips selected for examination should be those by vehicles carrying more than one person. These vehicle trips would be accumulated along the facility through a manual assignment based on visual inspection of the best route. The accumulated volumes suggest where the HOV lane should start. Figure 9 shows how the volume might be indicated.

It should be noted that this procedure identifies existing carpools only and fails to acknowledge the potential-carpool market. The institution of an HOV lane itself is likely to encourage a shift to carpooling, and this should also be addressed before a

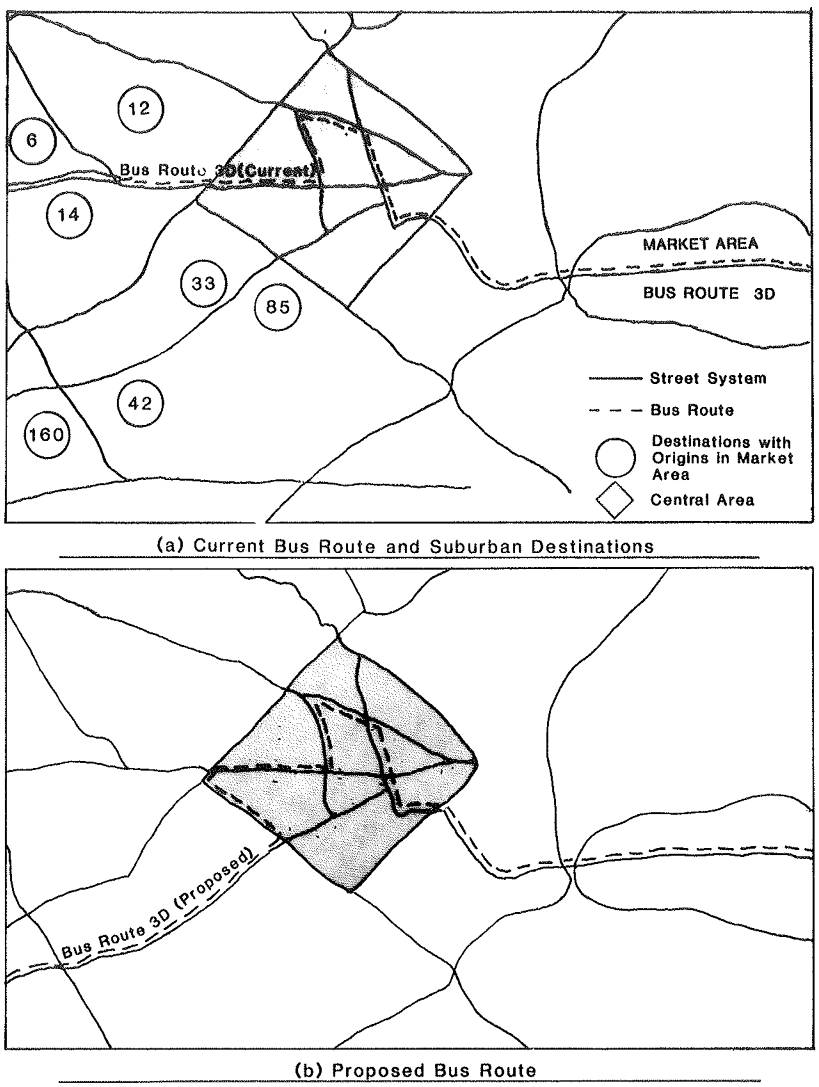


FIGURE 8 Bus routing analysis.

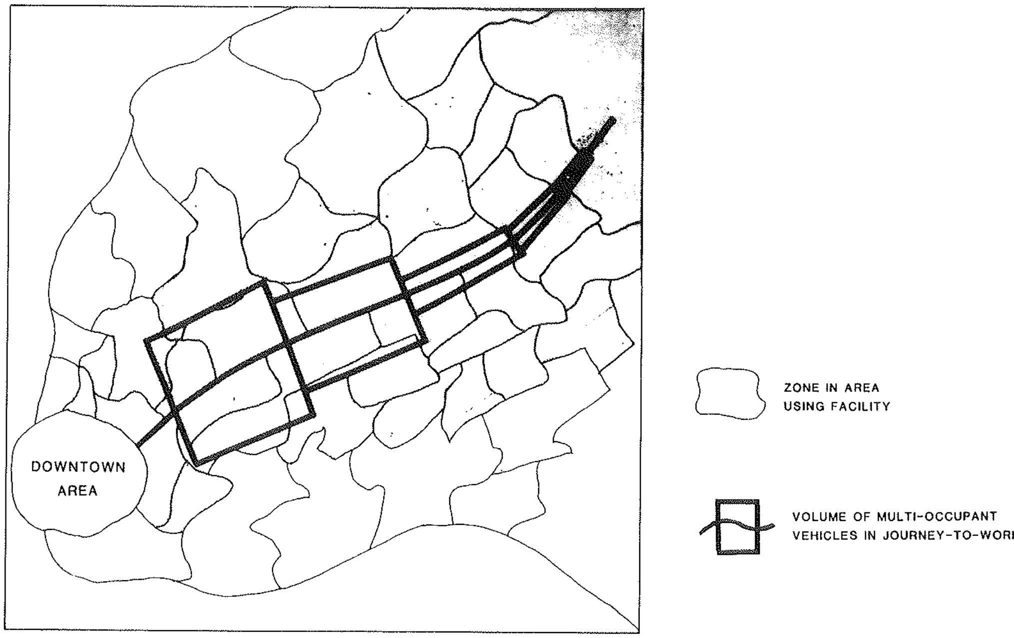
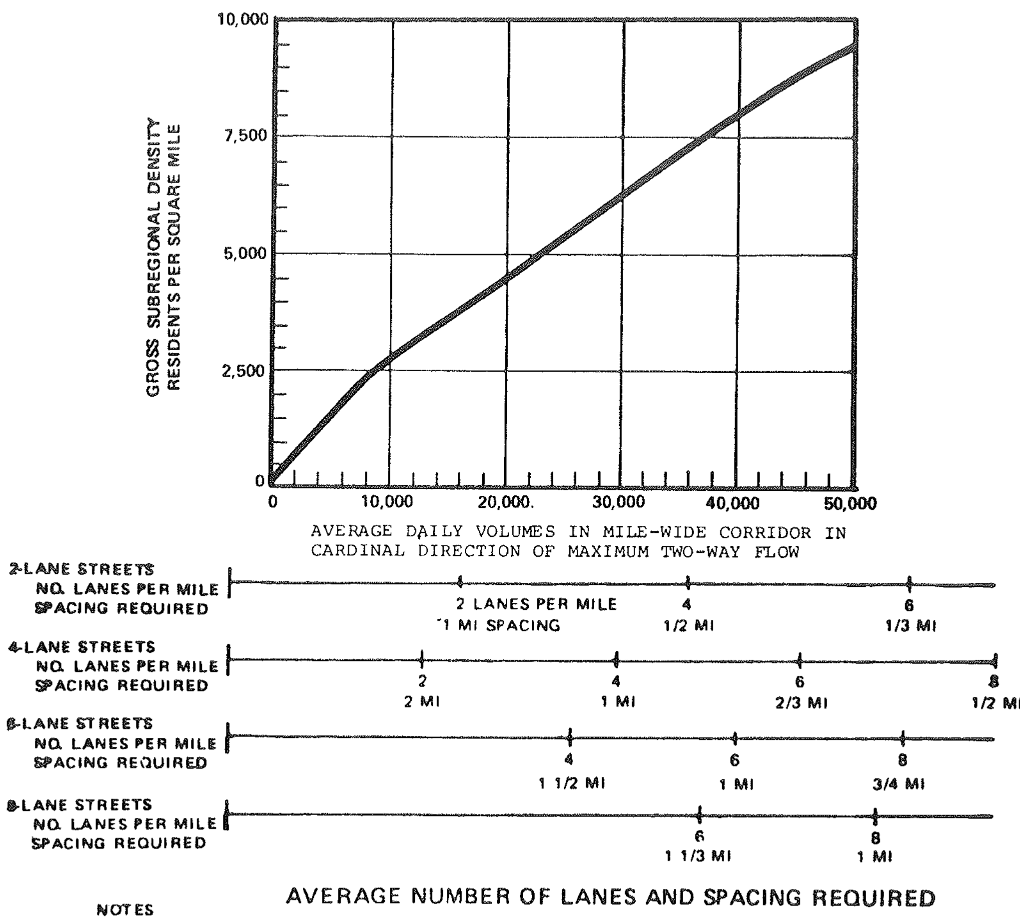


FIGURE 9 HOV-lane vehicle accumulation.



NOTES
ASSUMES:
UNIFORM DENSITY PATTERN OF RESIDENTIAL AND NON RESIDENTIAL DEVELOPMENT
SOME DELAYS AT PEAK PERIOD (LEVEL OF SERVICE "C") AND KD FACTOR OF 5.2%
TRANSIT USE: 3.5% OF ALL PERSON TRIPS OR 7.0% OF PEAK HOUR TRIPS
AUTO OWNERSHIP: 1.3 AUTOS DWELLING UNIT
MEDIAN HOUSEHOLD INCOME $7,000
UNIFORM GRID PATTERN OF STREETS (NO FREEWAYS)
DIRECTIONAL BALANCE OF TRAVEL WITHIN LARGE URBAN REGION.

FIGURE 10 Chart for subregional density versus average volumes and lane requirements for arterials *(6)*.

final decision is reached as to where the HOV lane will start or end.

Land Use and Arterial Spacing

A technique developed by Gruen Associates has proven useful in evaluating the impact of a proposed traffic generator (shopping center, industrial park, airport, etc.) on the highway system surrounding the development (6). The procedure can also be used to estimate arterial requirements in developing suburban sections of metropolitan regions where growth potentials offer a broad range of planning opportunities.

Figure 10 (6) shows the first step, an initial approximation of average traffic volumes adjusted by factors based on

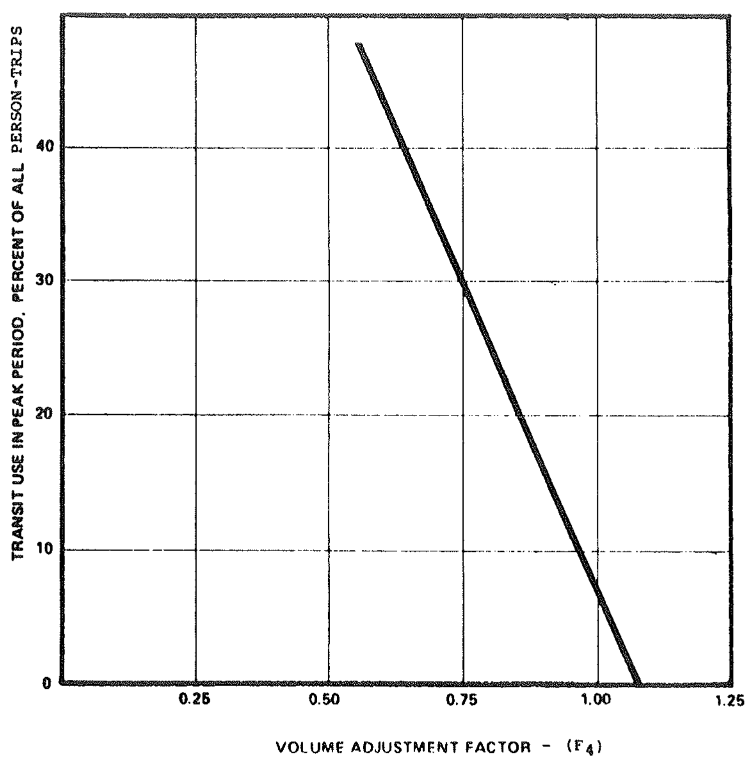
- Density and project size,
- Level of service,
- Automobile ownership,
- Transit utilization,
- Project and nonresidential or residential mix, and
- Freeway diversion.

The average number of lanes and the spacing required are derived from an estimate of gross subregional density in residents per square mile by using population data from the census divided by the area measured from a map. Many of the adjustment factors (for automobile ownership, household income, transit utilization, nonresidential or residential mix) can also be obtained from census data (e.g., UTPP Part I for residential and UTPP Part III for workplace data). The pertinent adjustment curves are shown in Figures 11-13 (6). Those interested in using this technique should refer to the FHWA report (6).

Selected-Link Analysis

In many locations traffic problems arise from the interactions of major movements through a section of highway or arterial roadway. Selected-link analysis is a useful tool for identifying these major interactions and can be performed using origin-destination data available from Part IV of the UTPP.

Although many selected-link applications are accomplished with computer programs available in PLANPAC and UTPS, evaluations of a small number of locations can also be done manually with a map and the journey-to-work trip information from the UTPP. This can be accomplished by determining from census data the origins and destinations of those trip movements that use the section of roadway being examined. The trips are then assigned to the section and accumulated in a fashion that allows evaluation of major movements.



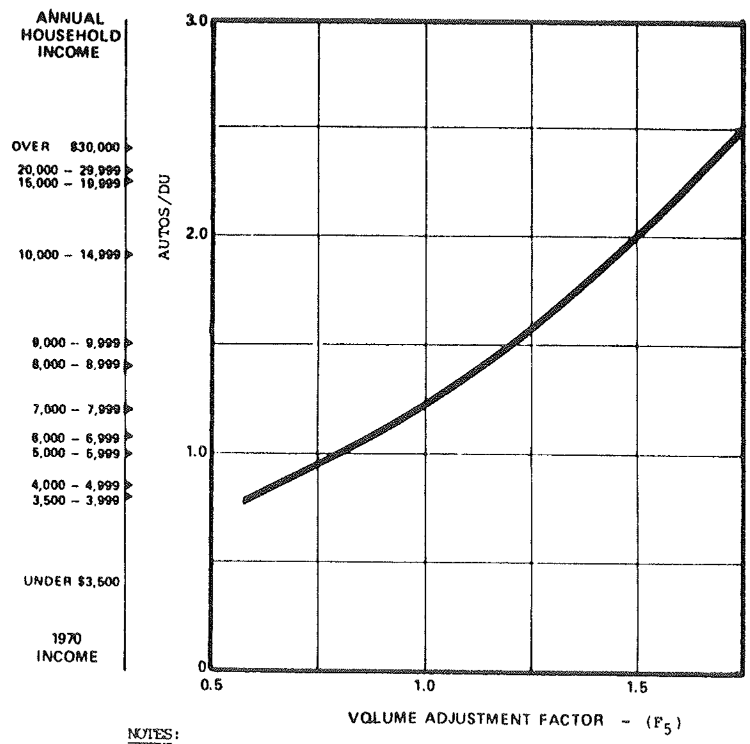
NOTES:

Assumes peak-period transit use of 7% for base condition.

Peak-period transit use of 7% is equivalent to 3.5% of all daily person-trips.

If any adjustment factor of under 0.85 is obtained from above, do not apply an adjustment factor from Figure 107 unless factors are determined to be independent.

FIGURE 11 Adjustment factors for land use: factor F_4 for transit utilization *(6)*.



NOTES:

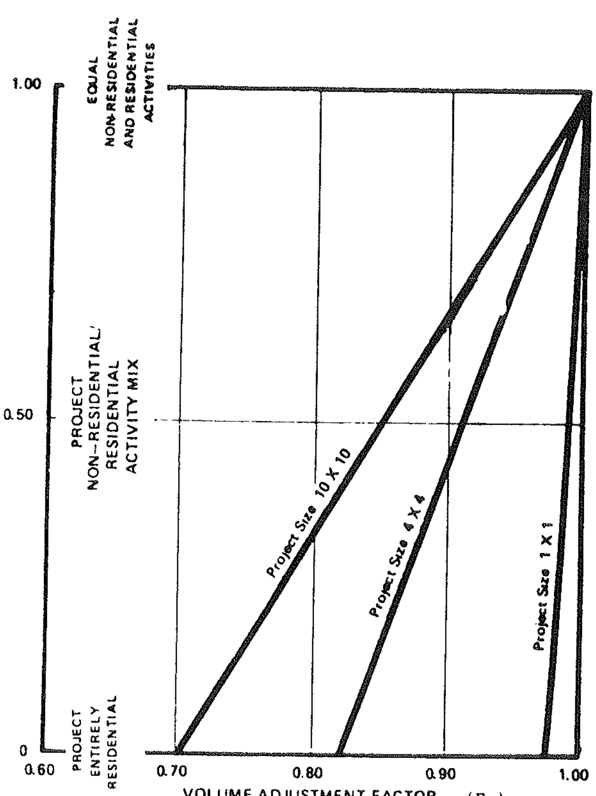
Use autos/DU as the primary parameter for volume adjustments.

Use income scale for approximation only if autos/DU data not available.

Income scale is non-linear.

See Figure 106 note concerning combined use of Figures 106 and 107.

FIGURE 12 Adjustment factors for land use: factor F_5 for automobile ownership and household income *(6)*.



NOTES:

Assumes uniform density pattern of residential development and project containing residential plus nonresidential development.

Assumes uniform grid pattern of streets (no freeways).

Assumes directional balance of travel in large urban region.

Project nonresidential/residential activity mix is defined as the number of jobs provided within project, divided by labor force within project.

For predominantly nonresidential projects (i.e., activity mix greater than 1), use of trip generation tables in Chapter 2 are recommended instead of Figure 108.

FIGURE 13 Adjustment factors for land use: factor F_6 for project nonresidential and residential activity mix *(6)*.

REFERENCES

1. Preparation for the 1980 Census. ITE Journal, March 1979.
2. R.C. Stuart and M.R. Hauck. The Census and Transportation Planning: Survey of Evaluations and Recommendations as to the Usefulness of the 1970 Census Data in Urban Transportation Planning. FHWA, U.S. Department of Transportation, March 1976.
3. Census Computer Programs: An Introduction to Management. Public Technology, Inc., May 1981.
4. Corradino, Coomer, and Upshaw. Successive Overlays: A Small City Transit Surveying Process. Traffic Engineering, Dec. 1974.
5. Special Area Analysis. FHWA, U.S. Department of Transportation, Aug. 1973.
6. Gruen Associates. Land Use and Arterial Spacing in Suburban Areas. FHWA, U.S. Department of Transportation, May 1977.

Model-Related Uses of Census Data for Transportation Planning*

ARTHUR B. SOSSLAU

ABSTRACT

Census data can be used in the application, calibration, and development of urban transportation planning models. A number of such uses are discussed.

The Urban Transportation Planning Package (UTPP) contains data essential to the application, calibration, and development of planning models used to analyze and evaluate complex transportation systems in both large urbanized areas and smaller areas that have fast-growth opportunities. The availability every 10 years of fresh census data on the location and characteristics of both population and employment is of critical importance. Without this information travel demand models would become obsolete and consequently useless tools in the transportation planning process.

Model-related uses of census data, census processing, analysis software, and procedures are discussed as well as factors that can be used to convert daily work-trip totals to levels of travel during peak hours.

TRANSPORTATION PLANNING USES

Following are uses to which census data can be put in the application, calibration, and development of urban transportation planning models.

1. Application
   a. Current socioeconomic data can be used as input to determine current trip generation with existing models (i.e., population, dwelling units, income, vehicles available, employees, etc.)
   b. Census data can serve as a 1980 benchmark against which updated long- and short-range land use and socioeconomic data may be checked
   c. Information from responses to journey-to-work census questions can be used as a secondary source for checking the validity of trip-length frequency distributions, trip ends, and work-trip tables
   d. The census supplies basic information required for some regional growth models
2. Calibration and development
   a. New trip-generation models can be developed using the basic relationships for work trips and secondary relationships for other purposes (e.g., car availability as related to income and household size) derived from census data
   b. Recalibration or checking of work-trip distribution calibration factors (e.g., gravity model F- and K-factors) can be done with journey-to-work trip tables derived from the census
   c. Work-trip mode-choice models, either direct demand or logit formulation, can be developed or recalibrated based on census data
   d. Existing work-purpose-related travel models can be verified or calibrated through accumulations of journey-to-work trips by mode across corridors, cut lines, and cordons around areas such as the central business district (CBD)
   e. Factors and procedures can be developed to convert the journey-to-work census information to peak-hour work travel, which in turn can be converted to all-purpose travel and to all-purpose peak-hour travel

*From Transportation Planners' Guide to Using the 1980 Census, FHWA, U.S. Department of Transportation, Jan. 1983.