CONFERENCE PROCEEDINGS 4

Decennial Census Data for Transportation Planning

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APPENDIXES

Summary and Conclusions

This document summarizes a conference of state and metropolitan planners, researchers, public officials from all sectors of government, and individuals from the private sector held to review the transportation community's experience with the 1990 census and to begin assessment of future needs and preparation of recommendations for the next census. This report is the third in a series. Previous meetings were held in Albuquerque, New Mexico, in 1973 and Orlando, Florida, in 1984 to assess the respective decennial censuses.

Overview and Context

The context in which this meeting occurred was in many respects more fluid and more complex than in the previous meetings. The context is made complex both by changes in the transportation environment and in the planning for the decennial census.

Past meetings had the characteristic of operating with a given census structure and format. Given that structure, the planners assessed their experience with responses to questions developed in the previous census, considered revisions of those questions, and debated the merits of additional transport-related questions in the upcoming census. Another concern of past conferences, typically, was the development of better mechanisms for tabulating and disseminating the data. The process was incremental and orderly.

In the new context both the nature of travel and the demands made on the transportation planning process itself are changing, but, most significantly, the real change in context is wrought by prospective changes in the nature of the decennial process itself. The following briefly summarizes the character of the new context.

Nature of Travel

The key concerns of the journey to work process are changing in significant ways. The movement of women into the labor force in large numbers has brought to light important travel characteristics that perhaps were previously more latent. Among these is trip chaining, wherein commuters make stops for ancillary purposes on the way to and from work. Another facet of the changing character of work travel centers on the stability, the regularity, of the work trip, in terms of frequency, time, mode, and almost every other aspect of the trip. Other factors of change were identified in the conference activities and are treated elsewhere in this document.

Nature of the Planning Process

The transportation planning process is undergoing substantial change in many respects. Legislative changes, including new transportation legislation [the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA)] and the Clean Air Act Amendments of 1990 (CAAA), give metropolitan and state planners new powers, new resources, and new responsibilities. Much of the focus of these new enactments is on the work trip. Among the current concerns in planning related to the census journey to work are the following:

- Demand management planning,
- Carpool facility planning,
- Transit planning,
- Air quality management, and
- Congestion management systems.

Nature of the Census Process

By far, the biggest change in context for the meeting was the prospective changes in decennial census structure. Fundamentally, it appears that the Congress, and the Bureau of the Census itself, has concluded that the past census[1] was too expensive and too ineffective in key respects and that the next census, if operated in the traditional fashion, will be an expensive failure. A major factor in these decisions has been policy conflict over the handling of differential undercounts in the census and whether there are mechanisms that can resolve these deficiencies.

The Bureau of the Census staff has developed alternative approaches at this early stage, including a very simple census focused exclusively on the constitutional need for a simple count of individuals, or on congressionally mandated purposes, or a continuous surveying process that could be cumulated over time to sum to a census-equivalent level of observations. All of these would affect the ability of the census to support transport planning. Other options are being considered, many of which would also substantially change the transportation utility of the decennial census. Whereas all of this must be of serious concern, it also must be recognized that it is very early in the decennial planning process. It is entirely possible that after careful consideration more moderate proposals for change will emerge.

Consequently, the approach taken in this document is to proceed along two avenues. The first assumes a "business as usual" census in which incremental changes in the transportation-related elements, or other elements of the census, would be appropriate. The second avenue is characterized by an approach that examines the census alternatives that are under consideration, in terms of their effects on transport census data needs. All of this militates in favor of another meeting of the conference participants later in the decade, after the census alternatives have been further refined and plans for 2000 have come closer to a final design.

Objectives

The objective of this conference was to bring together national experts to

- Review the existing federal, state, and local transportation statistical systems with respect to recent changes in law and regulations concerning the need for different, improved, or changed statewide and urban area transportation data for policy, planning, and administrative purposes;
- Evaluate the ability of the data products from the 1990 census and the Census Transportation Planning Package (CTPP) to help state and metropolitan officials meet the planning and analysis requirements of CAAA and ISTEA and determine what data products should be

provided from the 2000 decennial census, including the degree of accuracy required and the geographic framework necessary for these purposes;

- Discuss alternative solutions in determining realistic and balanced supplemental data collection programs for both statewide and urban needs that will allow the identification of the proper detail and level of accuracy of the entire data collection program;
- Share information on applications across user groups nationwide; and
- Identify research needs to aid in the proper determination of data programs, both census and supplemental data, and to allow for the development and implementation of a universal transportation data set based on the data collected in the decennial census considering recent legislation affecting the movement of persons.

General Findings and Recommendations

- *Changes in the policy context for urban and state planning make census data more crucial than ever.*

The state and metropolitan planning programs mandated by ISTEA and CAAA create a new planning context, including a mandate for comprehensive statewide planning. These programs, heavily oriented to commuting and peak-hour issues, reemphasize the demands made on the census data package for highly detailed data provided in a flexible geographic format. Symbolic of that fact was the very practical decision to produce the metropolitan area tabulations in descending order of air quality of the subject areas, with the areas of worst air quality receiving their packages first to more quickly respond to clean-air planning mandates.

- *The 1990 Census products represent a new era in the development of data and the tools to use the data.*

Several changes make the 1990 CTPP an extraordinary step forward. The most significant of these, without question, was the development of a set of tabulations with comprehensive national coverage (i.e., all areas of the nation were represented in special tabulation coverage). In addition, the development of separate state and metropolitan packages, centralized funding of the program, and the production of the tabulations on new compact disc ROM technology all represented institutional breakthroughs.

Two innovative technical advances in place-of-work coding were made for 1990. The first was the joint development by the Census Bureau and the U.S. Department of Transportation (DOT) of the Census/Metropolitan Planning Organization Cooperative Assistance Program. This program gave local metropolitan planning organizations (MPOs) the opportunity to assist the Census Bureau in improving the accuracy of place-of-work data for their regions. Planning organizations took part in three activities: providing files of employers and their locations to the Census Bureau, working with major employers to ensure that their employees reported accurate workplace addresses, and assisting the Census Bureau in coding place-of-work responses that census clerks could not code. More than 300 MPOs took part in these cooperative activities. The Federal Highway Administration (FHWA) made the costs incurred by the MPOs for this work an eligible activity for use of Federal-Aid Highway Planning Funds.

The second advance in place-of-work coding was the implementation by the Census Bureau of an automated place-of-work coding system. Place-of-work addresses were keyed to create machine-readable files that were then matched to address coding and major employer files to assign geographic codes to the place-of-work responses. Cases that could not be coded on the computer were sorted and clustered and referred to clerks for research and computer-assisted coding. The automation of place-of-work coding allowed the Census Bureau to accomplish the coding operation efficiently and cost-effectively.

- *The American Association of State Highway and Transportation Officials (AASHTO) deserves commendation for its role in developing a compatible national product.*

AASHTO made many of the innovations identified in the previous paragraph possible through its centralized funding of the tabulation process and its organization of coordination activities. Other agencies played notable roles as well. FHWA played its traditional design and training role, and the new Bureau of Transportation Statistics (BTS) provided the technological skills and resources to develop the CD ROM products.

• *Prospective changes in the decennial census program for 2000 represent a very serious threat to the viability of state and metropolitan planning programs mandated by Congress.*

In this environment, in which policy mandates from Congress have made immense data demands on local planning institutions, Congress and Census are considering approaches to the 2000 census that would eviscerate the planning capability provided by that data set. Apparently because of a sense that the past census was a technical, institutional, and financial failure, proposals would reduce the census to the few questions essential to redistricting every 10 years. Most such approaches leave the transportation planning profession without its fundamental data source at the levels of observation density that make it an effective planning tool. *The transportation planning community certainly does not view the 1990 decennial as a failure*. The quality of the product has been found to be high, superior to previous decennial products. The responsiveness to user needs of the agency itself has been high. The current program is highly effective. Census plans for 2000 must be watched carefully as they evolve over the next few years to ensure that they recognize state and local planning needs. Any alternative must be tested against its ability to respond to transportation requirements.

• *Geographic detail is the centerpiece of census capability.*

The conference again confirmed, both implicitly and explicitly, that this program represents a very important product to the profession and that the fundamental element that makes it all worthwhile is the availability of statistics at small areas. The small area data, provided in flexible geographic area formats defined by users, such as traffic analysis zones (TAZs) and planning districts, is the core of the census capability. Any proposed census alternative must be tested against that requirement.

Decennial census data for small areas such as census tracts and TAZs are used to meet the provisions of ISTEA, which require a comprehensive transportation planning process at both the state and metropolitan levels. The census provides the baseline origin-destination data on local work trips, household characteristics, and worker characteristics for use in travel forecasting models and for monitoring carpooling, public transit use, and other travel behavior. These data are now provided to all the states and metropolitan planning agencies in the CTPP at a cost of only $10 per 1,000 population, or 1 cent per capita. Funding for the CTPP comes through ISTEA.

• *The need for companion data collection to support the census capability is reinforced by new trends.*

The evolution of the dynamics of transport planning, especially air quality analyses associated with that planning, generates an expanding data requirements environment. Many of the new requirements could be best met by census data. The transportation community will examine its evolving data needs conscientiously over the next few years, as the census plans go forward, to refine these needs and establish the feasibility of census alternatives for their collection. As valuable as the work travel sources are, the increasing importance of nonwork travel and traditionally off-peak travel must be recognized.

• *Agencies, such as DOT, can provide supporting funds and other resources for the development of census tools and products but must leave funding of the core decennial census program within the control of the Department of Commerce.*

The last census has been an expensive undertaking, and the next can be predicted to be more so. Every effort that can be made to reduce program costs without compromising data availability and quality should be strongly considered. However, in a larger sense, the funding required seems small alongside the benefits generated and the scale of programs affected (e.g., the $150 billion ISTEA program, which leverages another $250 billion to $300 billion in local and state funding). Whereas the programs that benefit from the census could certainly fund it, as has been proposed from time to time, this would produce an unworkable situation where program responsibility and financial responsibility would be separated. A more effective working arrangement is to keep funding responsibility with the design and management responsibility and let user agencies focus on developing the requisite supporting tools and capabilities.

DOT has sponsored the preparation of special journey-to-work tabulations from the decennial census in 1970, 1980, and 1990. Of the more than 70 similar efforts conducted by the Census Bureau across a wide variety of programs and topic areas, the CTPP is the largest. Through AASHTO, states and MPOs coordinated their needs to sponsor these special tabulations, resulting in the $2 million budget for the Census Bureau to prepare the tabulations. This sponsorship reflects the level of demand for transportation and mobility data and the reliance on the census to provide this information.

• *Mechanisms for the continuing refinement of transportation agency–Bureau of the Census coordination of efforts need to be established.*

Nothing is a greater challenge than developing coordinated programs among federal, state, and local agencies. The CTPP process and all the development activity around it have been a model of effectiveness. But there is still room for substantial improvement. The Bureau of the Census must examine its procedures to ensure greater cooperation with local agencies so that the expertise of those agencies is brought to bear on practical program development issues.

An extensive period was set aside for questions and answers after the presentations. The following summarizes some of the points raised in that period.

• Initially, Congress indicated that only data required by statute would be collected in the 2000 census. This was later revised to include data required to be collected, but not limited to data statutorily mandated. Content decisions will not be made until 1997 and will not be made final until 1998.

• This could generate a spate of legislation to mandate needed items. The reauthorization of the surface transportation legislation in 1997 could mandate that the census obtain journey to work data items.

• There is a concern for "method" leading the census design process rather than "content." Methodological decisions might preclude later choices on content.

• An issue regarding continuous measurement is whether Congress will sustain interest and therefore sustain funding over the long term.

• Continuous measurement would yield the same data for rural and metropolitan areas over time as the present process. Data would be summed over 60 months to get reliable responses, and therefore the questions could not be changed unless that threshold were met.

• There is not yet a clear sense as to whether other users are as concerned as transportation users. One of the differences is the strong modeling capability put in place by MPOs, which is oriented to the present data structure.

• The biggest factor in the design of the next census may well be how each alternative deals with poverty statistics.

• There could be conflicts over continuous measurement because of the policy implications of cumulated data over time versus annual observations.

• The concept of matrix sampling has some appeal but is complex and needs testing and clarification of details.

• There needs to be greater involvement of the MPOs with the Bureau of the Census to build the coding reference materials needed for conducting the census. It would be very difficult to sustain this, however, as an annual process. The ability to sustain the work address files on an annual basis is even more problematical. Census is considering sharing the Master Address File (MAF) information with localities.

DETAILED FINDINGS AND RECOMMENDATIONS

Content

Socioeconomic Areas

- 100 percent census items: There were no specific recommendations concerning the 100 percent census items other than to note that the Summary Tape Files (STFs) 1 and 3 that provide basic socioeconomic statistics are the backbone of planning and are just as crucial as the journey to work statistics. The general undercount in transit-oriented areas is the only major issue area noted.
- Sample items:

H13. How many automobiles, vans, and trucks of one-ton capacity or less are kept at home for use by members of your household?

○ None
○ 1
○ 2
○ 3
○ 4
○ 5
○ 6
○ 7 or more

There has been no indication of problems so far with loss of detail on cars, vans, or trucks in the 1990 census compared with 1980. At least provisionally this reduction in questions can be considered a success.

18. Does this person have a physical, mental, or other health condition that has lasted for 6 or more months and which—

a. Limits the kind or amount of work this person can do at a job?
○ Yes ○ No

b. Prevents this person from working at a job?
○ Yes ○ No

19. Because of a health condition that has lasted for 6 or more months, does this person have any difficulty—

a. Going outside the home alone, for example, to shop or visit a doctor's office?
○ Yes ○ No

b. Taking care of his or her own personal needs, such as bathing, dressing, or getting around inside the home?
○ Yes ○ No

There seemed to be general dissatisfaction with these questions. The view was that these questions were not useful for transit planning. No specific alternative designs were proposed. The overall recommendation was that the approach be carefully evaluated in the light of all user needs before 2000.

Transportation Items

General discussions of content indicated that there was greater concern for preserving the integrity of the existing system than for making major expansions in the level of detail provided or in new questions. One of the new topics concerning content was variations in the regularity of work travel and mechanisms to capture variation in time, mode, and location of work.

21a. Did this person work at any time LAST WEEK?
◯ Yes—Fill this circle if this person worked full time or part time. (Count part-time work such as delivering papers, or helping without pay in a family business or farm. Also count active duty in the Armed Forces.)
◯ No—Fill this circle if this person did not work, or did only own housework, school work, or volunteer work.—*Skip to 25*

b. How many hours did this person work LAST WEEK (at all jobs)? Subtract any time off; add overtime or extra hours worked.

______ Hours

It was believed that change was needed here. A need was expressed to modify these questions to identify multiple jobs held by individuals. This was a confirmation of the recommendation from the 1980 census review. A similar view holds that Part 21b should be revised so that the hours worked per week in each job could be obtained. The growth in variability of jobs per capita and job hours was noted, and further growth was expected to make this an important topic for 2000.

22. At what location did this person work LAST WEEK? If this person worked at more than one location, print where he or she worked most last week.
a. Address (Number and street)

____

(If the exact address is not known, give a description of the location such as the building name or the nearest street or intersection.)
b. Name of city, town, or post office

____

c. Is the work location inside the limits of that city or town?
◯ Yes ◯ No, outside the city/town limits
d. County

____

e. State __________ **f. ZIP Code** __________

Work location was viewed as the highest-priority item in the census transportation battery. Most participants agreed that the system for workplace description has finally been resolved and that revisions do not need to be considered. There was a recommendation made that if multiple jobholders were identified as recommended in Q21, each work address should be identified here.

Some discussion arose as in previous meetings concerning use of the census to collect travel data on trips made for other purposes. It was agreed that only school trips for those who were not workers might stand a chance of passing the test of feasibility.

Another possibility was an "access" question rather than a trip question (such questions as "How far is the nearest hospital, . . . , school, etc.?"). Given the interest in health care in many circles, this question, properly structured, could be a valuable addition to the sample data set. It was recommended that such questions be tested.

23a. How did this person usually get to work LAST WEEK? If this person usually used more than one method of transportation during the trip, fill the circle of the one used for most of the distance.

◯ Car, truck, or van	◯ Motorcycle
◯ Bus or trolley bus	◯ Bicycle
◯ Streetcar or trolley car	◯ Walked
◯ Subway or elevated	◯ Worked at home *Skip to 28*
◯ Railroad	◯ Ferryboat
◯ Taxicab	◯ Other method

If "car, truck, or van" is marked in 23a, go to 23b. Otherwise skip to 24a.

b. How many people, including this person, usually rode to work in the car, truck, or van LAST WEEK?

◯ Drove alone	◯ 5 people
◯ 2 people	◯ 6 people
◯ 3 people	◯ 7 to 9 people
◯ 4 people	◯ 10 or more people

A number of topics arose concerning the mode to work questions. Some of these topics can be seen as hardy perennials that have arisen each time the topic has been discussed; others represent new concerns resulting from evolving demographic trends.

Many of the issues about mode coding concern transit. One concern is to obtain all modes used in the work trip rather than the mode used for most of the distance. A variant of this approach is to obtain access modes to transit where transit use is indicated by the respondent. It was pointed out that Bureau of the Census tests of collecting all modes to work had proven to be "a disaster." It also was pointed out from data generated in the Nationwide Personal Transportation Study that multimode work trips are very small in number and, like the access to transit factor, are heavily oriented to just a few large cities.

Another recommendation with a transit orientation was to consider use of local terms for transit operations in each area of the nation. The words metro, muni, train, and so forth have distinct meanings in different parts of the country. This, it was noted, would be in keeping with the bureau's goal of making the questionnaire more user friendly. This has been done in phone surveys. Although it would add to logistics costs, it could be an important factor in improving the quality of transit responses.

With regard to Question 23b, it was suggested that if question space were at a premium, the number of detailed categories for carpooling could be reduced. This suggestion was tentatively supported. It was noted that four-person carpools had dropped from 1.4 million to 0.7 million between 1980 and 1990, and that five-or-more-person carpools had dropped from more than 1 million to less than 0.6 million. A final decision could be made after more areas had received and could more thoroughly review their data. It was noted that carpooling data may be increasingly important because of road construction limitations under ISTEA.

A suggestion that was made and supported, at least conceptually, but not fully resolved as to method, was to obtain data on occasional use of modes. This included transit use by automobile users and vice versa, and also working at home on an occasional basis (e.g., once a week or once every 2 weeks). Ideas were discussed for capturing the statistics of occasional use. One option was to ask separate questions about frequency of use of these modes (e.g., "Did you use transit at all this week for a trip to or from work?" "No," "Yes, once," "Yes, twice," etc.).

24a. What time did this person usually leave home to go to work LAST WEEK?

______ ◯ a.m.

______ ◯ p.m.

b. How many minutes did it usually take this person to get from home to work LAST WEEK?

______ Minutes—*Skip to 28*

The topic of the restructuring of start time and elapsed time arose again. Experience with the new data from start times was limited, and all agreed that more experience was needed before any recommendation for change could be considered. It was noted that the tendency for work-trip travel time estimates to concentrate around 5- or 10-min intervals had effects on the time duration estimates. It was recognized that field test attempts at the alternative approach—obtaining departure time from home and arrival time at work—had proven ineffective.

Geographic Coding

There is a sense that the overall level of coding quality and sophistication in geographic representation of data has reached high levels. Improvement over 1980 has been noted. One of the benefits of the development of a statewide element of the CTPP has been that the outer edges of metropolitan areas now are represented statistically in the state package, providing a stronger capability for metropolitan areas in assessing growth in their fringe areas.

National coverage by TIGER has been good.

Remaining concerns are further links between transportation and census geography, both technically and institutionally. Among the recommended areas are the following:

- The ability to reconfigure units of geography at the block and block group level to establish new corridor areas is an important planning tool. A "point and click" capability to build transit analysis corridors is the kind of state-of-the-art idea that planners dream of. The Bureau of the Census must evaluate mechanisms to meet these needs.
- The introduction of TAZs into TIGER as a standard area system would give TAZs greater permanence and utility.
- The ability to have two area systems in the CTPP to represent a metropolitan area (for instance, TAZs and a different planning system) would enhance the use and flexibility of the package in individual metropolitan areas.
- Plans for cooperation between MPOs and the Census Bureau in upgrading mapping and coding materials and assisting with census address problem coding fell through in the last census because of disclosure concerns. MPOs were able to provide information input to the development process but were not permitted to play other, more active roles. The bureau must resolve these concerns and allow MPOs to assist in maintenance and address coding to ensure a superior product.

There is considerable variability in the level of maintenance of TIGER in different MPOs. The Census Bureau must get local governments more involved in coding and coding materials development to ensure access to local knowledge and experience. A starting point is better communication between the bureau and local governments and MPOs.

One of the issues in the cooperative program is whether addresses themselves are data items subject to disclosure protection in the interpretation of Title 13 that governs the bureau's ability to provide information. Many MPOs and the bureau would benefit from the sharing of the MAFs if this can be made possible. The Bureau of the Census should pursue all appropriate efforts to implement this sharing program.

Another need is the extension of MAF to business addresses. Residential addresses are necessary for locating households and distributing questionnaires, but business addresses are also a crucial element in the geographic system development process. It is recognized that business addresses would add a new level of complexity, because a business address inheres in the name of the organization rather than in a physical space. But it is an essential ingredient in a viable overall program.

There is concern that any attempt at a continuous measurement system for the census would have to mandate a parallel continuous update system for geographic coding materials. This would place a substantial burden on local support operations. It is not clear that resources are available for such an activity. Whereas the idea of a continuously updated geographic base system rather than one updated every 10 years has merit, the costs and the staffing required could be well beyond the capabilities of many organizations. The costs of this activity have to be factored into any assessment of continuous measurement options.

Institutional and Administrative Items

Although it is still early in the process of obtaining and using the CTPP, there was uniform support for the process and the overall program. AASHTO, in particular, was singled out for its institutional and administrative initiative in creating a nationwide, "wall-to-wall" system of census data and facilitating the state funding of that program. The following treats some of the topics of current concern and then looks forward to consider likely future issues.

Products—Scope and Timing

The number of tabulations has grown substantially from the 43 produced in 1970. After all segments of the user community have had the opportunity to gain experience working with the CTPP, they should determine which tables are not being used, so that design decisions for 2000 can be based on that experience. A significantly smaller core package, more modular and with more user-friendly access, could accelerate delivery in the future.

Users, especially new areas, have had difficulty obtaining comparable data from previous censuses so that trends can be developed. It is recommended that the Bureau of the Census and BTS seriously consider producing any future tabulations accompanied by previous years' tabulations (i.e., 1990 and 1980).

The timing of arrival of the census products is a perpetual source of concern. It has been the focus of discussion in every decade. Any actions that will facilitate the speed with which tabulations are delivered must be taken. It appeared that although transport needs were well accommodated in terms of being among the first to receive summary work files as input to the CTPP, time was lost because of the lack of programming personnel within the bureau. The ability of the BTS or other agencies to accelerate product delivery needs to be investigated. Recent experience with this approach has proven beneficial.

The staging of delivery of products, wherein the files were subdivided by state and MPO and a first, basic set of tabulations was provided to all users and then a second, more complex tier of products was produced and distributed later, proved to be effective and was strongly supported. It was noted that some of the STF materials, such as STF-5 (the county-to-county flow files), were extremely valuable despite their inherent limitations, simply because they were available so early. In the trade-off between speed of delivery and quantity of tables, speed of delivery is the more valuable. It was recommended that the staging approach be further extended to enhance the speed of delivery.

State data centers proved effective in distributing early products, such as the STF. Perhaps a role for them in facilitating distribution could advance delivery speeds to some users. The direct delivery of the products to the states and MPOs, who are the prime clients, must not be impeded.

Media

It has been learned over the years that the medium on which the transportation package is delivered changes very rapidly and is a key factor in the successful use of the package. In 1980 CD-ROM technology was virtually unknown, and advanced thinking focused on floppy disks. Users of the 1990 package have almost abandoned magnetic tape and prefer to wait for CD-ROM availability. Obviously, the preferred medium for product access in 2000 can only be guessed.

The view of the assembled group was that the stage will be set in 2004 for a less standardized product than the CTPP. Many users foresee that a direct user-specified "retail" tabulation approach will become typical, in which each state or MPO can specify its own tabular requirements via direct access communication with the Bureau of the Census and receive direct response. In this ideal environment, a standardized package of tabulations appears unnecessary or secondary, except for state and national summaries. It is also recognized that the technological capabilities have always moved faster than the institutional means to effectively use them.

Another option for the future would be to extend the current capabilities realized under Public Use Microdata Sample (PUMS), in which individual respondent records are made available with geographic identification limited to large areas of 100,000 to avoid disclosure. One concept, labeled contextual PUMS, would have local users turn over local data (such as walking distance to transit) to the census, to be entered into the PUMS file without local ability to identify the linked data in detail.

The centerpiece of all these concepts is the issue of disclosure of census data about individual respondents. Disclosure rules will determine how flexible a custom-built tabulation system can be. There has to be concern that two files designed separately without disclosure could be combined or subtracted from each other to permit disclosure. Disclosure concerns will control how small a geographical area will be permitted to be used for PUMS—so-called PUMAs. They will dominate the discussion of technologically determined access opportunities for the 2000 data.

As stated in the 1984 report, "It was recommended that new technologies such as on-line access to data be employed, permitting menu-driven data development with highly flexible output tabular formats. This would require, in addition to adoption of new technologies available now, automated suppression and disclosure analyses. It is these institutional restraints, rather than technological capability, that are currently the biggest obstacles to rapid access to census products in flexible format."

Other Institutional Issues

State Experience

State experience with the CTPP so far has been limited. Although it was noted that the journey to work is less crucial a factor at the state level, it was also clear that the socioeconomic data provided by the census had great value. As the new models, which incorporate the socioeconomic data from the census, are developed and brought into the state planning process, the data set will gain greater use and interest. States are still engaged in understanding and incorporating the new legislation and regulations into their programs. It may be years before all aspects of the changes are fully incorporated. The dependence of rural and small metropolitan areas on the census data was strongly emphasized. There are no alternative sources.

A number of states have already begun to use the data in innovative ways. Michigan has studied needs of the elderly and handicapped. California has used the data for economic development analyses. Maryland has linked vehicle registration data to the census. Colorado has used the data to target seat belt programs. In another state the data were used to assess jobs/housing balances by area of the state. One of the problems noted was that many states and small metropolitan areas had too few people with the appropriate skills to make the best use of the data.

A role for private marketers was identified—states could hire consultants to assist small areas with their local census data needs. Staff turnover was an issue, as was the lack of priority given to data analysis by policy makers. In recent years the programs of states and MPOs have tended to be less data intensive. The costs and the dedication of other resources to data development and use have to be recognized.

Training

As noted earlier, the profession lacks skilled people capable of dealing with these techniques. The training activities of FHWA and the Federal Transit Administration (FTA) have been beneficial. More needs to be done to extend that training to more people and to extend the capabilities for interpreting the data to higher-level managers. One weakness of the training process has been that the lack of availability of real data at an early stage has hampered training in general and case study approaches in particular. Software development that permits better data synthesis, such as CTIPS, is one approach that needs support.

Private-Sector Use

It was noted that the opportunities provided by the data for private uses had not yet been realized. Their value in siting facilities, such as service stations, banks, and fast-food outlets, has been noted. A recommendation for greater cooperation between NARC, state data centers, and others was made. It was also recommended that BTS and AASHTO develop cooperative programs to assist agencies that would not have the resources otherwise.

Research

It is recommended that Committee A1CO3 take the lead in defining the Transportation Research Board research agenda for the transportation-related elements of the 2000 census program. National Cooperative Highway Research Program and Transit Cooperative Research Program projects could focus on testing ideas for better arrangements and institutional mechanisms to help the Bureau of the Census, DOT, and the states and MPOs work together. The modeling applications of the census data at the state level are also a fruitful area for research.

Other research opportunities identified were

- The handling of multijob workers and how their hours and addresses would be treated,
- The option of school trip recording,
- Establishment of ways to measure occasional use of modes as well as variant times and days of travel,
- Assessment of the nature and scale of multimodal trips, and
- Assessment of the nature and scale of transit access trips.

Assessing the New Census Alternatives

As noted in one of the sessions, it was unclear whether the attitude of the group toward census alternatives was one of guarded optimism or guarded pessimism. There were misgivings among all participants. This is primarily a product of the view that the current census program is working well, particularly for transportation needs, and that the notion that the program is "broken" and needs fixing is incorrect. Even the costs cited for 2000 are minor relative to program scale and importance.

A key concern was that a "risk everything" approach to 2000 could prove disastrous without an appropriate safety factor of some kind. An improved, incrementally changed, "business as usual" census for 2000, but with a pilot program alongside of it running in parallel as in the recent revisions to the unemployment statistics program, was cited as a safer option. The workability of each of the proposals was strongly questioned. The sense of the group was that they would have to know much more about the options before even seriously considering, much less supporting, the new proposals. *Given the extreme risk to the nation of failure of any proposed alternative approach, it was recommended that the standard census approach, with appropriate improvements, be implemented in 2000 along with a parallel test of a continuous measurement process, so that by 2005 a continuous process would be in place. The costs of duplication would be far outweighed by the cost of failure.*

Comments regarding the main options were as follows:

Continuous Measurement

If the continuous measurement process is seen as a tremendously expanded Continuing Population Survey (CPS), it is difficult to disagree with it as a concept, but only if it is used as a supplement rather than a substitute for the decennial census.

Uncertainty is great about this approach as a census substitute. Questions include the following: Would costs rise to equal or exceed census costs? Can Congress's continuing annual support be assured? How often would output be available? How would averaging work? What is 5-year average automobile ownership, or automobile occupancy? Can average data be protected from annual reporting needs?

The approach is generally preferred to the matrix option.

Matrix

The matrix approach is seen as a hopelessly complex system as far as transportation is concerned. This may not be true for other census data users, but it could be typical.

The transportation package uses 100 percent items, sample demographic items, sample housing items, and the transportation items. It would have to be ascertained that all were embedded in the same sample structure to be workable. Linking across samples could be an insurmountable obstacle. The existing census has technical and institutional difficulty linking between housing and population items from the same survey. What would happen in a mixed framework? Previous experience with a limited approach to matrix sampling in the 1970 census, which used two samples of 15 percent and 5 percent, was, to be polite, very negative—"a disaster," according to one attendee. The sample structure would have to be designed to permit small area reporting for a combination of several items. Methods for imputation of data items for samples where specific items were not collected would have to be carefully evaluated.

Such an approach damages the ability to go to a PUMS individual record type approach in the future.

The one advantage of each of these approaches is that the amount of data to be collected apparently could be increased.

Action Items

There are a number of action steps that the various players need to take over the coming years as the 2000 census plans unfold. The census transportation planning program is a complex undertaking involving many institutions and participants—many federal agencies, all state departments of transportation, and many local governments and MPOs. The steps are as follows:

All Participants

Continue to work at coordination. Consider new mechanisms for closer coordination among participants.

U.S. DOT

- BTS needs to take the lead in decennial census matters, representing the interests of the transportation community and acting in coordination with other DOT agencies.
- BTS needs to develop contingency plans for the various options for the 2000 census. Specifically, it needs to develop the costs of alternatives that Congress may consider.
- FHWA and FTA need to assess MPO and transit agency needs and capabilities in terms of use of census data for transportation planning. Training aids and assistance and other tools need to be considered. Integration of the census data use process into the overall planning process needs federal assistance.
- DOT should consider a newsletter mechanism for disseminating information and maintaining contact among interested participants.
- DOT should strongly consider convening a new conference in 2 years.
- DOT should transmit these recommendations to the Bureau of the Census with its support.

Bureau of the Census

- The Bureau of the Census must recognize the number of programs and organizations dependent on it for information as it designs for the future. It must become more aware of and sensitive to the immense cost burdens it imposes on others by small changes in its programs. The transportation planning programs of the nation at all levels are heavily dependent on census products.
- Additional options for using outside assistance to program the special package should be considered. Joint DOT-Census approaches need fuller consideration. Current procedures in which BTS is funding support for Census staff to more expeditiously meet and resolve state and local problems with the CTPP can be a model.
- New options need to be considered in using outside assistance in producing mapping and coding materials at the local level. The support needs of local agencies should be recognized.
- Users should be kept involved and informed as planning proceeds for the 2000 census.

States and MPOs

- Support Census coding material needs.
- Obtain and train adequate staffs.
- Incorporate new data into new methods and capabilities.
- Assemble data and express needs for data as they evolve.
- Disseminate data broadly.
- Support Census data program requirements.

Congress

- The transportation authorities of Congress need to be better informed of the implications of proposed census changes for the transportation programs Congress has instituted.

Cost and benefits need careful examination in these programs. Cost savings in census programs must be balanced against immense cost increases in transportation programs.

- Congressional staffs should be better informed of overall transportation data needs.

NOTE

1. As a convention, the census, lowercase c, refers to the activity of counting the population every 10 years; Census, uppercase C, refers to the agency conducting that activity—the U.S. Bureau of the Census.

GENERAL OVERVIEW

Historic Uses of Census Data in Transportation Planning and Future Needs

Alan E. Pisarski, *Consultant*

The history of the census journey-to-work statistics and the supporting statistical package is a history of growth in sophistication and efficiency in both the technical capabilities and the institutions that support those capabilities. From its beginnings with the 1960 census to the present, first the metropolitan planning process and then the state process have become increasingly dependent on these data, including all of the supporting socioeconomic data from the census that provided flexible small area population characteristics for input to trend analyses and forecasts.

When the census journey-to-work program is described, it is best to differentiate at least three product areas to aid understanding: (*a*) the census socioeconomic data presented at user-defined small area geography; (*b*) Bureau of the Census-provided journey-to-work statistical products; and (*c*) the package of standardized tabulations produced cooperatively with the U.S. Department of Transportation (DOT), which has had various names over the years but is presently called the CTPP—Census Transportation Planning Package.

Table 1 briefly summarizes the historical landmarks along the four-census history of the journey-to-work package.

A vast array of issues confront the planner-statistician considering the future of the program. The central issues from the transportation side tend to fall into two groups. The first concerns changes in the institutional mandates that define the ways in which the census data are used, and the second concerns changes in the travel behavior that these statistics seek to describe. A third area concerns changes in the census program itself and how they may affect the ability to provide effective journey-to-work products.

The changes in the institutional context have been dramatic since the last design of census products. Among the changes are the Intermodal Surface Transportation Efficiency Act transportation legislation and the Clean Air Act Amendments. Both of these legislative enactments place substantial new planning and analysis demands on states and metropolitan areas. Much of the required planning is focused on journey-to-work characteristics and how they affect air quality. A major case in point is the emphasis on construction of carpool lanes, rather than simple road expansion, in the new federal legislation—the census data are the only viable source of carpool numbers and characteristics. All of the planning activity is heavily dependent on census socioeconomic statistics. Many of the mandated planning requirements have stringent time schedules, placing additional demands on the data development process. Another issue of some significance is the current conflict between states and the federal government

TABLE 1 Highlights in History of Journey-to-Work Package

CENSUS DATE	TECHNICAL CHANGE	INSTITUTIONAL CHANGE
1960	First data	First step
	Broad geography	OMB stimulus
1970	First data detail	First package—"UTPP" 43 tabulations
	Block-level geography	112 buyers
	First ACG/DIME	First-come-first-served
	Local TAZs	Caveat emptor
		First DOT funding
1980	More data detail	JTW staff
	Better geographical quality	Better geographical QC
	Imputation of JTW	Better UTPP delivery—150 buyers
		Cost—$2 million
1990	More data	Wall-to-wall AASHTO funding
	First state package	Cost—$2.5 million
	First CD-ROM	

concerning unfunded mandates—that is, demands made by federal enactments that place financial burdens on states, without federal assistance to defray the costs. The census-related package stands out as an example of the federal government taking practical action to assist states and metropolitan areas in responding to the costs of mandated activities.

The behavioral context is changing as well. The parallel development of the Nationwide Personal Transportation Study (NPTS), with its great breadth of coverage of travel behavior, has permitted insights into important facets of work travel behavior that need to be considered in census plans for the future. Future NPTS approaches, especially the ability of states and metropolitan planning organizations (MPOs) to purchase additional observations, provide a great opportunity. As we look to the future we will see significant changes that will affect our data needs.

One characteristic of many of these trends is the increasing need to understand the periodicity surrounding aspects of work travel behavior. What is required is a mechanism to provide a "test of regularity" of many of these aspects of work travel. These aspects are summarized briefly in the following table:

Area of Concern	*Characteristics*
Regularity of location	Different work sites, occasional work at home
Regularity of time/frequency	Occasional work at home, variation in time of departure, variation in days worked
Regularity of mode use	Occasional mode use, weekly variations, incidental use
Regularity of purpose	Linked trips, work trip chains

In effect, the methods of data collection have masked the variation, the periodicity, of many of the characteristics of work travel. Whether using a definition oriented to "trips made yesterday" or "trips usually made," the data collection process does not permit identification of trends in the regularity of work travel. There is suspicion that the degree of variation, such as that related to occasional working at home and the chaining together of trips to and from work, is increasing. There is also some reason to believe that occasional use of transit by "usual" private vehicle users can cause significant swings in the level of transit use.

In certain respects these trends can modify or mask the role of work trips in overall travel. They appear to make work travel both less and more important. For example, with trip chains linked to work trips growing in frequency, the share of work trips in the peak hour will decline.

There will also be increasing pressures to better understand the social issues associated with work travel. Among these issues is the so-called reverse-commuting behavior of inner-city residents seeking to follow job opportunities that have moved to the suburbs. There will be a greater focus on such social equity issues, including concerns about the work travel needs of women and the elderly.

When we look at the time frame in which our plans will operate, it is almost staggering. There are almost

- 6 years to the next census,
- 10 years to the availability of the next data set, and
- 20 years to a replacement of these data.

Thus, issues in 2014 will be treated with these data. An example of this is that we can be almost certain that by 2010 an important census question will be the type of fuel a vehicle uses, yet the question now appears to have limited value. We cannot assume that our census capabilities will automatically improve as computers advance. One only need recognize that the Bureau of Transportation Statistics today is trying to reestablish capabilities that existed at DOT in the 1970s to realize that movement is not always forward.

Given the span of time we will encompass with these data sets and the public investments and policies that will be affected by them, it is painfully clear that we cannot allow a casual approach to our data needs. We must think prospectively about our future program needs and the future data resources to meet those needs. The program of the Bureau of the Census that provides these valuable data every 10 years has become a trusted resource and a friend. We cannot squander the opportunity it provides. We cannot permit it to be lost.

The 2000 Census: A New Design for Count and Content Data

Robert D. Tortora, *U.S. Bureau of the Census*

The research program for the 2000 census is described and options for collecting count and content data are outlined. Count data are used to reapportion the United States House of Representatives and are the major data source for developing legislative district boundaries under the Voting Rights Act in each state. In all previous censuses in the United States these data have been collected by an enumeration of the entire population. However, since 1940 the Census Bureau has measured a differential undercount in minority/ethnic populations and for certain geographic areas, such as large cities. Content data, used by a wide array of government agencies, businesses, and institutions, are defined as the data historically collected from a sample on the census long form.

This paper is divided into two parts: (*a*) design features for the 2000 census count that are independent of content and (*b*) design features and options for data content.

The choice of design features not affecting content will be selected after a 1995 census test in three locations (Oakland, California; Paterson, New Jersey; and six rural parishes in northwest Louisiana) throughout the United States. Decisions affecting content design are on a different path. The content determination process ends in April 1997 when the Office of Management and Budget (OMB) and the Census Bureau recommend the final content to Congress. Federal data needs will be the major driver of content, but the Census Bureau will also obtain input from other government entities and other users of census data. In April 1998 the Census Bureau will recommend final wording of census questions to Congress. During that time period the Census Bureau will obtain input on the options being considered for content collection. In addition to use of a sample long form in 2000, the Census Bureau is conducting research on other ways to collect content. One option is to use multiple sample forms in 2000. Another option is to collect content through a continuous measurement survey—a survey conducted each month during the decade instead of the sample long form.

Census Design Features Not Affecting Content

The 2000 census research and development program began, in 1991, to consider options on how to fundamentally change census methodology. The overarching goals of the program were

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Opinions expressed in this paper are solely those of the author.

to develop design features that (*a*) reduce the differential undercount, (*b*) reduce or contain costs, and (*c*) provide for an open process by informing stakeholders of the current status of the research and obtaining their input and advice. However, the research and development program began because of the differential undercount and costs. Thus, the program was designed to fundamentally change census methodology to attain these first two goals. Why are fundamental change and these goals so important?

There are at least five motivating factors for fundamental change: changing societal trends in the United States, cooperation by the U.S. population in responding by mail to the census, the cost of the census, the differential undercount, and the two-stage decision strategy (i.e., deciding after census counts are provided for reapportionment and redistricting whether to adjust the census to reduce the differential undercount). These five factors are interrelated.

Societal Trends

Our society is changing. Between 1980 and 1990 the United States population grew by about 10 percent. However, the Asian and Pacific Islander population grew by 108 percent; Hispanics (of any race) by 53 percent; American Indians, Eskimos, and Aleuts by 38 percent; and African Americans by 13 percent. Other changes are occurring as more households are composed of unrelated individuals, the number of single adult households grows, and more individuals stay in more than one household. All of these trends make conducting the census with the methodology used in 1970, 1980, and 1990 more difficult and unlikely to improve the picture for differential undercount or costs.

Cooperation

Since 1970 the mail response rate has been declining. The 1970 rate was 78 percent, the 1980 rate was 75 percent, and in 1990 the rate was 65 percent. At the same time the number of housing units grew from 69 million in 1970 to 88 million in 1980 and finally to 102 million in 1990. So, in 1990 (as in 1970 and 1980) the Census Bureau was faced with sending enumerators to each household not returning a questionnaire by mail up to six times to collect the data. This nonresponse follow-up was the single most costly component of data collection—$450 million out of the total $1.3 billion for data collection.

Cost

The overall cost of the 1990 census was $2.6 billion, approximately $25 per housing unit. In 1990 dollars, the 1970 and 1980 censuses cost about $11 and $20 per housing unit, respectively. Assuming 1990 methodology and using estimates for housing unit growth, inflation, and productivity increases, the 2000 census will cost more than $4.0 billion. Especially in these times of fiscal restraint, this is a dramatic increase in cost that is unacceptable to many, particularly with the persistent differential undercount.

Differential Undercount

Since the Census Bureau began measuring undercount in 1940 (using demographic analysis, which estimates the population by starting with the last census count, adding births and immigration, and subtracting deaths and emigration), there has been a differential undercount of the African American population at the U.S. level. Table 1 compares African American undercounts with non-African American undercounts from 1940 to 1990 using demographic analysis.

Table 1 shows a declining but nearly constant difference in undercount rates from 1940 through 1980. Note the upturn in 1990.

TABLE 1 Differential Undercount of African Americans and Non-African Americans, 1940–1990, Based on Demographic Analysis

CENSUS YEAR	AFRICAN AMERICAN UNDER-COUNT	CHANGE IN AFRICAN AMERICAN UNDER-COUNT	NON-AFRICAN AMERICAN UNDERCOUNT	CHANGE IN NON-AFRICAN AMERICAN UNDERCOUNT	DIFFERENCE[a]
1940	8.4	—	5.0	—	3.4
1950	7.5	−0.9	3.8	−1.2	3.7
1960	6.6	−0.9	2.7	−1.1	3.9
1970	6.5	−0.1	2.2	−0.5	4.3
1980	4.5	−2.0	0.8	−1.4	3.7
1990	5.7	1.2	1.3	0.5	4.4

[a] African American minus non-African American.

In 1990 an independent survey, conducted immediately after the census, was also used to measure the differential undercount. That survey obtained estimates of undercount for various population groups (Table 2) as well as for various geographic areas.

Table 2 indicates the difficulty in counting racial and ethnic populations as accurately as the non-Hispanic white and other population. Since many members of these populations live in large urban areas or are concentrated in a few states, these undercounts translate to undercounts in these types of geographic areas. Even some rural areas with large minority populations, say parts of the south and southwest, have a differential undercount.

Cost

The 1990 census methodology has been in use since 1970. As noted earlier, the cost of the census was $11 per housing unit, $20 per housing unit, and $25 per housing unit for 1970, 1980, and 1990, respectively, standardized to 1990 dollars. During those decades the largest increase in cost on a per housing unit basis comes from 1970 to 1980, when costs almost doubled. Using the data from demographic analysis (Table 1), the differential undercount of African Americans decreased by 2 percent (the largest decrease since measurement of this phenomenon began), and the difference between the African American and non-African American undercounts dropped to 3.7 percent. Between 1980 and 1990, a different picture emerges. Costs went up by 25 percent, from $20 per housing unit to $25 per housing unit, and differential undercounts increased for both African Americans and non-African Americans, to 5.7 percent and 1.3 percent, respectively. Would a $40 per housing unit census have resulted in a different story for differential undercount? Would Congress have funded a $4.0 billion census in 1990?

TABLE 2 Undercounts for 1990 by Population Subgroup Based on the Postenumeration Survey

POPULATION	UNDERCOUNT ESTIMATE	SAMPLING ERROR
Non-Hispanic White and other	0.7	0.2
American Indians	4.5	1.2
American Indians on reservations	12.2	4.7
Asian and Pacific Islander	2.3	1.4
African American	4.4	0.5
Hispanic	5.0	0.7
United States	1.6	0.2

Two-Stage Decision Strategy

In 1990 the Census Bureau had a two-stage decision strategy with respect to the final counts. The Census Bureau conducted the 1990 census and provided the counts to President Bush on December 26, 1990. The law requires that these data, used to reapportion the House of Representatives, be provided no later than December 31 of the census year. By law, the states were provided voting rights data (race and ethnicity of those at least 18 years old by block) no later than April 1, 1991. After the completion of census data collection (Stage 1), the 1990 Postenumeration Survey was started. The results from that survey and the evaluation of it were studied by the Census Bureau to determine whether the counts should be adjusted (Stage 2) to reduce the differential undercount as well as undercounts for all levels of geography. In July 1991 Secretary of Commerce Mosbacher decided not to adjust the 1990 census (*1*). (An August 1994 decision by the Second Appellate Court in New York ruled that an adjustment should have been made. It is possible that the 1990 census will continue its judicial journey into the last half of the 1990s.) Part of the rationale behind the decision not to adjust was the turmoil adjustment might cause, since 1990 census data had already been used for reapportionment and redistricting.

Research Program for 2000 Census

The five factors led the Census Bureau to conclude that methodology used since 1970 needed to be changed in a fundamental way, particularly to deal with differential undercount and costs. Recognition that traditional counting methods could no longer be used resulted in the start of research and development to redesign census-taking methodology in 1991. This research phase alone represents major change. In preceding decades, the bureau entered into a planning stage, knowing the final design goal, about the fourth year into a decade. Now, faced with introducing fundamental change, the Census Bureau developed a research philosophy with the following goals:

1. Consider a variety of census design alternatives or options with a wide range of design features (the components of a census method).
2. Use the time before 1995 to conduct many small-scale experiments to provide data on various design features.
3. Use the design options and research results to select the most promising design features as building blocks for a design to be tested in 1995.
4. Obtain continuous stakeholder input on the research and development program.
5. Conduct the 1995 test census to inform final design decisions by the end of calendar year 1995. ("Inform" is used instead of "select" because other nontechnical factors may affect the final choice and because some features may be found acceptable but will require refinement before 2000.)

As a result of this research philosophy, 14 census design alternatives were developed (*2*). The alternatives covered a broad spectrum of census designs—from an administrative records census to a sample census. The alternatives included high-tech options for data collection and capture, ways to increase the mail response rate, making questionnaires widely available, stopping data collection earlier than usual, using administrative records to improve coverage, using improved enumeration techniques in historically undercounted (small) areas, improving the list of addresses used for mailing questionnaires, and (most important) using statistical sampling and estimation to account for households that do not respond by mail and integrating statistical sampling and estimation into the census process to reduce differential undercount.

Table 3 gives the design features selected for testing in 1995. The features are categorized into five major groupings: new uses of sampling and estimation, new procedures to count the undercounted, new uses of technology, new avenues for greater involvement, and a new method for collecting long-form data (the other new method for collecting long-form data,

TABLE 3 Fundamental Changes and the 1995 Census Test (U.S. Bureau of the Census)

	MAJOR GOALS	
FUNDAMENTAL CHANGE FROM 1990	REDUCE DIFFERENTIAL UNDERCOUNT	REDUCE COST
New Procedures To Count the Undercounted		
Use an easy-to-fill-out questionnaire with multiple mail contacts to improve response		X
Use revised questions to ensure a complete listing of household members	X	
Mail Spanish-language questionnaires to areas with large concentrations of Spanish-speaking households	X	X
Make census questionnaires available at convenient locations for those who did not receive a questionnaire or feel that they were not counted	X	
Use special targeted methods to count historically undercounted populations and geographic areas	X	
Count persons with no usual residence by a method that uses the places where these individuals obtain services	X	
Use administrative records to identify persons missed in the census	X	
New Avenues for Greater Involvement		
Develop cooperative ventures with other federal agencies; state, local, American Indian tribal, and Alaska Native village governments; and private and nonprofit organizations to form partnerships in taking the census	X	X
Evaluate initial efforts to compile and maintain an address list and geographic files in cooperation with the U.S. Postal Service and state, local, American Indian tribal, and Alaska Native village governments	X	X
Use the U.S. Postal Service to identify vacant housing units or mistakes on the address list		X
New Uses of Sampling and Estimation		
Use sampling and estimation procedures to reduce the differential undercount and the cost of the census. This means using an integrated coverage measurement sampling and estimation technique. Use sampling and estimation techniques for housing units that do not return questionnaires by mail	X	X
New Uses of Technology		
Use "real-time" automated matching to improve census coverage	X	
Use new technologies to contact persons or to allow them to contact the Census Bureau		X
Develop a new data capture system using electronic imaging		X
New Method for Collecting Long-Form Data		
Experiment with collecting sample (long-form) data using multiple sample forms		X

continuous measurement, is in a research phase outside of the 2000 research program and will be discussed later). Table 3 indicates which of the two overarching goals of reducing the differential undercount and containing or reducing the cost each feature attempts to address.

Many of these features appear in the 1995 test census because of the successful implementation of the research philosophy. For example, the easy-to-fill-out questionnaire with multiple mail contacts is being used because of a series of tests (*3*) conducted between 1991 and 1993. The tests indicated that a significantly higher mail response rate can be obtained (at least in a noncensus environment) if one uses first-class postage with envelopes indicating that response is required by law, a prenotice letter, a respondent-friendly questionnaire, a reminder/thank you card, and a replacement questionnaire for those not responding to the initial questionnaire.

Many other field and simulation experiments were conducted and include such studies as how people live and attach themselves to households, how people understand census concepts and words such as residency and "living or staying," effect on mail response rates of Spanish-language questionnaires in areas with large concentrations of households that speak Spanish, availability and quality of administrative record system, uncertainty introduced by sampling nonresponding households, and the feasibility of integrating into the census process a statistical method to reduce the differential undercount (*4*). Before discussing the content collection possibilities for 2000, it is worthwhile to consider the consequences of the latter two statistical techniques, namely sampling for nonresponse follow-up and integration of statistical sampling and estimation for reducing the differential undercount. There will now be *measured* uncertainty along with the final census results. The uncertainty comes in the form of sampling error from both the sampling of housing units that do not respond initially by mail and from the method, called Integrated Coverage Measurement (ICM), to reduce differential undercount.

In 1995 two sampling procedures for those not returning a mail questionnaire will be evaluated—a block sample and a unit or address sample. In the block sample all nonresponding households will be enumerated either by telephone (if a telephone number can be attached to an address) or by a personal visit. For the address sample all households not returning a mail questionnaire will have a chance of being selected for the nonresponse follow-up sample. Three questions need to be answered. First, how much sampling error is introduced into the census at various levels of geography such as block, tract, and site level for each procedure? Second, how much bias is introduced at these geographic levels for those units not sampled? And third, what is the cost of each procedure?

An ICM technique (sometimes referred to as Censusplus) being studied in 1995 calls for an independent listing of housing units in blocks randomly selected into the sample. (The Census Bureau will also compute estimates using the capture-recapture methodology of the 1990 Postenumeration Survey. These estimates will be compared with the Censusplus estimates. If the Censusplus results do not indicate a potential to reduce the differential undercount, a modified postenumeration survey will be used in 2000.) The independent listing will be compared with the Master Address File (MAF) to identify missed, duplicate, or incorrect addresses. The original MAF will be the frame for the census. In the randomly selected ICM blocks, some housing units will return a questionnaire and others will not. For the former an independent computer-assisted personal interview, using a refined measurement instrument, will be conducted to establish the household count on census day. For the nonresponding housing units a computer-assisted personal interview will be conducted, again using a refined measurement instrument, to establish household counts on census day. These interviews should result in a more accurate count (the 1995 test results will have to establish this fact) in each sampled block. Then a statistical estimation technique will be used to "adjust" for the undercount in the census. If the 1995 test is successful, it appears feasible to design an ICM survey that will produce direct estimates reducing the differential undercount for each racial and ethnic population, each state, and many major cities. For these populations and geographic areas the reduction in undercount will be larger than the error added by sampling. For smaller areas the Census Bureau will have to use an estimation technique to carry down adjustments. For these smaller areas it will be extremely difficult to decide on a case-by-case basis whether the census count was actually improved.

However, there will be measures of the uncertainty for these smaller areas. In contrast, in all past censuses except 1990, there were uncertainties in the accuracy of the counts for these areas as well as large geographic areas and population groups, but these uncertainties were not quantifiable. In 1990 the Census Bureau produced estimates of the differential undercount and the uncertainty (see Table 2) in these estimates using the Postenumeration Survey. But these data were not available until July 1991 (see preceding discussion of dual strategy).

From Table 3, the last category of change being tested in 1995 is a new method of collecting long-form data using multiple sample forms. Another option being considered is a continuous measurement survey to replace long-form content. The remainder of this paper compares three options for content—the long form, multiple sample forms, and continuous measurement.

Design Features Affecting Content

As mentioned earlier, OMB and the Census Bureau will report, for congressional approval, on the content needs for the 2000 census in April 1997. Specific question wording for the content will be recommended to Congress in April 1998. These two reports are the only dates cast in concrete with respect to content and the 2000 census. The methodology for collecting content data is still open. At least four possibilities exist: (*a*) use a 1990-like sample and (respondent-friendly) questionnaire design but with reduced content, (*b*) use a 1990-like sample and (respondent-friendly) questionnaire design with about the same content length as in 1990, (*c*) use multiple sample forms in place of the long form for content, and (*d*) use a new monthly continuous measurement survey to collect content over the decade. The remainder of this paper will compare these options in terms of the advantages and disadvantages of each, including a (simulated) comparison of sampling errors for the multiple sample forms and continuous measurement options. For any of these options the count portion of the census would include the fundamental changes described earlier.

Reduced Content, 1990-Like Design

Under this design the census would have one short form and one long form (it is always assumed that any form used by the Census Bureau will be respondent friendly and that the improved mail implementation strategy will be used) with the latter having fewer content items relative to the length of the 1990 long form. The short form would collect data that must be obtained for all persons (or housing units) for reapportionment, redistricting, and other statutory requirements. Currently this includes the following data: roster of persons in each housing unit, name, age, sex, relationship, race, Hispanic origin, tenure, telephone number, and coverage probes.

Long-form questionnaires contain only data that are needed for only a sample of persons (or housing units). The reduction in content for the long form might take the form of the content in the 1995 test. Here, either a federal statute specifies that the decennial census must provide the data or federal agency statutes indicate that the census is the most appropriate source of the data. From the former the reduced long form might contain education, place of birth, citizenship, year of entry, language, income, number of rooms, year built, and farm residence. From the latter the reduced long form would also include marital status, disability, children ever born, veteran status, labor force status, place of work, journey to work, occupation, industry, class of worker, units in structure, rent, year moved in, number of bedrooms, plumbing, kitchen, telephones, number of vehicles, fuels, water, sewer, utilities, and ownership costs. On the basis of Census Bureau and OMB review of agency requirements, the following content items from 1990 would be dropped: ancestry, residence 5 years ago, work last year, year last worked, value of home, and condominium. (This content determination was based on a review of federal agency statutes that occurred primarily in late 1993 and early 1994. It does not mean that these items will have the same status in 2000.)

There are at least three potential advantages of a reduced-content long form. First, there is a potential for an improved mail response rate. The 1995 test will provide some insight into this potential, since three forms with varying lengths will be tested. Second, asking fewer questions reduces the burden placed on individual respondents in terms of time to complete the questionnaire. And third, some savings occur because of reduced data capture and processing costs. However, depending on the actual reduction in the number of questions, these savings might be small.

A reduced-content long form also has several disadvantages. Perhaps most important would be the loss of some data that many use. Second, because the 2000 census may incorporate sampling of housing units that do not return a questionnaire by mail, the sampling error for content data may increase somewhat. The remaining two disadvantages accrue to any census methodology that collects content only once a decade. Data collected once a decade become out-of-date. The median age of data from past censuses is 7 years. It is not uncommon for important (funding) programs to use data at least this old or older. For example, in 1993 the federal government allocated education funds to states on the basis of 1980 census data with a 1979 reference year, using data 14 years old.

Finally, and particularly for small areas, sample data may reflect an unusual condition or temporary aberration, such as bad weather, that changes a person's behavior for the reference period. For example, unusual weather can affect data such as journey to work or mode of transportation. Such an anomaly is carried forward for all uses of the data over the decade.

Similar Amount of Content, 1990-Like Design

There would be one short form and one long form under this design. The main advantage of this scenario is that data users can expect to see about the same data content from 1990 to 2000. In addition, a respondent-friendly design should have a positive influence on initial mail response rates. This might only minimize the possibility of a further drop, or it may, when introduced with other components of the mail implementation strategy, bring about a small increase in response rate. Except that there is no loss of content, this design has the same disadvantages as the previous design.

Multiple Sample Forms

Under this design more than one sample form would be used to replace the traditional long form. Each form would have a different amount of content, although there would be certain questions common to all forms. The goal would be to develop several forms that, overall, produce the same amount of content as in 1990 without increasing respondent burden on any one form.

On the plus side, a multiple sample forms design can reduce individual respondent burden by asking fewer questions on many or all of the forms (when compared with the length of the traditional long form). To the extent that length of the questionnaire influences response, such a design may increase mail response rates.

There are at least three disadvantages of this design. First, multiple sample forms add operational complexities in properly fielding the design. The Census Bureau would have to develop a management control system that would ensure that the proper sample form was collected at the right address, particularly in nonresponse follow-up. Second, this design requires the development of new estimation and imputation techniques, since not all questions would be asked of each sample household. Third, sampling errors may generally increase under this design. Tables 4 and 5 present comparisons of relative sampling errors with 1990 long-form estimates for selected transportation variables. Finally, sampling error may increase for

TABLE 4 Illustrative Confidence Intervals Calculated for Selected Transportation Characteristics: 1990

		CONFIDENCE INTERVALS (90 PERCENT)		
CHARACTERISTIC	1990 ESTIMATE	CENSUS	MULTIPLE FORMS	CM
Percentage of workers using public transportation				
Forest Heights Town, Md.	12.9	+4.0	+5.0	+4.6
Census Tract 7044.01	20.4	+4.7	+5.9	+5.9
Mean travel time to work				
Forest Heights Town, Md.	33.0	+2.0	+2.5	+2.3
Census Tract 7044.01	30.6	+4.3	+5.4	+5.4
Persons per vehicle				
Forest Heights Town, Md.	1.27	+0.21	+0.26	+0.24
Census Tract 7044.01	1.04	+0.16	+0.20	+0.20

TABLE 5 Illustrative Confidence Intervals Calculated for Selected Commuter Flows for Persons Living in Washington, D.C.: 1990

		CONFIDENCE INTERVAL (90 PERCENT)		
PLACE OF WORK	1990 ESTIMATE	CENSUS	MULTIPLE FORMS	CM
Silver Spring, Md. (CDP)	3,134	+349	+436	+380
Hyattsville, Md. (CDP)	771	+174	+217	+189
Landover, Md. (CDP)	314	+111	+138	+121

some variables, not only because of the sampling for nonresponse follow-up, but also because some of the questions may be asked of fewer households.

Continuous Measurement

A continuous measurement (CM) design represents the most dramatic change for content collection. This design spreads content collection over the entire decade through a series of large monthly surveys. The current prototype design (5) envisions mailing questionnaires to about 250,000 addresses from the MAF each month. Each month a new sample of housing units, spread evenly across the country, will receive the questionnaire. Units that do not respond by mail, after several reminders, will be interviewed by telephone whenever the telephone number can be obtained.

Units not responding by mail or telephone will be sampled for a face-to-face interview at a rate of about one in three for most areas. A rate of about one in five will be used in remote areas. The total monthly interviewed sample size will be about 200,000 units, including vacant housing units; over a 5-year period the total number of interviewed housing units is about 12,000,000. In 1990, long-form data were obtained from 14,500,000 housing units.

The main objective of the CM design is to produce small-area (or small-domain) estimates that are better overall than those provided by the traditional long-form design. CM would provide estimates corresponding to any estimate that can be produced from the long form, including estimates for tracts, block groups, traffic analysis zones, school districts, and so forth, and small population subgroups consisting of about 0.1 percent of the population. The main differences between CM and the traditional long form are as follows:

1. The CM estimates will be an average over a 5-year period (3 years for 1999 to 2001 with a sample size of 400,000 per month).
2. The 5-year average will be updated annually.
3. The estimates from CM will have sampling errors typically about 25 percent larger than estimates from the long form.

Tables 4 and 5 compare simulated relative sampling errors from CM with sampling errors from the long form.

In addition, note that as the geographic level or the demographic subgroup size increases, CM will produce an abundance of estimates on a regular basis during the decade. Providing there is the need, one can imagine reliable estimates being produced quarterly, semiannually, or annually for states, large urban areas, congressional districts, and so forth. Table 6, extracted from Alexander (5), compares relative sampling errors for CM with 1990 long-form estimates for the estimate of the percentage of children 5 to 17 in poverty in Maryland for areas of different population size and for each of the eight congressional districts. The estimates from CM are based on 12- and 60-month accumulations.

The CM approach to content collection has several advantages. First, it simplifies decennial operations by allowing the entire effort to be directed at reducing the differential undercount and containing costs. Second, conducted over the decade, the CM model provides for updating

TABLE 6 Illustrative Comparison of Reliability Between Decennial Census and Continuous Measurement Data (Collection Systems for Areas in Maryland: Percentage of Children 5–17 in Poverty)

	DECENNIAL CENSUS			ILF[a] CV[b] (PERCENT)	
AREA	POPULATION SIZE	ESTIMATE	CV[b] (PERCENT)	12-MONTH[c]	60-MONTH[d]
Maryland total	4,781,468	10.5	1.1	3.2	1.45
Baltimore City	736,014	31.3	1.5	4.1	1.8
Anne Arundel County	427,239	5.3	5.6	15.7	7.0
Carroll County	123,372	3.6	10.0	32.3	14.7
St. Mary's County	75,974	9.4	9.2	N.A.	11.9
Gaithersburg	39,542	7.4	16.2	N.A.	21.2
Somerset County	23,440	15.6	14.0	N.A.	18.3
Kent County	17,842	12.9	14.9	N.A.	22.4
Hyattsville	13,864	5.6	25.8	N.A.	35.1
Harve de Grace	8,952	23.5	14.2	N.A.	19.6
Capitol Heights	3,633	7.2	46.5	N.A.	61.7
Cottage City Town	1,236	5.0	46.0	N.A.	103.8
Congressional District 1	597,684	10.2	3.2	9.1	4.1
Congressional District 2	597,683	6.3	4.2	11.8	5.3
Congressional District 3	597,680	11.9	3.0	8.4	3.7
Congressional District 4	597,690	8.0	3.6	10.4	4.6
Congressional District 5	597,681	4.7	4.7	13.9	6.2
Congressional District 6	597,688	8.3	3.5	10.2	4.6
Congressional District 7	597,680	30.2	1.6	4.7	2.1
Congressional District 8	597,682	4.1	5.2	14.8	6.6

NOTE: N.A.—Not applicable.
[a] Calculations of reliability for intercensal long-form (ILF) estimates are based on (*a*) a sample size 64 percent of that needed to provide reliability comparable with that from the decennial census and (*b*) no oversampling of governmental units under 2,500 population.
[b] The coefficient of variation (CV) is a measure of sampling variability. The CV is the ratio of the standard error of a sample estimate to its expected value. There is no specific rule to determine whether a given CV is good or not. This determination is based on considerations such as use of the data, consequences of making the wrong decision, and so forth. In practice, a CV of 10 percent or less is often considered to be adequate, between 10 and 50 percent to be acceptable, and 50 percent or more to be undesirable.
[c] Estimates are based on weighted observations from 12 months of interviews.
[d] Estimates are based on weighted observations from 60 months of interviews.

of the MAF. Third, the annually updated moving averages provide for regular updates of the estimates, instead of updates once a decade. Fourth, it creates a permanent data collection staff knowledgeable about CM methods and procedures. Fifth, it creates long-term efficiency gains for other household surveys such as the Current Population Survey. When needed, it also provides an efficient sample (frame) for rare subpopulations. Sixth, it allows for more uniform treatment of seasonal effects, seasonal resort areas, and aberrations due to adverse weather or other causes. Finally, it allows more flexibility in adjusting sample sizes when necessary, correcting for errors in estimates identified by independent local sources, conducting ongoing experiments to evaluate and improve the quality of the design, using variable reference periods to reduce recall error, and responding to new data needs as they arise.

On the other side of the coin, CM has disadvantages. First, over the entire decade CM will cost more than collecting traditional long-form data (precise cost estimates are not available at this time). Second, with the added sample size comes added total respondent burden. Third, data users will have to adjust to using moving 5-year averages. Fourth, it will have less complete coverage of housing units than the long-form survey. Fifth, it is possible to increase within-household undercoverage, as is the case with all current household surveys. Sixth, there is an inability to control tract-level estimates to short-form counts. Finally, income measurement inaccuracies may occur if the current recall period of income last year is retained over an annual cycle.

Conclusions

The 2000 census design program has been conducted with the aim of addressing the two major problems of continuing differential undercount and rising costs in past decennial censuses. To attain both goals, the design program has looked at fundamentally different ways of conducting the census, recognizing that past methods will not be able to overcome these problems. The two most important method changes are integrated coverage measurement and sampling for nonresponse follow-up. The former is designed to reduce differential undercoverage—the latter to reduce or contain cost.

Fundamental change includes not only new methods of improving housing unit and person coverage and reducing costs, but also different ways to collect content. In addition to the use of 1990-like options for the 2000 census, this paper discussed two other approaches—multiple sample forms and continuous measurement. The results from the 1995 census test will provide data important in making the final design decisions at the end of calendar year 1995.

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Implications of the Census Bureau's 2000 Census Plans for the Continued Availability of Transportation Data from the Decennial Census

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Data from the decennial census are the backbone of the statistical system that supports the transportation planning process of our nation. The U.S. Department of Transportation (DOT), as well as state and local transportation planning organizations, have relied on the consistent data collection provided by the decennial census since 1960, when transportation questions were first added to the census questionnaire. Today, these organizations are increasingly reliant on census data to implement the requirements of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) and the Clean Air Act Amendments of 1990 (CAAA).

Although the next census is still more than 5 years in the future, planning for the 2000 census is well under way at the Census Bureau. The Office of Management and Budget (OMB) is already reviewing federal agency requirements for decennial census data to set priorities among competing data needs. The decisions that OMB and the Census Bureau make will determine what transportation data will be collected in the decennial census to meet the nation's data needs at the turn of the 21st century.

At this stage of the 2000 census planning cycle, the continued availability of data needed by transportation planners and policy makers and historically collected in the decennial census is by no means assured. In response to congressional criticism, the Census Bureau has taken a zero-based approach to what the 2000 census will look like. One major thrust of the bureau's approach is to consider alternative "designs" for the census (i.e., the fundamental details of how the census is conducted). A second is to question the justification for collecting any data in the decennial census beyond the minimal information required for congressional reapportionment and legislative redistricting. Both are meant to move the decennial census in the direction of achieving the Census Bureau's stated 2000 census objectives: to reduce the undercount of the population and the cost of conducting the census.

The objective of this paper is to place current and future needs for transportation data from the decennial census within the context of the Census Bureau's plans for the 2000 census as well as within the political context of the 2000 census planning process. I recount the rich history of transportation data in the decennial census and describe the critical need for and uses of the data to meet the requirements of federal legislation. I provide an overview of the political context of the 2000 census planning process and how it has influenced the Census Bureau's plans. Finally, I summarize the Census Bureau's 2000 census plans and present what in my view are the implications of those plans for the continued availability of transportation data from the decennial census.

History of Transportation Data From the Decennial Census

The 1960 Census: First Transportation Data from the Decennial Census

DOT and the Bureau of the Census have a long tradition of working together to meet the nation's needs for transportation data. Transportation data were first collected in the 1960 census, when questions on city and county of work, means of transportation to work, and the number of automobiles available to each household were added to the census questionnaire. The pioneering regional transportation studies undertaken in many large cities in the latter half of the 1950s and provisions of the Federal-Aid Highway Act of 1956 to provide alternative interstate service into, through, and around urban areas gave impetus to the demand for comprehensive statistics on the amount and character of commuting within metropolitan communities.

The Federal-Aid Highway Act of 1962 required that approval of any federal-aid highway project in an urbanized area of 50,000 or more population be based on a continuing, comprehensive urban transportation planning process. By 1965, all then-existing urbanized areas had an urban transportation planning process under way. This planning process created the need for more geographically detailed commuting data for urban areas to monitor local travel patterns.

The 1970 Census: First Transportation Data from the Decennial Census for Traffic Analysis Zones

The development by the Census Bureau of computerized address coding guides made it operationally feasible for the bureau to collect the actual street address of workplaces in the 1970 census and code them to the city block level. Local transportation planning agencies, supported by state highway planning and research funds, assisted the Census Bureau at its request in the development of these coding tools.

After the 1970 census, DOT contracted with the Bureau of the Census to produce compilations of block-level socioeconomic and travel-to-work data aggregated to traffic analysis zones. The standardized tabulations contained in this "transportation planning package" were designed to provide a common data base for transportation studies and reduce processing costs. Metropolitan planning organizations submitted census block-to-traffic analysis zone equivalency files for their metropolitan areas, and the Census Bureau produced the traffic zone data packages on a cost-reimbursable basis.

In 1973, the Transportation Research Board of the National Academy of Sciences held the first national conference on Census Data and Urban Transportation Planning in Albuquerque, New Mexico. The conference was attended by DOT and Census Bureau officials, as well as professionals throughout the nation working in census and transportation planning activities. They reviewed their experiences in using the data from the 1970 census in the transportation planning process and formulated recommendations for improvements in transportation data from the 1980 census.

The 1980 Census: First Census with a Fully Developed Journey-to-Work Statistics Program

The energy crisis of the early 1970s heightened the need for transportation statistics to assess the transportation implications of energy shortages and costs. To meet the need for data, DOT sponsored a travel-to-work supplement to the Annual Housing Survey, conducted by the Bureau of the Census for the Department of Housing and Urban Development. The travel-to-work statistics collected in the Annual Housing Survey between 1975 and 1977 became the model for the transportation items collected in the 1980 census. The increasing importance with which the Bureau of the Census viewed transportation statistics was also demonstrated in 1978 when it established a journey-to-work statistics staff.

The 1980 census was the first for which the Census Bureau had a fully developed journey-to-work statistics program. The number of transportation questions asked in the census increased significantly in 1980. In addition to the inquiries on place of work, means of transportation to work, and the number of automobiles available to each household that had been included in the census in 1960 and 1970, the 1980 census asked new questions on carpooling arrangements, the number of persons in the carpool, travel time from home to work, the number of persons with disabilities that limited their use of or prevented them from using public transportation, and the number of trucks and vans available.

The geographic reference materials used to code responses to the place-of-work question for the 1980 census were improved, resulting in an improvement in the accuracy and completeness of the coded data. Major employer files and reference lists of buildings, colleges and universities, military installations, shopping centers, and other employment sites were developed to code workplace responses.

The development of computerized Geographic Base File/Dual Independent Map Encoding (GBF/DIME) files by the Census Bureau to code addresses for the 1980 census also contributed greatly to the improved accuracy of block-level place-of-work data. Regional transportation planning organizations in the nation's metropolitan areas assisted the Census Bureau in the development of the GBF/DIME files by creating and updating the files on the basis of local maps and expertise. DOT provided funding to support this cooperative effort.

Once again, for the 1980 census, DOT contracted with the Census Bureau to create a series of special tabulations in a transportation planning package. Metropolitan planning organizations obtained the data tabulated for their traffic analysis zones on a cost-reimbursable basis. To increase the utility of the census data for local transportation planning, the Census Bureau developed an innovative procedure to assign incomplete place-of-work responses to census blocks so that they too could be tabulated at the traffic analysis zone level.

After the 1980 census, the Transportation Research Board conducted the second National Conference on Decennial Census Data for Transportation Planning. Held in Orlando, Florida, in 1984, the conference was structured to review data user experience with the 1980 census and recommend improvements in the program for the 1990 census. Officials from DOT and the Bureau of the Census participated in the conference along with state and metropolitan transportation planners.

The 1990 Census: Refinement of Transportation Questions and Innovations in Place-of-Work Coding and Transportation Data Dissemination

The 1990 census transportation statistics program marked the continued refinement of transportation data available from the census, technical improvement in the geographic coding of place-of-work responses to small areas within metropolitan regions, and the creation and dissemination of innovative transportation data products. The 1990 census again included questions on place of work, means of transportation to work, carpooling, carpool occupancy, and travel time to work. An important new question on time of departure from home to work was added to the census questionnaire to allow tabulation of commuting patterns and characteristics by peak hours of travel. The questions on the number of automobiles available to each household and the number of trucks or vans available to each household were combined into one question on the total number of vehicles (cars, trucks, and vans) available. The question on public transportation disability was replaced with a more general question that identified persons whose disabilities limited their ability to get around outside the home.

Two innovative technical advances in place-of-work coding were made for 1990. The first was the joint development of the Census/Metropolitan Planning Organization Cooperative Assistance Program by the Census Bureau and DOT. This program gave local metropolitan planning organizations the opportunity to assist the Census Bureau in improving the accuracy of place-of-work data for their region. Planning organizations took part in three activities:

providing files of employers and their locations to the Census Bureau, working with major employers to ensure that their employees reported accurate workplace addresses, and assisting the Census Bureau in coding place-of-work responses that census clerks could not code. More than 300 metropolitan planning organizations took part in these cooperative activities. The Federal Highway Administration (FHWA) made the costs incurred by the metropolitan planning organizations for this work an eligible activity for use of federal-aid highway planning funds.

The second advance in place-of-work coding was the implementation by the Census Bureau of an automated place-of-work coding system. Place-of-work addresses were keyed to create machine-readable files that were then matched to address coding and major employer files to assign geographic codes to the place-of-work responses. Cases that could not be coded on the computer were sorted and clustered and referred to clerks for research and computer-assisted coding. The automation of place-of-work coding allowed the Census Bureau to accomplish the coding operation efficiently and cost-effectively.

Significant innovations in the dissemination of the journey-to-work data also were achieved for the 1990 census. Two transportation planning packages were produced: statewide packages for each state and the District of Columbia, and urban packages for the transportation study area defined by each metropolitan planning organization. Production of the packages by the Bureau of the Census was sponsored by the state departments of transportation under a pooled funding arrangement with the American Association of State Highway and Transportation Officials. This arrangement supported the production of data for the entire country instead of only those areas that decided to purchase the data as in previous censuses. Funding to develop the 1990 Census Transportation Planning Package Program was provided by FHWA and the Federal Transit Administration.

To make the data contained on the data tapes easily accessible and widely available, the Bureau of Transportation Statistics released the 1990 Census Transportation Planning Packages on CD-ROM and provided software to display and retrieve the data. This revolutionary advance in disseminating census data in a format compatible with widely available microcomputers democratized data accessible only on mainframe computers in previous censuses.

Now, in April 1994, the Transportation Research Board is sponsoring the third National Conference on Decennial Census Data for Transportation Planning. DOT officials, Census Bureau officials, and state and local transportation planners are meeting in Irvine, California, to review their experiences with using the 1990 census data for transportation planning and to make recommendations for the 2000 census.

Uses of Decennial Census Data for Transportation Planning

Department of Transportation Uses

Transportation data from the decennial census are used by DOT as a comprehensive data base supporting development of new policies and programs and as benchmark data with which to evaluate the impacts and overall effectiveness of previously implemented programs.

DOT works in partnership with states and local governments to assess project and corridor-level effects of implemented plans, programs, and specific projects. In supporting ISTEA and CAAA, as well as other federal legislation such as the National Environmental Protection Act, Title VI of the Civil Rights Act of 1964, the Uniform Relocation Assistance Act, and the Highway Safety Act, decennial census data facilitate a consistent level of responsible federal oversight and review of state and local plans and programs. For example, census data are an important tool in the environmental review process required under the National Environmental Protection Act to assess the potential effects of yet-to-be implemented projects. In consideration of the CAAA, journey-to-work data from the 2000 census will provide important feedback on the overall effectiveness of today's national air quality agenda. To respond to the requirements of the Americans with Disabilities Act for transportation fully accessible to all segments of the population, data on persons with mobility limitations that are traditionally provided by the census provide an opportunity for DOT to conduct a nationwide assessment of service needs.

State and Local Uses

Decennial census data for small areas such as census tracts and traffic analysis zones are used by states and metropolitan planning organizations to meet the provisions of ISTEA, CAAA, and the Americans with Disabilities Act.

ISTEA—Comprehensive Planning

ISTEA contains specific provisions requiring comprehensive transportation planning processes on a statewide basis as well as at the metropolitan area level. States, local governments, and regional agencies must analyze the impacts of transportation plans, policies, and programs. The procedures involved are data intensive, and small-area data from the decennial census provide much of the required information. Principal among these procedures is travel forecasting.

The function of transportation models is to replicate how people travel, to model their travel to and from different locations, by time of day, purpose, and mode. Models are used to forecast how people will travel in the future. Assumptions are made about transportation infrastructure development and changes, land use changes, parking cost and availability, and changes in individual travel behavior. By building these models, planners can evaluate alternatives. For example, will adding carpool lanes along a particular highway reduce or increase congestion in the future, and how do these results compare with building general-purpose lanes or increasing transit service? For most travel models, the forecasting horizon is 20 to 30 years. Thus, data from the 1990 census are used to test the reliability of current models to predict 1990 travel behavior, and to then forecast travel in 2000, 2010, and 2020.

The decennial census provides the baseline of household and person characteristics, origins and destinations of work trips, and travel characteristics for small areas such as traffic analysis zones used in regional and local travel demand modeling efforts. These forecasts are used by state, regional, and local agencies to develop, test, and refine methods for projecting future travel needs at the regional, subarea, and corridor levels. Using these models for travel forecasting allows analysis of alternative highway, transit, and multimodal developments with various policy scenarios.

In addition to supplying data for travel forecasting, the decennial census provides important information for transportation planners to monitor trends in travel behavior. Census data permit the tracking of travel times and peak hours of travel by mode of travel and by residence and work location. The census also provides estimates and data for trend analyses of rates of carpooling and public transit use in the journey to work.

ISTEA—Transportation Improvement Program: Project Selection

ISTEA specifically requires that statewide and metropolitan transportation plans address broad issues such as land development and demographic growth, effects of transportation facilities on population segments, and regional mobility and congestion levels. These plans must consider the social, economic, and environmental effects, including air quality effects, of transportation plans and programs. Projects contained in transportation improvement programs must be found to conform to the emissions reduction schedules in a state implementation plan. Census data on commuter travel flows and travel behavior patterns provide important baseline values against which transportation improvement program projects can be evaluated and selected.

ISTEA—Traffic Congestion Management

ISTEA requires states, in cooperation with metropolitan planning organizations, to develop traffic congestion management systems. Transportation control measures and travel demand management programs often use census data on the journey to work as baseline values from which to establish goals for increasing average vehicle occupancy and for decreasing single-occupant vehicles. Census data also are used for preparing a comprehensive profile of peak-period commuter flows.

ISTEA—Corridor Preservation

ISTEA provides a planning framework for early identification of transportation corridors needing some form of capacity expansion. Small-area data from the census provide a basis for defining these corridors and the number and characteristics of residents and jobs affected.

CAAA

Regions cited for being in nonattainment of federal air quality standards must comply with Environmental Protection Agency and DOT requirements under CAAA. The transportation/air quality planning requirements of CAAA require state and local public agencies to prepare comprehensive vehicular travel and pollutant emissions profiles. Preparation of these profiles requires analysis of detailed household and worker characteristics, means of travel, commuting patterns, and journey-to-work trip lengths obtained from the decennial census.

CAAA also requires severely polluted areas to compute regional average rates of vehicle occupancy in the commute to work. The census provides these data in a consistent manner nationwide.

Under CAAA, preparation of the state implementation plan and the comprehensive urban transportation planning process must be coordinated. Transportation facilities and projects proposed as part of the long-range transportation plan must be evaluated for their effect on air quality. Thus, forecast travel volumes along specific routes are translated into forecast traffic speeds and emissions. The results are used in conformity analyses of the state implementation plan. Data from the decennial census are the basis of these forecasts.

Transit System Development and Modification

Understanding regional travel patterns assists transit agencies in developing new services and revising existing services. These services may include vanpools and carpools in addition to fixed-rail and fixed-route bus services. Small-area census data for traffic analysis zones on journey-to-work characteristics are used for route planning, market analysis, publicity, and advertising.

The Americans with Disabilities Act requires states and local transit operators, with oversight and policy review by DOT, to provide service levels that are fully accessible to all segments of the population. Data from the census that describe the geographic distribution of persons with disabilities limiting their ability to get around outside the home are used to develop and improve transportation services for this population.

Political Context of Planning for the 2000 Census

As the preceding sections indicate, DOT as well as state and local transportation planning organizations have relied on decennial census data since 1960. The Census Bureau itself has supported and encouraged this reliance as it worked with DOT to develop the bureau's journey-to-work statistics program. Today, transportation agencies at all levels of government are even more dependent on census data to implement the mandates contained in ISTEA and CAAA. Why, with this long history of data collection and the increasing need for the data, is the continued collection of transportation data in the decennial census even questioned? The answer is that congressional action currently under way to limit the amount of information collected in the 2000 census has the potential to eliminate the transportation data that are so critical for DOT and state and local planning agencies in meeting the requirements that Congress has created in ISTEA and CAAA.

Congressional Criticism of 1990 Census

After the 1990 census, the Census Bureau received a great deal of criticism from members of Congress who believed that the census cost too much and because of the differential undercount among certain geographic areas (usually large cities) and among minority groups. This criticism was exacerbated by the decision by then Secretary of Commerce Robert Mosbacher not to statistically adjust the 1990 census results to correct for the undercounts, even though the Census Bureau was prepared to do so and Census Bureau Director Barbara Everitt Bryant herself recommended that the 1990 counts be adjusted.

On the basis of the widely held opinion in Congress that the 1990 census was too costly and inaccurate, Representative Thomas Sawyer, Chairman of the Subcommittee on Census, Statistics, and Postal Personnel of the Committee on Post Office and Civil Service, which oversees the Census Bureau's operations, warned the bureau that any plan for the 2000 census that did not provide for a change in the way the census is conducted would not be acceptable to Congress. He also stated repeatedly, in hearings, speeches, and in the press, his belief that the large amount of data collected in the census contributed to the diminished accuracy of the population counts and that data users might have to find alternative sources for data previously collected in the census. In an open letter to the members of the Association of Public Data Users (APDU), published in the May 1993 *APDU Newsletter*, Representative Sawyer wrote, "I can assure you that efforts to keep 1990 content in the 2000 census will be greeted by skepticism, at best, and opposition, at worst, in Congress."

In response to its congressional critics, the Census Bureau has taken a zero-based approach to planning for the 2000 census. In January 1991, the Year 2000 Research and Development Staff was created within the Census Bureau, and formal 2000 census planning began.

The Year 2000 Research and Development Staff developed 14 alternative designs for conducting the 2000 census. The alternatives ranged from a "census" based on administrative records with no actual data collection, to a more traditional short-form-long-form census but with a number of innovations in data collection and processing, to a "continuous measurement" census that would include only a basic head count in 2000 and a series of surveys throughout the decade to obtain the characteristics of the population collected on the long-form questionnaire in previous censuses. The work of the staff focused on the viability of these alternative designs, to determine one or two candidate designs for testing in 1995.

Selection of a 2000 Census Design

The Census Bureau published a notice in the March 25, 1993, *Federal Register* to announce and request comments on its proposed criteria for assessing the 14 alternative 2000 census designs and selecting two designs for testing in 1995. The notice set forth mandatory criteria that a design must meet as well as desirable (but not mandatory) criteria against which designs would be evaluated. Under the mandatory criteria, the 2000 census would provide only counts of the total population and the population 18 years and over by race and Hispanic origin to provide data for reapportionment, state redistricting, and enforcement of the Voting Rights Act.

The requirement that the decennial census continue to provide the full range of subject matter content and small-area data (such as the transportation data) that are best and uniquely supplied by a census was proposed by the Census Bureau to be a desirable but not mandatory criterion for selecting a 2000 census design. The most frequent comment that the Census Bureau received from data users in response to the *Federal Register* notice was that this criterion be mandatory. The Census Bureau, however, chose not to accept the recommendation.

On May 20, 1993, the Census Bureau issued as series of Design Alternative Recommendations describing the results of its assessment of each of the 14 alternative 2000 census designs. The bureau announced that it was rejecting all 14 designs and, instead, proposed to test a "hybrid" design in 1995 composed of the most promising features selected from among the 14 candidate designs.

Congressional Response to 2000 Census Planning Process

Congressional reaction to the direction that the Census Bureau was taking in planning the 2000 census came through the budget process. The Census Bureau requested $23 million for fiscal year 1994 for 2000 census planning activities. In the June 1993 markup by the Subcommittee on Commerce, Justice, State, the Judiciary, and Related Agencies of the House Committee on Appropriations, the Census Bureau request was cut to $8 million. In its report, the subcommittee commented as follows:

1. The 1990 census was too costly and inaccurate.
2. The Census Bureau's rejection of all 14 census design alternatives that had been under study for more than a year suggested that the bureau was not serious about correcting the concerns of Congress.
3. It is not acceptable to conduct the 2000 census under a process that follows the general plan used in the 1990 decennial census.

The committee further stressed that the basic purpose of a decennial census is to enumerate the population, in accordance with the Constitution, and that other data that were collected in the 1990 census could be determined through alternative methods. Finally, the committee encouraged OMB to ensure that only data needed to satisfy statutory requirements be collected in the census at taxpayer expense.

In early August 1993 the Census Bureau issued its 1995 Census Test Design Recommendations describing the proposed goals and methods for use in the 1995 test census. The results of the 1995 test will determine how the Census Bureau will conduct the 2000 census. The Census Bureau originally planned to use the 1990 census questionnaire in 1995, since the 1995 test census was not meant to be a test of questionnaire content. In response to Congress and to guidance from OMB, however, the bureau took the position that 1995 census test would contain only questions needed to satisfy current statutory requirements. Although the transportation data collected in the decennial census are the backbone of the statistical system that supports the transportation planning process in the United States, no law requires that transportation data be collected in the decennial census. Thus, if the Census Bureau and OMB adhered to the criterion that the census should include only questions required to satisfy statutory requirements, no transportation data would be collected in the 1995 census test or the 2000 census.

Subsequent Congressional Action

After many federal agencies, including DOT, expressed strong objections to restricting the data collected in the census, Congress eased somewhat its criterion of "statutory requirements" in subsequent guidance included in the House-Senate conference report on the Census Bureau's fiscal year 1994 budget request. The report stated that the conferees expected the Commerce Department and OMB to ensure that all concerns of the Congress, the absolute data requirements of federal departments and agencies, as well as state and local government data needs, were considered in the 2000 census planning effort.

On the basis of this new guidance, the Bureau of the Census, with approval from OMB, will include in the 1995 census test those 1990 census questions providing data mandated by law for collection in the census *and* data specifically required by federal legislation and for which the decennial census is the only or historical source. The transportation items collected in the 1990 census fall under the latter category and thus will be included in the 1995 census test. OMB also is using these broader criteria in determining the questions to be included in the 2000 census, which bodes well for the continued collection of transportation data in the census if Congress agrees with OMB's interpretation of federal data needs.

Census Bureau's 2000 Census Plans

The Census Bureau's designs for fundamental change are embodied in the census attributes that it will be testing in the 1995 census test and in its research on a continuous measurement system as an alternative to the traditional census. The most significant design changes and the continuous measurement system are described next.

Design Changes To Be Tested in 1995 Census Test

Use of Sampling and Statistical Estimation To Reduce the Differential Undercount and Census Costs

The primary aspects of this design change are integrated coverage measurement and sampling for nonresponse. With the inclusion of integrated coverage measurement, the 2000 census will produce a single set of census results combining counting and estimation techniques. A statistical adjustment to correct for undercounts will be incorporated in the census before the counts are released. Using sampling for nonresponse, only a sample of nonrespondents will be followed up after the initial data collection, rather than attempting to contact all nonrespondents as in previous censuses.

Increasing Census Response Options

In addition to the mail out–mail back enumeration, the Census Bureau plans to make unaddressed questionnaires available at many locations for people who may not receive a questionnaire or believe they may not have been included on a census form. The Census Bureau also plans to collect data electronically where feasible using computer-assisted telephone interviews and other technologies to reduce the unit cost of data collection and provide alternatives to respondents.

Use of Respondent-Friendly Questionnaires and Implementation Methods

Respondent-friendly implementation has three components: the design of the questionnaire to make it easier for the respondent to understand and complete; the mail implementation, involving multiple mail contacts (a prenotice letter, a reminder card, an initial questionnaire, and a replacement questionnaire); and first-class postage instead of bulk rate mailing.

Cooperative Ventures

Opportunities for the U.S. Postal Service, local governments, and private and nonprofit organizations to play a role in the census will be expanded. This role would be primarily in the area of coverage improvement to reduce differential undercounts (such as updating the census address list) but also would include outreach and promotion.

Targeted Methods To Count Historically Undercounted Populations and Geographic Areas

The Census Bureau would develop a data base to enable it to target areas where there are major enumeration barriers and use specific methods from a "tool kit" of special methods to overcome barriers.

Capture of Data for the 2000 Census Using Electronic Imaging

The Census Bureau plans to implement a system to scan and capture an electronic image of the pages of census questionnaires to reduce clerical handling of paper documents and processing costs.

Collection of Sample Data Using Multiple Sample Forms

Using a "matrix sampling" approach, the questions traditionally collected on the long-form questionnaire would be split up into multiple, medium-length forms. The samples derived from the medium-length forms would be cumulated to provide estimates for small areas. Matrix sampling could allow the Census Bureau to either expand the level of content compared with 1990 and maintain average respondent burden or maintain the content level and reduce average respondent burden.

Continuous Measurement

Independent of the 1995 census test, the Census Bureau is also studying the operational feasibility and cost of implementing what it calls a continuous measurement system as an alternative to the traditional census. Under a continuous measurement system, the 2000 census would collect on a 100 percent basis only population and housing unit counts and minimal population and housing data, such as the information traditionally obtained from the short-form questionnaire. The characteristics obtained in past censuses from a sample of households using the long-form questionnaire—place of work; mode of travel to work; carpooling and vehicle occupancy; travel time; time of departure from home to work; the number of vehicles available to each household; persons with mobility-related disabilities; and the whole range of detailed social, economic, and housing data—would not be collected. Instead, the long form would be replaced with an Intercensal Long-Form Survey.

The Intercensal Long-Form Survey would comprise a monthly 400,000-household sample that would be cumulated to produce rolling averages over various periods of time. National estimates could be monthly estimates or quarterly averages. For large geographic areas, such as states and metropolitan areas or cities with more than 250,000 population, annual average estimates could be produced. For the smallest areas (the level of sample data used to produce data for census tracts or to aggregate into traffic analysis zones), the estimates would be 5-year moving averages.

For example, if the survey were to begin in 1998, small-area data for traffic analysis zones could be released in 2003 on the basis of the cumulated average of survey data collected between 1998 and 2002. Since the survey would be continuous, the Census Bureau could theoretically produce new 5-year moving averages for small areas each year if resources allow and demand warrants (e.g., 2004 based on the average of 1999 to 2003, 2005 based on the average of 2000 to 2004, and so on). However, year-to-year comparisons of data for small areas would not provide good estimates of annual change, since only one-fifth of the sample from which the moving averages are derived actually changes each year.

Options for 2000 Census Content

The demand for fundamental change in the census places congressional questioning of content needs, perception of the adverse impact of the length and complexity of the census questionnaire on the undercount, and interest in reducing cost in direct conflict with the strong legislative requirements and legitimate needs for transportation data from the decennial census. The current circumstances present four options for content for the 2000 census:

- Reduced content: Congressional questioning of content needs, perception of the adverse impact of the length and complexity of the census questionnaire on the undercount, and interest in reducing the cost of the census offer the very real possibility that the amount of information collected in the 2000 census may be reduced significantly compared with past censuses. In the extreme, the long-form questionnaire could be eliminated.
- Traditional long form: This option would provide data comparable with the 1990 census and previous censuses. At this point in the planning cycle, it is unlikely that a full traditional long form will be used in 2000, given the sense of Congress.

• Multiple long forms (matrix sampling): The Census Bureau is testing the use of multiple medium-length long forms in the 1995 census test. Operational complications of administering, collecting, and processing multiple forms may preclude this option from use in the actual decennial census.

• Continuous measurement: There is a great deal of support for continuous measurement at the Census Bureau, especially because it represents radical change in an attempt to appease congressional critics and removes the collection of the sample data from the decennial enumeration. The Census Bureau has focused its research on the operational feasibility of a continuous measurement system without much concern for its ability to meet data needs. Now, part of the bureau's program is to overcome data user resistance to continuous measurement data. Nevertheless, it behooves users to decide what effect continuous measurement will have on their programs, since it is a very real possibility.

Implications of Census Bureau Plans for Transportation Data

General Implications for All Subject-Matter Topics

1. Nearly all of the innovations the Census Bureau is testing and planning for use in the 2000 census are focused on reducing the undercount and reducing the cost of the census rather than meeting data needs. With the exception of the indirect benefits of respondent-friendly questionnaires and the image capture system for the collection and processing of long-form data (if there is a long form), all of the bureau's plans deal with the counts rather than meeting data needs.
2. Less emphasis on counting and more emphasis on estimation could have a detrimental effect on the quality of sample data if there is a long form. If integrated coverage measurement and sampling for nonresponse are implemented, more sample data will be imputed. This may be a particular problem for place-of-work information.
3. Emphasis is being given to separating the count from the collection of data on characteristics. Despite the Census Bureau's own research evidence to the contrary, the perception on the part of Congress is that collection of characteristics is detrimental to simply counting the population. One of the main attractions of continuous measurement to the Census Bureau and Congress is that it reduces the census to little more than a head count and relegates the collection of programmatic data to monthly surveys.
4. Emphasis is being given only to the cost of the census and not to the replacement cost of the data. If transportation data are not collected in the census, DOT estimates that it would cost more than $900 million to replace the transportation data with new, locally administered surveys.
5. All of these plans respond to congressional guidance.

Specific Implications for Transportation Content

Reduced Content

If Congress mandates a reduction in the number of questions asked in the 2000 census, there will be intense competition among the legitimate data needs of the various federal agencies and their constituencies at the state and local levels. Reducing the content of the census also will make it unlikely that new questions to meet emerging data needs will be added to the census.

The decisions about which census questions to retain and which to drop will ultimately depend on congressional perception of the importance of the data on each topic that is covered by the census. This perception will be influenced greatly by the legislative justification for collecting the data in the census.

In its analysis of federal agency requirements for 2000 census data, OMB is classifying each topic into one of three categories: (*a*) decennial census data specifically mandated by legislation; (*b*) data specifically required by legislation for which the census is the only or historical source; or (*c*) data used for program planning, implementation, or evaluation or to provide legal evidence.

Questions that collect decennial census data specifically mandated by legislation obviously stand the best chance of being included in the 2000 census, as long as Congress does not pass new legislation to remove the requirement. Other questions that collect data specifically required by legislation would have second priority, and questions that collect data to fulfill program needs would have the lowest priority.

The Census Bureau, under OMB's guidance, will include in the 1995 census test those 1990 census questions that fall in the "mandatory" and "required" categories. Questions in the "program" category will not be asked. The transportation items are included in the "required" category, so they will be included in the 1995 test questionnaire. When the time comes to determine the questions that will actually be asked in the 2000 census, it likely will come down to which agencies are successful in making their questions mandatory and convincing Congress that their items are the most critically needed. Questions that fall in the "program" category will not be included in the census, and those in the "required" category will be closely scrutinized to prove that their inclusion is warranted. If a reduced-content census becomes a reality, it will be in the transportation community's best interest for DOT to take whatever steps are necessary to make inclusion of transportation questions in the decennial census mandatory.

One Long-Form Questionnaire

If the 2000 census again uses a long-form questionnaire similar to that used in 1990 and most recent censuses, the content will be determined by assessing the relative priority among many worthy competing topics and questions. Use of a conventional long form would make it somewhat easier to include new questions, so long as existing questions were dropped to keep the questionnaire burden neutral.

Under a long-form scenario, congressional perception of the relative importance of competing data items will be heavily dependent on the legislative justification of those items. Transportation will again have to make its case. Legislation to make the inclusion of transportation items in the decennial census mandatory would be very helpful in making this case.

Multiple Long Forms (Matrix Sampling)

The use of multiple long forms would be a satisfactory alternative for transportation topics as long as all the transportation items plus questions that provide data needed for cross-tabulation with transportation items are included on the same questionnaires. The multiple long-form option also offers the greatest possibility for expanding the traditional decennial census questions to collect information on such topics as multimodal commuting trips and stops made by commuters on the way to and from work. As stated earlier, the likelihood that multiple long forms will actually be used in the 2000 census is slim because of the operational complexities of controlling and processing more than one sample form on a national scale.

Continuous Measurement

The implications of transportation data from a continuous measurement system are much more difficult to assess than the previous content scenarios, because it is difficult to conceptualize what continuous measurement data would actually mean. The point-in-time estimates of commuting patterns between traffic analysis zones that the last three decennial censuses have provided would be replaced by data that are derived from a 5-year average of those commuting patterns. Can a data set that portrays the average zone-to-zone commuting flows for a metropolitan region over a 5-year period be used to calibrate travel forecasting models?

A continuous measurement system would give annual averages for large geographic areas of 250,000 or more. Would the availability of annual data for these areas be beneficial in monitoring macro-level travel trends and making model-based estimates for smaller geographic areas?

A continuous measurement system could theoretically produce a moving 5-year average picture of commuting between traffic analysis zones every year, once it is fully operational. Would transportation planners use data available with that frequency, or would new data every 3 or every 5 years be sufficient?

If journey-to-work data are provided by a continuous measurement system, the Census Bureau would have to implement and maintain a continuous place-of-work coding system that included commercial addresses, geocoded establishment names, buildings, colleges, hospitals, shopping centers, and other workplaces and that was continually updated with changes to be able to handle coding requirements for the continuous monthly surveys. Changes in city boundaries and traffic analysis zone geographical definitions would have to be added to the coding system on an ongoing basis to reflect geographic changes over time. Is the Census Bureau prepared to invest in this level of coding support?

To address these and other questions, the Bureau of Transportation Statistics has funded a formal study of the implications of continuous measurement for the uses of decennial census data in transportation planning. A panel of experts representing the broad range of data users within the transportation field has been selected to participate in the study. In September 1994 the panel will meet in Washington, D.C., for a 1-day workshop to gain a thorough knowledge of continuous measurement. The panel will be briefed by Census Bureau staff and statistical experts, who will discuss the methodology and the pros and cons of continuous measurement compared with a traditional census.

After the workshop, the panel members will return home to carefully study the implications of continuous measurement for the traditional uses of census data within their particular area of expertise (travel forecasting models, clean air models, transit planning, planning for large metropolitan areas, planning for small metropolitan areas, statewide planning, etc.). Each panel member will prepare a position paper giving views on the adequacy of continuous measurement to meet transportation data needs. These position papers will be the basis for the second meeting of the panel.

The panel members will return to Washington, D.C., in November 1994, for a 2-day meeting to present their views on continuous measurement and make formal recommendations with regard to its possible use as a replacement for the traditional census. The contractor conducting the study will then prepare a final report of the study that summarizes the panel's findings and recommendations. The Bureau of Transportation Statistics expects to be able to submit the report to OMB, the Department of Commerce, the Bureau of the Census, Congress, and the entire transportation community in February 1995.

The Future City: Its Changing Role and Prospects

Martin Wachs, *University of California at Los Angeles*

I am honored and delighted but also rather puzzled to have been invited to be your keynote speaker. The reasons for being honored and delighted are obvious. This is a distinguished group that includes many old friends, and I thank the steering committee for inviting me to fill this important role. On the other hand, I was puzzled because I hardly consider myself to be an expert on the uses of census data in transportation planning, and in fact many of you are the experts to whose work I turn for assistance when I need to know something about census data in transportation. I became more puzzled when I was told not to worry about the fact that I know so little about the subject of the conference. My assignment, I was told, was not to talk about the subject of the conference—there would be plenty of papers on the technical topics associated with the subject. Instead, I was asked to give an "uplifting" talk on the future of cities in general, which is in itself a fairly open-ended assignment. Although I also know relatively little about the future of cities, this worried me less, since I do not think that many other people know much about this topic either. At the very least, whatever I say about the future of cities, focusing on 30 to 50 years into the future, there is very little likelihood that I will be proven wrong before the end of this 3-day conference.

The nature of the city of the future probably is an unanswerable question for several reasons that I will go into soon. Perhaps as a college professor I am well equipped to expound on unanswerable questions because over the years my students have posed to me with earnestness and sincerity some of the most ridiculously unanswerable questions anyone here can imagine. Since it is customary to begin an after-dinner speech with a bit of humor, before turning to my assigned topic I thought I would share with you the five most entertaining and absolutely unanswerable questions about transportation that I have been asked by my students over the past decade in response to my class lectures. Are you ready for them?

First, after a lecture on the Interstate highway system, one student asked me, "How can there be Interstate highways in Hawaii?"

When I was teaching a class on traffic safety a student asked me, "Since it is illegal to drink and drive, why do you need a driver's license to buy liquor?"

On another occasion, after a lecture on the history of transportation systems, a student asked me, "How come we call the place we park our car a driveway, yet we call the place we drive our cars a parkway?"

In a similar vein, another student once asked me, "Why is it that when we transport something in a car we call it a shipment, but when we transport something in a ship we call it a cargo?"

And finally, the most unanswerable question I've ever been asked about transportation, which came during a lecture on the transportation problems of disabled people: "Why do they put Braille dots on the keypad of drive-up automatic teller machines?"

Now I'm going to turn to some more weighty questions about the future of the city and the role of urban transportation systems in that future. Even though I was told that I did not need to consider the transportation uses of census data explicitly, I plan to incorporate some observations about the ways in which planners, politicians, and lay citizens relate to data about the city in an effort to say at least a few things about the future of the city in a way that relates to the theme of this conference.

The City of the Future as a Link With the Past

The city of the future is largely the city of the past. Throughout the entire world, only a few cities will exist in 2020 that we do not already recognize as cities in 1994. In New York or Los Angeles or Washington, D.C., or Phoenix, the vast majority of the houses, workplaces, streets and highways, parks, and institutions of the city of 2020 are already built, and the majority of the people who will live in those cities are already born. Just as the city of 1994 already existed to a great extent in 1950 or 1960, it is also true that the city of the middle part of the coming century is already largely extant. We know a great deal about the city of the future because it is in fact the city of the present. Whereas that may not be a very "uplifting" thought, I think it is obviously correct.

The unique characteristics of our cities—the special features that they do not have in common with one another—are an important part of our culture and will of course continue to be a special part of our character as a people. These unique characteristics relate to the geography and topography and climate that they inherited—and to the highly specialized economic or political functions that they have acquired. The mild climate of a San Diego, the harsh climate of a Minneapolis, and the interaction between cities and major bodies of water, as in the San Francisco Bay Area, Seattle, New York, and New Orleans, give those cities and their transportation systems something of a special character. We should work hard to preserve, protect, and enhance their uniqueness. The special functions of political capitals, like Washington, D.C., and cities rich in historical sites—like Boston and Philadelphia—are similarly unique and worthy of protection and enhancement. Despite the commonalities of culture that we all share—our increasingly national uniform culture of television and movies and popular music—our cities are our collective memories of our diverse roots and the permanent symbols of our heritage and essence as a people. Their unique architectural styles, streetscapes, open spaces, and vistas should continue to be cherished and nourished through programs of historic preservation and educational and cultural programs to remind each generation that a special sense of place gives us an important part of our humanity. Americans best understand the extent to which cities are central parts of a national culture when they visit Paris, London, or Milan, and we are finally realizing that in their own way the special feelings associated with Denver or Baltimore can be nurtured even if they do not yet quite evoke the feeling of a Rome or a Venice.

Transportation facilities are important parts of our culture and central elements of that sense of place. Can you conceive of San Francisco without its cable cars or bridges, of New York without its great bridges or subways, or Los Angeles without freeways? Only recently have we transportation planners, managers, and engineers realized that our work is part and parcel of creating American culture and history as well as fulfilling obvious utilitarian roles. This realization, as exemplified in the artistic work associated with the Seattle bus tunnel or the Red Line subway in Los Angeles, or the sensitive and aesthetically pleasing design of the Interstate highway through Glenwood Canyon in Colorado, is a mark of our maturity as a professional field and a mark of America's maturity as a nation. We now share an understanding of the fact that in the past we have rather crassly destroyed neighborhoods, historical landmarks, and environmental treasures in the name of transportation progress. We are far less likely to be so insensitive to our culture or natural environment in the future. Even though transportation facilities and policies are primarily utilitarian, we are now much more respectful of their historical, cultural, symbolic, and aesthetic values as well as their functional purposes. Our decisions about what to build and what to save are far more informed and sensitive today than they were a mere few decades ago. I certainly hope that we define the future city largely in terms of this understanding of its ties to the city of the past and that we see our roles quite self-consciously as preservers of the special qualities of our cities as well as creators of the functional cities of the future. The city can be both efficient and symbolic, both effective and beautiful. We should settle for nothing less as we set out to create the city of the 21st century.

To acknowledge the linkage between future cities and their historical evolution, as I just did, is certainly not to deny that cities also change substantially as they evolve. Barring major catastrophes such as wars or massive earthquakes, cities actually change rather gradually—over centuries. Even when we rebuild cities after such catastrophes, for cultural and political reasons we frequently choose to rebuild them as they were before their destruction rather than take advantage of the opportunity to start again from scratch by creating a different kind of city in a new image. After the great London fire of 1666, Sir Christopher Wren's master plan to rebuild the city was rejected because the proposed revisions to the street plan would have disrupted the historical locations of major public facilities and churches. After the 1906 earthquake and the ensuing fire in San Francisco, with the exception of the addition of the major diagonal street called Columbus Avenue, the city fathers chose to rebuild the city in keeping with its previous development patterns rather than to implement Daniel Burnham's 1905 plan for the city. And in Europe, many cities were rebuilt after World War II to recreate the street plans, housing patterns, and densities as they existed before the bombing.

Cities in the Coming Century

Cities change slowly by adding new sections that reflect the tastes, technologies, and cultures of their day, but without thoroughly destroying or replacing the older districts that also reflect the tastes and technologies and cultures of their day. New York is quite a different city from Los Angeles not because the two cities have different world views or different economic or social goals today, but rather because they grew to maturity in different eras and their forms encapsulate some of the basic patterns that characterized their youth. Thus, for example, New York's density and street patterns reflect the fact that it was a mature city of millions of people before the introduction of subways and the invention of the automobile. The dispersed low-density form of Los Angeles reflects the fact that it grew to maturity after streetcar lines made decentralized development desirable and possible and after the invention of the automobile, which accelerated the decentralized pattern that had arisen in the first instance as a result of transit technology. And, whereas New York's physical form and culture are clearly derivative of its western and northern European roots, the character of Los Angeles is in both obvious and more subtle ways reflective of its Latin American and Spanish heritage. London's older industrial areas exist in a band outside the central city because they were added to a city that was already well established at the time of the industrial revolution. The industrial areas of most American cities are in the central areas adjacent to ports and rail lines because they were the economic base of cities that were established after the technology of the industrial revolution had become central to urban development. Cities of the coming 50 or 100 years will continue to reflect these many special characteristics that are the result of historical processes—the technology, social issues, and politics during their most formative years and their periods of most rapid growth. These unique histories will continue to give cities their physical forms and their unique characteristics.

There are, of course, many speculations as to which of our current trends will dominate the patterns of urban evolution into the new century and which will be remembered as quaint footnotes to history, like hula hoops and polyester leisure suits. One is always entering risky territory when making predictions. Like many academics, I am sort of a collector of past predictions made by academics, and there is no doubt that the vast majority of them have proven to be far from the mark. Consider, for example, the very widespread predictions made in the late 1940s and early 1950s that by the 1980s the personal helicopter would completely replace the automobile as the most common vehicle providing personal mobility. Imagine what difficulty we transportation professionals would have today had those predictions been accurate. Can you imagine what it would be like to deal with three-dimensional urban traffic congestion rather than the two-dimensional variety, which is sufficiently frustrating?

At the risk of seeing our predictions of today ridiculed in two decades for their obvious absurdity, I can state several visions of the future with which most of us would concur—because they are frequently made and because they seem completely plausible. For example, I would feel comfortable forecasting that for the next 20 or 30 or more years, advances in telecommunications technology will continue to reshape our ways of behaving in the world as radically as the transportation revolution did a century ago. The ability to instantaneously transmit and receive images and data is growing exponentially, and the "information highway" will very soon be a reality. Many more people will handle information and operate computers than is the case today, and this will undoubtedly lead to the further decentralization of residences and places of work in our metropolitan areas. The process of decentralization has been under way for more than a century, and the prediction that it will continue appears to be safe. City cores and specialized suburban office and retail concentrations, increasingly called "edge cities," will continue to exist and in some cases to prosper, but in relative terms more growth in employment, residential population, and economic activity will occur at low and medium density than ever before. This will occur simply because there is no economic or social necessity for high densities. We can conduct our daily work with ever fewer face-to-face contacts and with less reliance on heavy or bulky raw materials, which tend to keep manufacturing and industrial employment near ports and railheads.

This pattern will be facilitated by improved multimedia communications links, and electronic linkages among us will account for a greater and greater share of our interaction with one another. But there will still be a need for and a desire to travel—perhaps with different frequencies and time patterns and perhaps to different destinations. Longer but probably less frequent trips to office headquarters, schools, and shopping centers will continue to congest roads and streets at peak periods. Growth in traffic congestion will probably slow down, but it will continue because there will be more people; because household income will in general continue to rise among middle- and upper-income groups, though perhaps more slowly than in the past; and because richer people will have more desires that must be met at different locations. I believe that suburb-to-suburb trips will continue to be the fastest-growing kind of trip and that peak periods will spread because of more flexible working hours as well as better management of transportation capacity.

Some observers believe that we will re-create in the coming decades the older, mixed-use, higher-density city cores that characterized the turn of the last century. Under the heading "neotraditional town planning," some have been advocating a return to pedestrian-oriented and transit-oriented land use planning with much higher degrees of mixed land uses. I am actually quite sympathetic to this notion. I personally dislike automobile-oriented residential neighborhoods without sidewalks or transit and with shopping opportunities only at megamalls rather than in street corner shops. I prefer to live near a transit station at which I can catch a train to downtown and in a community where I can walk to the store. I welcome the addition of these "new-old" communities because they increase the range of choices available to us in the housing market and because I think that more choice in the marketplace is almost always a good thing. And although I hope that many such neotraditional communities are successful in market and social terms, I do not expect them to reverse the general long-term trend toward lower-density communities. I believe that so far most neotraditional communities have served only upper- and middle-income people and that in many cases, despite their neotraditional appearances, their actual densities have remained suburban in character. In few or no cases have the concepts of neotraditional planning been used to renew decaying inner-city neighborhoods. Whereas I hope that some initiatives of that type will actually take place, I think that, for obvious reasons related to market economics, they will remain exceptional examples and not the general trend.

I expect that transportation technology will see its greatest advances in the gradual and systematic augmentation of movement technology by communications technology. I believe that before too long we will have access to smart buses and shuttles, for example, which will be public transit systems providing users with a much-improved level of information on where approaching transit vehicles are located, what their costs and levels of seat availability will be, and what their arrival and departure times will be. We will probably slowly decrease the extent to which we operate transit on fixed routes in favor of flexible, demand-responsive routing, especially in lower-density areas. Similarly, I believe that the most significant improvements in individual vehicle technology will be the result of enhancing automobile capabilities through communications. In congested corridors on key links of each region's highway system, automobiles will eventually be guided along computer-controlled automated highways with something like three or four times the capacity of current highways within existing rights-of-way. Various forms of route guidance and automatic braking systems will serve as technological milestones along the way to automated highways.

I also believe that it will be possible, within a couple of decades, to envision urban transportation systems relatively free of the most common air pollutants that are the single most consistent focus of current policy, although we may face other struggles to control pollutants and toxics that are as yet not well understood. Despite the fact that transportation demand management and transportation control measures dominate our conversations today, I expect that most of the progress in resolving air pollution problems in the future will be through technological innovations rather than through massive shifts in travel behavior or the wholesale abandonment of automobiles for transit, cycling, and walking.

Like most people associated with the field of urban transportation, my visions of the future city include major advances in the capacity of technology to address some of the more vexing aspects of daily life. I honestly do have confidence that changes in transportation and communications technology will gradually but certainly enable us to solve some of the problems, like air pollution and energy efficiency, that we as transportation experts consider dominant in our field. Yet I worry about visions of the future that focus exclusively on new technological marvels. My concerns about the future of the metropolis reflect my belief that technology cannot really solve our most pressing social problems, especially some that we now identify as being outside the realm of transportation planning but that I personally see as being very much involved with transportation.

Social Dimensions of the City of the Future

Most urban economists and demographers see the city of the future in troubling terms. The gap between the incomes of the richest and the poorest Americans is expected to continue to widen; the economic well-being of the poorest segments of our society is expected to continue to decline; the racial and ethnic composition of our cities is expected to become increasingly diverse; and the quality of education, health care, and welfare services is expected to continue to decline for decades to come unless there are major policy interventions. Doesn't it trouble you that we frequently see the city of the future as a haven that is the product of technological marvels, yet we usually also see the city of the present as the locus of unmanageable social and economic problems? Our confidence that we can solve problems of traffic congestion and air pollution with technological advances must be tempered by our society's repeated failures in other realms. Our metropolitan areas are plagued by violence, crime, homelessness, unemployment, racial and ethnic inequality, and fiscal deficits. There is a pervasive feeling that we cannot solve these problems because our political systems are more gridlocked than our highways and that our social systems have no will to solve them. What major contribution has transportation planning, investment, and management made to address these problems during the past decades? Some might say that by increasing the ability of some Americans to opt for upper-income, ethnically homogeneous suburbs, transportation systems have, if anything, heightened these problems. I honestly believe that transportation planners and national and regional transportation policies have in some cases innocently and in a few specific cases even deliberately contributed to the worsening of these social problems. I also believe that the realization of all of our high hopes for technological change in the future will fail to improve the quality of urban life unless and until transportation planners recognize and accept some responsibility for problems in these other realms and design transportation policies explicitly to attempt to overcome them.

Transportation systems certainly are not the primary causes of poverty, racism, or homelessness in our cities, yet we cannot turn our backs on these problems. We must accept some of the responsibility for addressing them. If I have one major disappointment with the professional community of transportation planning of which I am a part, it is our collective failure to grasp the pervasive, complex relationships between transportation systems and the social and economic failures of our cities and the absence of an ethical commitment on the part of many—though certainly not all—transportation planners to address these issues. In my view, if the city of the future is to be a more satisfying environment for people of many different backgrounds, we must address transportation problems with a commitment to deal with these problems head on that we have not yet shown.

We can no longer be blind to the fact that in American cities transportation systems provide access to the richest array of economic, educational, cultural, and recreational opportunities, but that because land use has adjusted to the nearly universal availability of automobiles, the carless are more generally isolated from those opportunities than urban Americans have ever been. And, since the carless are likely to be the poorest citizens, disproportionately consisting of the elderly, the very young, recent immigrants, the disabled, and members of minority groups, the rising fares of public transit systems and the declining service provided by transit are becoming a significant social problem in many metropolitan areas. We increasingly rely on local sales taxes to bear most of the cost of providing public transit. Sales taxes are generally regressive—they take a much higher proportion of the income of poorer people than of richer people. At the same time, we are increasingly putting our transit resources into new rail systems and express bus operations serving wealthier suburbanites, who already have very high rates of automobile ownership. To the extent that we continue to do this, we will be creating cities in which gaps between the haves and the have-nots grow because of widening differences in mobility and in disposable income. Our transportation policies might well be worsening both the access and the income components of this problem. The nature of the future city will depend at least to some extent on the actions we take to create greater access and mobility for those who need it most—the poor, disabled, old, young, and immigrants. I believe that we should address the needs of the transit-dependent population much more directly in transit planning and, more generally, in transportation planning.

Although we decry the problems of crime and violence in our cities, collectively we have seen a very small direct role for transportation planners and managers in the realm of crime prevention. We now have enough information about crime patterns, however, to know that in many cities a substantial proportion of crime occurs at bus stops, in large parking garages, on the highways, and in subways or involves victims who are walking to or from transit stops. My own research on transit-related crime in Los Angeles, for example, demonstrated that rates of victimization were up to seven times as high as those reported by local transit police departments. Whereas we envision a future of automated, high-technology highways, we do little to improve the safety of our existing systems through improved lighting, patrolling, policing, and sensible designs with security as the single most important design criterion. The nature of the future city will depend to at least some extent on the actions we take and the policies we create to recognize the role of transportation in urban crime prevention and reduction.

Transportation systems also could become a greater contributor to racial and ethnic equality in America than they have been. We could argue that transportation investments make people and economic activities accessible to one another and thereby potentially contribute to ethnic and racial integration and to the betterment of the poorer segments of society. It is also clear, however, that in other ways they may well facilitate racial and ethnic segregation and economic isolation. The building of superhighways and suburban rail lines into the far-flung suburbs makes it possible for economically secure white people to live and work in communities far removed from one another and to travel through communities of minority poverty without ever really interacting with or understanding them. The accessibility thus provided has enabled capital investment to flee from the inner cities, bypassing minority communities and concentrating in mostly white-owned suburban areas. We construct new suburbs from scratch and allow inner-city communities to decline. We don't create segregation, but we create conditions that enable people with resources to consciously pursue segregated neighborhoods. At the same time, rights-of-way for transportation facilities have removed disproportionately the residential neighborhoods and community facilities serving minority communities. The nature of the future city will depend to at least some extent on the actions we take and the policies we create that recognize the role of transportation investments in economic development, job creation, community renewal, and the reduction of the gaps in opportunities available to rich and poor people.

On the one hand, I argued earlier that the city of the future is largely the city of the past. Our technological breakthroughs and new communities only marginally and slowly change the basic urban physical patterns that we inherited. On the other hand, the city of the future is largely what we choose to make it through our complex processes of governance and decision making. Investments in transportation systems are among the most influential in creating those marginal changes. I worry, however, that our governmental decision-making structures are becoming less willing to deal with the poverty, inequality, crime, and violence that plague our environment. In metropolitan areas we sometimes have hundreds of separate bodies of government, each trying to provide specific services to particular groups of citizens and all failing to make commitments to share in governance toward common regional goals. Whereas most of us now recognize that the region is the functional economic unit of most importance, it is at the metropolitan regional level where our government is weakest and we are failing to act collectively in the common interest. The nature of the future city will depend to at least some extent, and perhaps to a great extent, on the actions we take and the policies we create to recognize the role of transportation systems in regional integration, economic development, and more unified governance.

Political Nature of Transportation Decision Making

Despite my concern that we have not done enough to address the social needs of the increasingly diverse population through transportation policy, I must admit that over the last 40 or 50 years transportation policy making clearly has become more democratic, open to participation by diverse interest groups, and sensitive to a variety of perspectives. Requirements added to the transportation decision-making process—including those related to public hearings, comments, and workshops and environmental impact reviews—and the emergence of transportation user groups, community-based organizations, and interest groups representing environmental concerns have surely democratized transportation decision making. These groups have of course differed in the resources they have been able to bring to bear on transportation policy debates, the skillfulness of their staffs, and the persuasiveness of their arguments. However, the effectiveness of advocates for air quality, rail system construction in some large cities, and the disabled in transportation policy making have proven that groups who are well organized and effective at constituency building can make an enormous difference in the outcomes of transportation policy debates.

If I am correct that the politics of urban transportation has become more open and accessible, yet that we have not adequately addressed the economic and social needs of our cities through transportation policy, I can think of two explanations for this shortcoming. The first is that effective coalitions of interests have not emerged on behalf of those whose social and economic needs are being inadequately met by transportation policy—the unemployed, minority groups, the elderly, and so on. In my idealized future city, sophisticated organizations representing the needs of these interests would emerge that are as active and effective as the interest groups concerned with air quality and energy policy that have emerged in the past two decades.

The second explanation is the lack of a deep, powerful, and convincing data base providing information that describes and codifies the performance of the transportation system with respect to economic and social development and equality of opportunity. It seems clear that progress in addressing air quality and energy conservation through transportation policy making has been enhanced dramatically by data establishing, for example, the extent of and distribution of air pollution and the change in the energy consumption characteristics of the vehicle fleet over time. The effectiveness of organizations advocating cleaner air and greater energy efficiency in transportation has been significantly enhanced by the availability of extensive and reliable data to help them make their cases. I believe that we do not have good information readily available to indicate the relative difference in accessibility for poor and rich people, the levels of transit service available to different communities, the extent to which capital investments in transportation facilities produce benefits to lower- and middle- and upper-income communities, and so forth. I believe that the ready availability of information on such issues would enhance the effectiveness of advocates for social change through transportation systems and within transportation programs and that the absence of such information itself hinders the formation of effective advocacy organizations.

Our data bases and the policy questions we address have something of a chicken and egg relationship. Transportation policy makers do not ask with sufficient frequency about the impacts of transportation investments on the well-being of poorer and minority communities, the elderly, the disabled, or even women as a group. Perhaps they fail to ask those questions because our data bases do not provide information on them, and perhaps our data bases do not highlight such issues because decision makers fail to ask about them. Nevertheless, there is an important need to be addressed here, and I believe that better information can be a spur to better policy making by making it possible for disenfranchised interests to argue more cogently for their needs in the transportation policy-making arena.

Conclusion: Our Role in Shaping the Urban Future

This conference will deal with the importance of information and, more particularly, with the nature of one source of information—the U.S. census—in transportation planning and policy making. In the light of what I have been saying so far about the future of the city and about the importance of good data bases in determining effective democratic participation in transportation policy making, I would like to argue that we share a responsibility for improving the data bases available to planners and policy makers. In the coming decade an important dimension of that improvement should relate to the social and economic status of diverse populations. I am aware of the political pressures to lessen the scope and depth of census data coverage of transportation issues. I would like to argue that we should collectively demand that our nation's commitment to the collection of travel-related information in the national census be strengthened rather than weakened; that our ability to link travel and transportation information with other social and demographic indicators of human well-being be enhanced rather than lessened.

To some extent, American cities of the future are already determined by the history of the cities we now see before us. We must study, understand, appreciate, and build on the ways in which our cities encapsulate our history and our culture. To some extent, future American cities will surely also be shaped by emerging new automotive, highway, transit, and especially communications technology. We should certainly work hard to understand the interactions between urban form, daily urban life, and the emerging technologies, but they will continue to marginally shape our cities—probably for the betterment of most people—whether we understand these forces or not. I believe that the social, ethnic, and economic divisions and tensions that characterize our cities today will grow to be the dominating policy issue of the coming decade, surpassing environmental concerns, and that we in the transportation community will be called on to play an increasing role in addressing those problems. Strangely, it is in this realm that I believe we have the greatest opportunities to influence the future of the city and the future quality of life for all Americans, yet it is in these areas that we as transportation experts have at this moment the fewest ideas and the weakest commitments to contribute. I hope that this situation will change, and I hope that as you consider the future role of census data in transportation, you will specifically address the ways in which census data and transportation data can together shed more light on the solution of the complex social and economic issues we will continue to face in the coming decades.

RESOURCE PAPERS: USE OF 1980 AND 1990 CENSUS DATA

The Decennial Census and Transportation Planning: Planning for Large Metropolitan Areas

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The purpose of this resource paper is to describe the use and application of decennial census data for transportation planning purposes in large metropolitan areas in the United States. In particular, use of the 1980 Urban Transportation Planning Package (UTPP) and the 1990 Census Transportation Planning Package (CTPP) will be discussed.

Large metropolitan areas are defined as regions with populations of 1 million or greater. Though this conference makes a distinction between large metropolitan and small to medium-sized metropolitan areas, the uses and applications of census data can be quite similar. Whereas transportation problems such as pollution and traffic congestion are typically an order of magnitude more severe in the larger metropolitan areas, this may or may not lead to more immediate and sophisticated uses of census data. The prime distinctions between large and small to medium-sized metropolitan areas are probably staffing levels and staff proficiency in managing large data sets such as the 1990 census.

Review of Literature: Use and Application of Census Data in Transportation Planning

The use of decennial census data in transportation planning has been covered extensively in the transportation research literature. The reader should specifically review three special reports issued by the Transportation Research Board covering census/transportation conferences held in 1970 in Washington, D.C. (*1*); in 1973 in Albuquerque, New Mexico (*2*); and in 1984 in Orlando, Florida (*3*). Also useful is the collection of articles in *Transportation Research Record 981*, published in 1984 (*4*). The reader also can refer to the Federal Highway Administration (FHWA) publications entitled *Transportation Planners' Guide To Using the 1980 Census* (*5*) and *Case Studies—Applying the Urban Transportation Planning Package (UTPP) in Transportation Modeling* (*6*). An ITE informational report entitled *Use of Census Data in Transportation Planning* includes sections on how census data have been used in transportation analysis (*7*). These reports provide a general overview of the use of 1970 and 1980 census data in transportation planning.

The Albuquerque and Orlando conferences were integral components of the formal and informal efforts of the Bureau of the Census to determine the census content for the 1980 and 1990 decennial censuses. Details on the Census Bureau's content determination efforts are described in a series of *Content Determination Reports*, including a report on place-of-work and journey-to-work issues (*8*). This 1994 Irvine, California, conference will be an important element of the content determination process for the 2000 decennial census.

Complementary to the literature on the use of census data in transportation planning are several reference works on census trend data. The most popular are Pisarski's *Commuting in America* report published by the Eno Foundation (*9*); the 1986 FHWA report *Journey-to-Work Trends* (*10*); and a new report by FHWA, *Journey-to-Work Trends in the United States and Its Major Metropolitan Areas: 1960–1990* (*11*). Also of interest is a 1992 report by Pisarski analyzing results of the 1990 census (using Summary Tape File 3A data) and the 1990 Nationwide Personal Transportation Study (NPTS) (*12*).

Getting the Data Out: Disseminating the 1990 Census

Processing and disseminating the 1990 census data was (and still is) a mammoth operation. For the 1990 census, the Bureau of the Census collected data from 92 million households in the United States at a cost of approximately $25 per housing unit, for a total cost of $2.6 billion (*13,14*). Approximately one household in six, or 15 million households, was given a census long form to fill out. Given the amount of data and the complexity of the data processing operations, the Census Bureau has staged the release of new census data on an almost continuous basis since 1990.

The staged release of census products has aided metropolitan transportation planners by effectively distributing the work load over a period of years. Census data products are like a giant jigsaw puzzle with new pieces added over time until the "picture" is finally complete. Had the opposite been true, with census data dumped all at once on eager clients, the rush to get the big picture probably would have thwarted efforts to carefully review results at a greater level of detail.

One of the findings of the 1984 Orlando conference was the desire to have staged releases of census journey-to-work data. Many metropolitan transportation planners had to wait until 1983 or 1984 data to get basic data on 1980 census county-to-county commute patterns. The 1984 conference said, "Get us county-to-county data as soon as possible; get us the zone-to-zone or tract-to-tract data after that." In response to these concerns and other data user comments, the Census Bureau, the U.S. Department of Transportation, and some volunteer transportation professionals devised a split package scheme for disseminating 1990 census journey-to-work results—the Census Transportation Planning Package/Statewide Element (CTPP/SE), containing place-to-place and county-to-county commuter flow data as well as place-of-residence and place-of-work tables, and the Census Transportation Planning Package/Urban Element (CTPP/UE), containing zone-to-zone or tract-to-tract data (and zone-of-residence and zone-of-work tables). In addition to the CTPP/SE and the CTPP/UE packages, the Bureau of the Census developed a new product, the Summary Tape File S-5, which included 1990 census county-to-county commuter flows (without stratification by means of transportation).

Other standard census products were an important component of metropolitan planning organizations' (MPOs') census analysis plans. These products included the 100 percent count data in the redistricting tape and Summary Tape File 1A, as well as the sample data in Summary Tape File 3A and the Public Use Microdata Sample (PUMS).

By law, the Bureau of the Census must provide total population counts by state to the President of the United States by December 31 of each census year for purposes of apportionment of the House of Representatives. In January 1991 the Census Bureau released place, county, and state total population counts as part of its *Thank You America* count program. This was followed in March 1991 by the release of the Public Law 94–171 tape. The PL 94–171 redistricting tape provided block-level population characteristics by race and ethnicity and for persons of voting age (18 or over). Within months, the rest of the 100 percent count items included in the 1990 census were released in the Summary Tape File 1A (STF1A) data sets.

The most significant release of census data in 1992 was the first long-form, or sample, data included in the much awaited Summary Tape File 3A (STF3A). The STF3A tape file included small-area (block-group) data on all sample long-form data: means of transportation to work, commute vehicle occupancy, average commute time, intracounty versus intercounty commuting, household vehicle availability, household income, and number of employed residents.

The release of STF3A was a benchmark for census analysts, a cause for celebration as well as consternation. Carpool shares went down compared with 1980 census values. Drive-alone shares went up. Transit and walk shares declined. The share of workers working at home increased dramatically. Metropolitan transportation planners were turned into "spin doctors" overnight trying to explain the 1980 to 1990 trends only a matter of hours after receiving the data themselves. The savvy transportation planner quickly assembled trend data and came up with logical answers for the inevitable question: What do the numbers mean? It was the Census Bureau's job to disseminate the data files to the local clients, the MPOs. It was the MPOs' duty to analyze the data in terms of trends, highlights, and missed and met expectations, and to articulate the reasons why these trends were occurring. Census data could then be readily digested by the public, the policy makers, and the media.

In December 1992 the Census Bureau released Summary Tape File S-5. This popular data file included all county-to-county worker flow data for the entire United States. No data on means of transportation were provided, but the basic county-to-county commute "puzzle" was filled in with STF S-5.

The CTPP/SE packages followed in spring 1993. By fall 1993 and early 1994, the CTPP/UE packages were streaming into MPOs.

The major disadvantage of a March 1994 conference on the decennial census and transportation planning is the all too brief time that metropolitan and state transportation planners have had to analyze the CTPP/UE. Certain metropolitan areas may have received their CTPP/UE packages as early as October 1993. Other major metropolitan areas still may not have their package. Probably less than half of the approximately 300 urban element packages are available now. On the other hand, all states and metropolitan areas have had nearly a year to review results from the CTPP/SE.

Despite the prematurity of this March 1994 conference, the immediate concern is to consider the Census Bureau's tight deadlines for determining content for the 2000 census. This process, scheduled from 1993 to 1996, will culminate in a national content test in 1996, with the final 2000 census questions to be transmitted to Congress in 1997. Usefulness of data tabulations in the CTPP/SE and the CTPP/UE, as well as specifications for 2000 journey-to-work tabulations, may wait until CTPP data users have had sufficient time to fully explore and analyze the new 1990 data sets. Recommendations for 2000 census content cannot wait.

USE OF CENSUS DATA IN METROPOLITAN TRANSPORTATION PLANNING

The following sections discuss various uses and applications of census data in metropolitan transportation planning, including trend analysis; travel demand model estimation, calibration, and validation; demographic and land use allocation model estimation, calibration, and validation; census data and estimation of small-area employment data; census data and household travel surveys; transit market analysis; miscellaneous transportation planning applications; and nontransportation planning applications of the journey-to-work data.

Trend Analysis

The most common application of census data is for trend analysis. How have things changed and why have they changed? How have growth rates changed over the decades? What are the emergent trends? Trend analyses afford an excellent opportunity for detailed cross-sectional and cross-temporal review of the sociodemographic conditions within and between metropolitan areas.

In contrast to trend analysis are the area profile analyses, in which all census data for a geographic area are included in a series of printed tables. These area profiles are an extremely popular way of disseminating census data, especially STF1A and STF3A data. Census analysts, as part of the state data center and regional data center programs, use commonly available software packages such as SAS or other data base software to prepare these tabulations. Federal Highway Administration staff, working with MPO staffs, are currently preparing program code to create area profile reports using data from the CTPP Parts A, B, 1, and 2.

An important element of trend analysis is understanding the changes in census content over the decades. Common questions, such as What was the average commute trip duration for residents in your region in 1970? What was the drive-alone share in 1960 and 1970? How many ferry commuters resided in your region in 1980? can only be answered, "The data do not exist because census takers did not ask the same question in earlier censuses." A useful addition to any trend analysis report is a brief summary of census content changes over the analysis period.

Examples of trend analysis reports include publications by the MPOs in Chicago, the San Francisco Bay Area, Philadelphia, San Diego, and Seattle. These reports are the best source for understanding changes in commute patterns and socioeconomic characteristics within regions. In contrast, the *Journey-to-Work Trends* report published by FHWA provides the best information on trend comparisons between regions.

The Chicago Area Transportation Study (CATS) publishes a monthly, two-color, six-page newsletter, *Transportation Facts*, which includes census trend information and other results from its household travel surveys. CATS also recently published a report containing profiles for all Illinois counties on transportation-related data from the STF3A and CTPP/SE (*15*).

The San Francisco Bay Area's Metropolitan Transportation Commission (MTC) has produced a series of working papers describing county, place, and "superdistrict" results based on STF1A (*16*), STF3A (*17*), STF S-5 (*18,19*), the CTPP/SE (*20*), and the CTPP/UE (*21*). Trend analyses include county-to-county commuters from 1960 to 1990; change in total population since 1860; change in households since 1940; and change in household vehicle availability since 1960. In addition, MTC has released an electronic publication (computer file on floppy diskette) that includes place-to-place workers, by detailed means of transportation, comparing 1980 UTPP and 1990 CTPP/SE commuter flows (*22*). To maximize the use and understanding of census data, MTC provides copies of census working papers to Bay Area public and private libraries, as well as to interested members of the public, professionals, and policy makers.

The Delaware Valley Regional Planning Commission (DVRPC) in the Philadelphia region has published a report documenting county-to-county commuter flows by means of transportation, comparing the 1970, 1980, and 1990 journey to work (*23*). The report includes useful "desire line" maps showing changes in commuting patterns—within the Pennsylvania suburbs, within the New Jersey suburbs, commuting to Philadelphia, reverse commuting from Philadelphia, and interregional commuting.

The San Diego Association of Governments (SANDAG) produces a multicolor bimonthly newsletter, *SANDAG INFO*, which contains graphics as well as tabular results.

The Puget Sound Regional Council (PSRC) in the Seattle region publishes a monthly data newsletter entitled *Puget Sound Trends*. PSRC, as the regional data center for the Seattle region, also provides area profile reports in hard copy and computer format and maps showing census tracts, census blocks, and ZIP codes.

The aforementioned reports and products are just a sample of the ways in which census data are processed and disseminated by MPOs in the United States. These tabular and graphic reports are excellent ways of providing information to the clients and partners of the MPO.

Travel Demand Model Estimation, Calibration, and Validation

One of the most common uses of census journey-to-work data is in travel demand forecasting. The census not only provides base-year benchmark sociodemographic information for use as input into standard travel demand model simulations, but also the journey-to-work commuter flow matrices can be adapted by the transportation planner into an observed work trip table for aggregate validation of work trip distribution and mode choice models.

The following working definitions are provided for the terms estimation, calibration, and validation. Also discussed are the terms aggregate and disaggregate. These are offered as working definitions rather than as accepted fact because of their various and conflicting usage in the profession. *Estimation* is the process of determining model coefficients and constants using statistical software packages. Logit models, cross-classification models, and regression models are *estimated. Calibration* is the process of adjusting model coefficients and constants using manual (or mechanical) procedures. The friction factors and *k*-factors in gravity models are calibrated. The modal constants in regression and logit models are also calibrated (adjusted) to match observed choices. Often the terms calibration and estimation are used interchangeably, generally leading to confusion in communication between transportation planning professionals. *Validation* refers to the process of comparing model-simulated choices with observed choices. Validation is typically a stage in the model development process, whereas calibration is the actual activity to achieve a validated model. "Observed" choice data bases are independent estimates of sociodemographic or travel behavior characteristics. Observed data bases include, for example, census data, traffic counts, transit on-board surveys, and household travel surveys.

Aggregate refers to survey or census records tabulated or analyzed at any level greater than the original level of data collection (e.g., 1990 census block-level data are aggregate data as well as place- or county-level data). Most 1990 census products, including the STF1A, STF3A, and the CTPP/SE and CTPP/UE, are aggregate data. *Disaggregate* refers to survey or census records maintained at the original level of data collection (e.g., the household level or the person level). Household travel surveys collected and maintained by MPOs and state departments of transportation are disaggregate data sets. The census PUMS is a disaggregate data set of individual census household and person records, even though the geographic identification is suppressed at the fine level of geography (less than 100,000 population groupings).

This last point about the CTPP/UE being an aggregate data set and the PUMS being a disaggregate data set may be confusing, given the very small geographic areas associated with the CTPP/UE in contrast to the very large geographic areas associated with the PUMS. This is a critical distinction, given that disaggregate choice models cannot be estimated using the CTPP/UE since the analyst does not have information on each household's or worker's characteristics and choices. Disaggregate choice models can, on the other hand, be estimated from PUMS data given that the analyst does have full information on each household's and worker's characteristics and choices (though not any detailed geographic characteristics).

Can models be estimated using the CTPP/UE data sets? Yes, aggregate gravity models can be calibrated using zone-to-zone observed trip tables. Yes, aggregate mode choice models ("diversion curve" models) can be calibrated using the same observed trip tables. *Should* travel demand models be estimated using the CTPP/UE data sets? Aggregate models should be avoided when the analyst can develop disaggregate models instead. (The reader should refer to transportation planning textbooks for the arguments in favor of and against disaggregate and aggregate demand models.) On the other hand, since all gravity models are aggregate models, it is appropriate to use the CTPP/UE as a fallback data set to calibrate an aggregate, home-based work person trip distribution model.

Demographic and automobile ownership models, other than land use models, can be estimated or validated, or both, using census data. Examples of demographic models include the following:

- Household income distribution models,
- Distribution of households by number of workers in household model,
- Distribution of households by number of persons in household model, and
- Distribution of households by number of vehicles available model.

Pearson (*24*) describes the estimation of aggregate households by household size and households by vehicle available models using the 1980 UTPP. Purvis (*25*) discusses the estimation of disaggregate households by workers in household and households by vehicles available models using the 1990 census PUMS. These two papers demonstrate the viability of using census data in estimating disaggregate and aggregate demographic and automobile ownership models for use in regional travel demand forecasting systems.

Part 1 of the CTPP/UE contains numerous zone-of-residence cross-tabulations that will be invaluable for aggregate validation of demographic and automobile ownership models. For example, Table 1-13 includes a cross-tabulation of workers in households (six categories) by persons in households (five categories) by zone or tract of residence (*26*). If the transportation planner carries a household size segmentation through his or her travel model set, Table 1-13 provides excellent observed data on workers in households by household size for validation at a zone, superzone, district, superdistrict, county, and regional scale. (In fact, the CTPP/UE is the only source of small-area census data that includes the distribution of households by workers in households. The STF3A file only has total employed residents by small area of residence, not differentiating between workers-in-households versus workers-in-group quarters units.) A commonly used market segmentation in travel demand model systems is households by household size and vehicles available. Table 1-17 is the only small-area census source for data on distribution of households by household size by vehicles available. The analyst may use this table for the estimation of aggregate models for splitting households by household size and/or vehicle availability level, or the analyst may use this cross-tabulation for the aggregate validation of these demographic models.

Trip generation models cannot be estimated using census data because of the total lack of information on trip frequency per household or per worker. On the other hand, the census workers-at-work data can be adjusted and factored to create observed home-based work person trip tables by means of transportation. Work trip generation and trip distribution models can then be calibrated to match, or closely approximate, the observed work trip travel patterns.

The 1980 and 1990 censuses asked persons in the long form "At what location did this person work [most of] last week?" and "How did this person usually get to work last week?" If the person was an employed resident but was absent from work the last week of March 1980 or March 1990 because of sickness, vacation, labor dispute, and so forth, that worker would not have provided information on the usual means of commuting or usual place of work. This is referred to as weekly absenteeism. Any information on "within week" variation in commute behavior, such as daily absenteeism or commuting 1 day per week by transit or carpooling, or commuting from home to work in one mode (say, casual carpool) and commuting from work to home in another mode (say, public transit), would not be accounted for in census journey-to-work data. No census information is available on moonlighting—increasing the number of jobs held by an employed resident.

The census is not an origin-destination survey. The census does not ask "From whose home did this person usually leave for work LAST WEEK?" This is the traveling salesman phenomenon, in which the person could be away from his or her real home on business and view a hotel or motel as a "home" during the census period. This is a cause for amusing and illogical commuter flows (e.g., persons reporting walk commutes from San Francisco to Los Angeles or subway commuters living in Honolulu and working in New York City). Typically a metropolitan area will have a small fraction of workers making absurdly distant commutes. The recommendation is to laugh them off and put them aside—there will always be unusual outliers in census (and survey) data sets that cannot be treated seriously in transportation planning analysis.

Metropolitan transportation planners have developed several techniques for factoring journey-to-work commuter matrices into observed home-based work trips. Mann describes procedures used for the Washington, D.C., metropolitan area to convert the 1980 UTPP commuter matrices to observed work trip tables (*27*). These procedures were implemented in the Puget Sound region as described by Deardorf and Schneider (*28*). Kollo and Purvis describe the use of the San Francisco Bay Area 1981 household travel survey in computing work trip rates per commuter to convert journey-to-work matrices to observed home-based work trips (*29,30*). Walker discusses the Philadelphia region procedures for conversion of 1980 UTPP commuter matrices (*31*). The 1980 UTPP adjustment procedures for the Washington, D.C., Seattle, San Francisco, and Philadelphia regions are based on a traditional definition of home-based work person trips that includes mechanized modes (drive alone, carpool, transit passenger) but excludes nonmechanized modes (walk, bicycle, other). The resulting home-based work trip rates range from 1.57 person trips per commuter in the Bay Area to 1.78 person trips per commuter in Philadelphia and range from factors of 1.54 to convert drive-alone commuters and 2.15 to convert carpool commuters into observed home-based work carpool trips for the Washington metropolitan area.

Probably the most legitimate technique for converting the 1990 CTPP/UE commuter matrices into observed home-based work trips is using work-trips-per-worker trip rates collected as part of regional household travel surveys. Several metropolitan areas in the United States conducted household travel surveys between 1989 and 1991, including Los Angeles, San Francisco, Sacramento, Chicago, Boston, Minneapolis, Atlanta, and San Antonio. Perhaps even data from the Nationwide Personal Transportation Survey could be used for estimating work-trip frequency per worker trip rates for metropolitan areas without current travel survey information.

Multiday household travel surveys would be an ideal source of information for adjusting and factoring census journey-to-work commuter flows. The Bay Area MTC, for example, collected multiple weekday travel diaries from nearly 1,500 households in spring and fall 1990. This type of data set could be used for analyzing daily versus weekly absenteeism patterns, work trip mode switching during the week, and the different travel modes used in the trips from home to work as well as from work to home.

The calibration and aggregate validation of home-based work-trip attraction models may be more problematic given potential differences in independent estimates of total employment compared with the CTPP/UE workers at zone-of-work. The CTPP workers at zone-of-work, derived from Parts 2 and 3, excludes the weekly absentees and moonlighting. Weekly absenteeism (only by area-of-residence) can be estimated from the STF3A or the CTPP/UE Part 1 tables. Moonlighting rates can be estimated from local sources, such as household travel surveys, or from national sources, such as the Current Population Survey conducted by the Bureau of Labor Statistics and the Bureau of the Census.

Other errors in the census workers-at-work data will include standard sampling error, geocoding errors, allocation errors, and the use of "default" or "workers-at-large" zones for communities or counties with incomplete address coverage in the census TIGER files. Ideally, the default or workers-at-large zone should be no more than 1 to 2 percent of the region's commuters.

The CTPP/UE data are not equivalent to total employment. Ideally, the CTPP/UE workers at work should be 90 to 95 percent of the regional agency's independent estimates of total employment (i.e., total jobs in the region). The recent study by DVRPC (*23*) used a 2.2 percent weekly absenteeism rate (derived from the 1990 census) and the national multiple jobholding rate of 6.2 percent of employed residents holding multiple jobs (derived from the Current Population Survey). DVRPC used the national moonlighting rates by industry sector, ranging from 4.7 percent for construction workers to 9.3 percent for those working in governments. (DVRPC also used other factors to bring the CTPP more in line with independent estimates derived from Dun and Bradstreet and municipal tax records.)

Trip distribution models can be calibrated using the adjusted and factored observed home-based work person trip tables and network levels-of-service files. This means calibrating the standard friction factors used in aggregate gravity models using either highway travel times or some combined impedance data. Socioeconomic adjustment factors, or *k*-factors in transportation planning jargon, could also be used to adjust county-to-county or district-to-district model-simulated home-based work person trip flows to match or approximate the observed trip patterns. The Seattle (*28*) and Philadelphia (*31*) reports provide more in-depth coverage on the use of the 1980 UTPP in work-trip distribution model calibration.

Work-trip mode choice models cannot be estimated from census data. On the other hand, existing work-trip mode choice models (estimated from disaggregate household travel survey data) can be calibrated and validated to match or approximate CTPP-derived observed home-based work trips by means of transportation. The modal constants in the model utility functions can be adjusted (calibrated) upward or downward to change the base-year model simulation. These modal constants are typically calibrated on a county-to-county or district-to-district basis.

Travel assignment models can use census journey-to-work travel time data as an element of the traffic assignment process. Walker describes the use of travel time data from the 1980 UTPP in analyzing New Jersey counties in the DVRPC region (*32*). Walker's research is germane in the light of current federal regulations on the Clean Air Act Amendments that relate to the use of "actual" or "observed" data in calibrating travel models for use in developing mobile source emissions budgets. The census journey-to-work data set can be an excellent source of data for the calibration and adjustment of speeds and travel times from traffic assignments.

To summarize this section, metropolitan transportation planners have demonstrated the utility of census data in the estimation, calibration, and validation of regional travel demand model systems. One essential use of census data is for benchmark, base-year socioeconomic small-area data used as input into travel model simulations. Analysts have used census data in statistically estimating and validating demographic and automobile ownership models, work-trip generation and work-trip attraction models, work-trip distribution models, and work-trip mode choice models and for validating the highway speed simulations in traffic assignments.

The 1990 census journey-to-work data included in the CTPP are *not* a substitute for a comprehensive household travel survey. Whereas the census contains invaluable socio-demographic data that are necessary for travel demand model systems, it does not have any information on work or nonwork trip frequency, on nonwork trip distribution, or on nonwork mode choice patterns. Transportation planners must not approach the CTPP data as the sole source of data to develop and maintain adequate travel demand models. This may sound obvious to the majority of metropolitan transportation planners in the United States, but sometimes the obvious needs to be said. The CTPP is a useful, independent, secondary data set to augment the disaggregate household data sets that a successful MPO needs to collect for the development of state-of-the-art or state-of-the-practice travel demand model systems.

Land Use Allocation Model Estimation, Calibration, and Validation

Land use allocation models are used in MPOs in the United States and elsewhere for distributing regional forecasts of employment and workers to districts (zones) within the metropolitan area. Examples of these models are the DRAM/EMPAL system of models used in several metropolitan areas in the United States; the POLIS model used in the San Francisco Bay Area; and the MEPLAN model system applied in various Canadian, European, and African metropolitan environments (*33,34*). The written record on the use of U.S. census journey-to-work data for calibrating and validating urban location models is weak, though efforts are afoot to incorporate 1990 CTPP/UE commuter flow data as they become available.

Twenty years after Lee's Requiem for Large-Scale Models appeared in the *Journal of the American Institute of Planners*, the American urban model-building scene was somewhat reinvigorated by a federal clean air act lawsuit in San Francisco and new federal air quality conformity regulations that "encourage" the use of formal land use allocation models in regions with serious, severe, or extreme air quality nonattainment status, though these models are "not specifically required" (*35*). MPOs are actively reassessing their land use model systems to meet the requirements of the 1990 federal Clean Air Act Amendments and the Intermodal Surface Transportation Efficiency Act of 1991.

Future work on building and applying urban location models is challenged by the increasing share of multiworker households and their household location patterns, the increasing share of "footloose" industries and their commercial and industrial location patterns, the increasing share of workers working at home and the whole issue of telecommuting, the confounding issues of local zoning controls and NIMBYism (not in my backyard) in determining the location of housing and jobs, and the increasing importance of community attributes (housing prices, crime, schools, shopping) in determining a household's location choices. Given these challenges, can we accurately simulate the metropolitan system? The CTPP data can function as a validation data set for urban location models, but they cannot substitute for a theoretically complete, consistent, and practical system of urban location models.

Census Data and Estimation of Small-Area Employment Data

As previously stated, the CTPP workers-at-work data are not equivalent to total employment or jobs. The CTPP workers-at-work universe excludes workers absent from work during the census reference week and does not account for second, or moonlighting, jobs held by employed persons. However, after taking these two characteristics into account, the CTPP can be a fairly good data source for small-area employment data.

Many MPOs use employment record data from state employment security departments or employment development departments. These are employment security files that states must submit to the federal Department of Labor and include data on employment and unemployment statistics. There are problems, however, with state employment security files. They are often difficult to acquire and require careful negotiations with state agencies that may not be too cooperative in sharing this information, and they only include covered wage and salary jobs, typically excluding family- and self-employed workers.

Other MPOs may conduct employer censuses as part of trip reduction programs or ridesharing data bases. These programs will probably exclude small employers of less than, say, 50 or 100 employees.

The best situation is to have two independent sources of employment: the CTPP adjusted for weekly absenteeism and moonlighting and employment security records adjusted for family- and self-employed workers. Unfortunately, the numbers may be pitted against each other, with in some cases the CTPP having the "right" number of jobs and in other cases the employment records having the "right" number of jobs—or neither estimate is correct! The job of the employment data analyst is to creatively adjust and reconcile the two competing estimates of small-area employment.

Census Data and Household Travel Surveys

Small-area census data are critical for use in the weighting and expansion of household travel surveys. Weighting and expansion of survey data are needed to adjust for nonresponse biases and geographic biases that occur as part of any household travel surveying effort. For surveys conducted in the 1989 to 1991 time period, 1990 census data can be used directly in weighting and expanding household surveys. For surveys conducted mid-decade, the analyst must carefully adjust the census to account for changes in the number of households and household composition. The analyst may even choose to reweight household surveys conducted in the mid-1980s by interpolating between 1980 and 1990 census data values.

Survey analysts for the 1990 San Francisco Bay Area and the 1991 Los Angeles household travel surveys used similar, complex weighting schemes. The Bay Area analysts used the 1990 census STF3A data to weight the survey by superdistrict of residence (34) by household size (1, 2, 3, 4, 5 or more) by vehicle availability (0, 1, 2, 3 or more) by tenure (owner, renter) (*36*). The Los Angeles analysts also used the 1990 census STF3A data, expanding the survey by regional statistical area (49) by household size (1, 2, 3, 4, 5 or more) by vehicle availability (0, 1, 2 or more) by structure type (single family, multifamily) (*37*). Further validation of the sample expansion scheme is done by comparing the expanded survey with other census variables such as workers per household, tenure, structure type, sex, age, ethnicity, and so forth. A Chicago study also used 1990 census data in weighting and expanding regional household travel surveys with an increased emphasis on correct expansion for low-response neighborhoods within larger weighting districts (*38*).

Transit Market Analysis

The use of census data in transit market analysis is discussed in the resource paper by Cervero. The role of the MPO is to provide the CTPP to the transit operator partners within a region; host training sessions on use of census data, particularly the CTPP, in transit service analysis; and generally help the transit operator meet analysis requirements. Of special note are the Title VI Federal Transit Administration requirements related to low-income, automobile-free, and minority populations within the transit operator service area.

Miscellaneous Transportation Planning Applications

Miscellaneous transportation planning applications of the census, including the 1980 UTPP and the 1990 CTPP (excluding transit planning and travel demand forecasting use), are as follows:

- Use of census data for background and "settings" chapters in long-range regional transportation plans,
- Use of journey-to-work commuter flow data in analyzing regional ridesharing programs,
- Use of commuter flow data in apportioning toll bridge revenues according to residential location of bridge commuters, and
- Use of mobility limitation (disability) data in apportioning discretionary state dollars for paratransit programs.

Other transportation applications will crop up as the data are disseminated to potential data users and applied in ways we cannot imagine.

Nontransportation Planning Applications of Journey-to-Work Data

This section discusses the nontransportation planning applications of the 1980 UTPP and the 1990 CTPP data. Other innovative and clever applications of these data will appear as potential users and clients are made aware of the availability and content of the 1990 CTPP.

Hammel (*39*) provides a good introduction to the nontransportation planning applications of the 1980 UTPP.

Census journey-to-work data provide detailed information on commuter flows and daytime population, which can be critical in disaster-preparedness and disaster-response planning. Census journey-to-work data were useful in disaster-response planning efforts after the October 17, 1989, Loma Prieta Earthquake in Northern California and the January 17, 1994, Northridge Earthquake in Southern California. The reader should refer to Fulton (*40*) for a description of estimating daytime population using data from the census journey to work.

City planning applications of the CTPP are numerous, including using the CTPP data in support of revision of general plan circulation, bicycle, housing, land use, seismic safety, and public safety elements; in understanding labor force characteristics of city resident workers; in understanding the characteristics of workers working within the community; and in local employment development programs. The information may be of interest to local policy makers who want to know who is commuting to their cities and where those commuters live, who commutes through the city, and where city residents work.

The journey-to-work data can be used by residential real estate developers to understand the commuteshed for residents of particular neighborhoods or communities. By knowing the current commuteshed of an area, a developer can market a product to workers working within that commuteshed. For example, a developer may use the information to determine the newspaper in which to advertise.

The journey-to-work data can be used by commercial real estate market analysts to determine optimal sites for locating or relocating a firm, on the basis of minimizing employees' commute times or the characteristics of the labor force currently working within, say, 30 min of a particular site. Another example is U.S. military base planners who use journey-to-work data to understand commutesheds around existing or proposed military bases and the STF3A data on housing prices within that commuteshed to determine site suitability.

The journey-to-work data can be used by radio stations to ascertain how many commuters are in private vehicles during any hour of the day.

The journey-to-work data can be used in Federal Transit Administration-sponsored reverse commuting demonstration programs to understand the current magnitude of inner-city resident workers commuting to jobs in the suburbs. The American Public Transit Association (APTA) has been actively involved in reverse commuting demonstration programs, publishing a report entitled *Access to Opportunity* (*41*) and sponsoring a session on this topic at the October 1993 APTA annual meeting in New Orleans. The Urban Institute in Washington, D.C., and other organizations have also been involved in reverse commuting demonstration programs in the country, including Philadelphia, Baltimore, Milwaukee, Chicago, St. Louis, and Nashville (*42–44*).

CONCLUSIONS

This paper discussed the staged release of 1990 census data and the use of census data in large MPOs in the United States. The various transportation and nontransportation uses and applications were discussed. One conclusion is that the decennial census is a major source of primary, small-area sociodemographic information that is critical for metropolitan transportation planning activities.

The census cannot provide the necessary disaggregate travel behavior information needed by metropolitan transportation planners. The census is not a substitute for a well-conducted household travel survey, but the census does provide critical data needed to adjust household travel surveys and independent estimates of small-area employment. Census journey-to-work data are appropriate for use as an independent, secondary data source for the calibration and validation of regional work-trip generation, distribution, and mode choice models.

Where do we want to be in 10 years, at the next conference on decennial census data and transportation planning? Can we anticipate the inevitable changes in technology and society, and can we anticipate our data needs in 2004? Will the oil wells run dry and will we all be commuting over a virtual reality network? Will there be new "means of transportation" that should be included in the 2000 census? Will we have traffic and travel behavior monitoring systems in place that will render the census obsolete? It may be too obvious that we cannot answer these questions in 3 days, let alone the next 3 years, but a conscious attempt by metropolitan transportation planners is needed to anticipate the travel demands of society after 2000. How can the 2000 decennial census be improved to anticipate these demands?

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Uses of Census Data for Travel Research

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Among the many possible uses often cited for data from the decennial census are those related to travel research. This is appropriate, because the social, economic, and locational data provided by the census are rich in information about factors that affect travel. This value has been enhanced by the journey-to-work data collected as part of several recent censuses. The availability of such information is often greeted enthusiastically by researchers unfamiliar with idiosyncrasies of journey-to-work data. This paper reports that a sample of researchers, having experienced those conditions, are apparently less enthusiastic about using these data for travel research. The value of census data appears to be greater for analyses associated with transportation planning.

The findings reported here are from a brief survey of a broad spectrum of individuals and organizations that appear most likely to use census data for travel research.

In this paper, the term "research" is intended to mean exploratory analysis to identify or determine relationships and includes model *development.* Model estimation, calibration, application, and related activities constitute the largest portion of responses to the survey and are reported here as *planning* activities.

Summary of Findings

Travel Research

Surprisingly little research on travel using journey-to-work data was reported. Only 11 respondents of 56 contacted indicated such activity. The travel research reported consists primarily of analyses of trends and comparisons of travel patterns among cities. Commuting patterns, including mode choice, were examined by seven respondents, and in two cases these were related to location trends. Travel by minorities and the elderly was studied by one respondent, and changes in travel time were examined by another. The travel research also included analyses of funding distributions and the effects of policy actions.

Data Bases

The journey-to-work data are being used to develop and validate data bases for research and planning. These activities include designing surveys, checking survey results, and verifying data from other sources.

Demographic Research

Census demographic data are used for several analyses related to transportation. These include population characteristics, income distribution, household structure, and vehicle ownership. Of particular importance are growth analyses of residential location and density trends. Demographic data were also used for Title VI studies.

Land Use and Development Research

Only one respondent indicated using census data for land use and development research related to travel. That work examined time series of data on transit effects. Analyses of transportation's effect on urban form, housing location, and residential density were also conducted. Research on the effects of development patterns on emissions strategies was reported as well.

Planning

Since many of the survey responses are more accurately characterized as planning applications of research results rather than as research, those responses are reported here. Those applications include uses of both travel and demographic data from the decennial census. Population, housing, income, and employment data are used by trip generation models for small-area analysis of factors influencing travel and for other aspects of travel forecasting. The other uses include estimating and calibrating travel models and comparing trip length frequencies and origin-destination patterns of trip distribution models.

Traffic peaking studies have also been conducted. The census data are also used for statewide and local transit planning, rural transit planning, transit accessibility analyses, and development of route-level transit models. The census TIGER files are used to develop transportation networks and identify critical facilities.

Description of Census Data Uses

This section provides more specific descriptions of the census data uses identified in the survey conducted for this paper.

Travel Research

Trend analyses and comparisons of patterns are the principal uses of census data for travel research. The Center for Urban Transportation Research (*1*) has conducted several analyses of census data along with data from the Nationwide Personal Transportation Study. (Numbers refer to the agencies and names of survey respondents listed at the end of this paper.) The conditions and trends of journey-to-work and demographic data for Florida were analyzed and compared with those of the rest of the United States. Trends of use and user profiles for commuting alternatives have been examined, and policy implications for changes in commuting behavior have been considered. Travel behavior of the elderly and minorities has been examined to identify characteristics and special needs of these groups. Information on minority location and transit use has been used to prepare Title VI analyses for the LYNX transit system in Florida.

The Texas Transportation Institute is analyzing changes in trip times reported between censuses. The Southeast Michigan Council of Governments (SEMCOG) has analyzed 1980 and 1990 census data to identify changes and trends in commuting patterns (*16*). METRO in Portland, Oregon, has used census data to track mode choice trends for the journey-to-work (*4*). Another researcher in Portland has analyzed commuting patterns in connection with IVHS studies (*23*). The University of Toronto has used data from the Canadian census to relate patterns and trends in residential location to commuting patterns (*5*). The university is continuing this analysis by attempting to develop an integrated land use/transportation model.

The metropolitan planning organization (MPO) for Charlotte, North Carolina, intends to analyze trends of work travel by households between 1980 and 1990 (*6*). Trends in mode choice and travel times were studied by Caltrans in cooperation with the MPO for the San Diego region (*14*). The San Francisco Bay Area Metropolitan Transportation Commission (MTC) has analyzed commuting trends and commuter characteristics (*15*). Researchers at Florida State University have studied trends in residence and job location and travel behavior, specifically mode choice (*17*). They have also used Public Use Microdata Sample (PUMS) data for disaggregate analysis of mode choice.

Twelve of the 23 survey respondents did not report activities that could be considered travel research according to the definition used in this paper. Several described analyses involving demographic research that are related to transportation and will be reported later in this paper.

Transportation-Related Demographic Research

Historical demographic and economic data have been compiled by The University of Texas and related to census transportation data to analyze and compare historical patterns of growth for 15 U.S. metropolitan areas (*7*). The Portland MPO is using PUMS to develop models of household structure and vehicle ownership to produce data for use by transportation models (*4*). This MPO has also used census data to compare demographic characteristics among metropolitan areas and as a source of employment location. SEMCOG has analyzed trends in demographics that are used by its trip generation models to better understand the effects of such changes on travel (*3*). The University of Toronto is using workplace location data to develop a microsimulation model of residential location (*5*). Portland State University is assessing a procedure based on housing value and rent to allocate income to blocks within census tracts (*8*). The Charlotte MPO has also used census data for income and population allocation within census tracts (*6*). It is using historical census data to develop a vehicle ownership model.

Land Use Research Related to Transportation

Most of the reported research in this area is being conducted at the University of California at Berkeley (*9*). That work includes an assessment of the effects of BART on the Bay Area, a study of housing location choices and density patterns, and an examination of the effects of urban development patterns on the success of emissions reduction strategies. Other research is being conducted on the relationships between transportation and urban form. The University of Texas is studying land activity data to characterize spatial density patterns in Austin (*7*).

Data Bases and Surveys

The University of California at Berkeley has prepared a data base on international transportation (*9*). The University of California at Irvine has used census data to check other surveys (*10*). The Charlotte, North Carolina, MPO has also used census data for data verification as well as for survey design (*6*). The Center for Urban Transportation Research at the University of South Florida has analyzed data from the census and the Nationwide Personal Transportation Study to prepare data bases of demographics and the journey-to-work and to compare results within Florida and with those of other states (*1*).

MTC used census data to weight and expand the data from a recent household interview travel survey (*15*). It also used census data to correct for nonresponse bias in that survey. The Association of (San Francisco) Bay Area Governments used census data as the basis for its demographic and land use forecasting techniques (*15*).

Transportation Planning Uses

Census data, particularly the journey-to-work information, are used for various aspects of transportation planning but especially travel model estimation, calibration, and validation. Researchers at Louisiana State University have used census data as input for travel forecasting models (*11*). The Center for Transportation Research has used census data for both statewide and local transit planning (*1*). Census data have been used for rural transit planning in Massachusetts, Florida, and Utah (*18,19,21*). Portland, Oregon, METRO uses trip length information from the census to check work trip patterns and frequency distributions (*4*). MTC has used census data to validate trip distribution and mode choice models (*15*). The Charlotte MPO also uses census data for trip generation model development (*6*). This use was widespread according to findings of research at the University of Oklahoma (*12*).

SEMCOG uses census data to analyze changes in the spreading of peak period traffic (*3*). Census data are also used by the Michigan Department of Transportation for analyses of transit accessibility (*3*). MTC has used census data to estimate vehicle ownership and other demographic models (*15*). The census was the source of information on intercounty commuting patterns and times in Broward County, Florida (*19*).

Network applications of census data include use of TIGER files for developing rural transportation networks (*2*) The Michigan Department of Transportation uses data from economic censuses to help define priorities for commercial traffic networks (*3*). It uses census population data in the formula that distributes state transportation funding to units of local government.

The use of census data is apparently much greater for transportation planning and related analyses than for what is described here as travel research. This is especially true for journey-to-work data.

Problems and Recommendations

The problems encountered in the use of census data can be classified into several categories. The problems include concerns about how questions were stated, the manner in which data are presented in products, and delays in availability. Unfortunately, the list of problems is nearly as lengthy as the number of uses, but survey respondents offered suggestions for overcoming many of the problems.

Problems with Questions

Concerns were indicated about the questions that ask where persons "worked most last week" and how they "usually get to work." It was recommended that information on workplace be requested for a specific day and that provision be made for persons reporting more than one job. Travel mode should be requested for the day worked, since the current question underestimates little-used modes. It was also recommended that the "worked at home" response be differentiated from telecommuting. Another concern is the incompatibility of census data with data obtained from transportation surveys, specifically the inconsistency in questions about travel characteristics but also demographic and other socioeconomic data. The limited number and nature of these comments on questions indicate that they have probably been fine-tuned to the satisfaction of most of the user community over the last three censuses.

Problems with Coding Detail

More detail is desired in various tabulations and computer media. The principal recommendations are for more detailed geocoding of workplaces and coding to blocks for entire metropolitan regions. Other requests were for additional disaggregation of socioeconomic data and more detailed cross-classification of household characteristics.

Problems with Coding Accuracy

Geocoding of census data according to local zone systems continues to be a problem. This occurs despite concerted efforts of all parties to alleviate past difficulties. There apparently needs to be better coordination, explanation, and agreement for traffic zone/census tract correspondence and in coding samples that cannot be accurately allocated to locally supplied zones. The allocation process for workplaces not codable was mentioned as a continuing problem from the 1980 census, and accuracy of workplace coding continues to be questionable. In metropolitan areas with more than one MPO, correspondence tables must be coordinated to avoid duplication of zone numbers and the resulting coding confusion. There were also concerns about the accuracy or consistency of place names. Data on inner-city residents, particularly immigrants, were questioned by one researcher.

Additional Data Needs

There is support for obtaining information about nonwork travel. One request was for school and shopping trips. It was requested that information be obtained about trip chaining on the journey to work. Additional information desired included the distance to work, the availability of transit for the work trip, and the distance to a transit stop. Information on level of service by mode was also requested. Other recommendations included providing data for analyzing travel characteristics of elderly and disabled persons. Information on intercity travel and job-related travel other than commuting was also requested. A longitudinal panel to provide better information on travel dynamics was recommended. For perspective, our Canadian respondent is envious of the amount of data available from the U.S. census.

Reporting Problems

There appears to be a need for the census reporting media to be more "user friendly." Problems in understanding the data formats and correctly reading computer data were cited. Problems were reported in reading STF3 because of "cumbersome organization." Geographic identity should be provided on traffic zone records; apparently the space is there, but data were not coded. One suggestion was to improve the downloading software for CD-ROM data. Improvements in documentation of computer data files were requested. The opportunity to special-order tapes with limited data for specific uses was another suggestion. The ability to obtain data organized for specialized geography was requested. Changes in geography between censuses was another reported problem.

Data Availability

The comments on data availability express the traditional concerns about delays from reported schedules (i.e., optimistic expectations), the amount of time to prepare products even when schedules are met, and the errors that cause additional delays for reprocessing after products are originally released. There was a request that data from previous censuses be available on CD-ROM for ready comparison with 1990 data. The sense of these comments is that the longer the data are delayed and the less specific they are, the less useful they are. Two comments indicated that the difficulties of obtaining and using the data rendered reliance on census data not cost-effective, and the 2000 census would not be used unless there were changes from the 1990 experience.

Census User Survey

The survey from which the findings reported here were taken was conducted by sending the following request for information to key informants:

- For what research have census transportation data been used?
- For what research closely related to transportation have other census data been used?
- For what transportation or closely related research do you plan or want to use 1990 or 2000 census data?
- What problems have been encountered using census transportation and related data?
- What recommendations do you have for improving the census transportation or related data in 2000, other than producing it faster and with more accuracy?

The survey was conducted in three stages. First, surveys were sent to 20 selected, well-known, and respected researchers, primarily at academic institutions, who were considered likely to know of any research conducted at their institution or other organizations. When the response from those people was somewhat negative, a second mailing was sent to 19 additional individuals, including practitioners as well as academic personnel. The results from the second mailing were disappointing, with few responses and little additional comment. Finally, surveys were sent to 17 chairpersons of Transportation Research Board committees requesting that they ask members of their committees at the Annual Meeting for leads to researchers using the census. That resulted in 17 additional potential sources. They were contacted, and several offered additional comments.

Respondents to Requests for Information on Uses of Census Data for Research

1. William Ball, Center for Urban Transportation Research, University of South Florida, Tampa
2. Thomas Williams, Texas Transportation Institute, Texas A&M University, College Station
3. Cheryl Parish, Michigan Department of Transportation, Travel Demand Analysis Section, Lansing
4. Keith Lawton, Metropolitan Services District, Planning Department, Portland, Oregon
5. Eric Miller, University of Toronto, Department of Civil Engineering, Toronto, Ontario, Canada
6. Terry Lathrop, for the Mecklenberg Union MPO, Charlotte, North Carolina
7. Shekhar Govind, The University of Texas, Austin
8. Kenneth Dueker, Portland State University, Center for Urban Studies, Portland, Oregon
9. Elizabeth Deakin, Department of City and Regional Planning, University of California, Berkeley
10. David Brownstone, Institute of Transportation Studies, University of California, Irvine
11. Peter Stopher, College of Engineering, Louisiana State University, Baton Rouge
12. Richard Marshment, Department of Regional and City Planning, The University of Oklahoma, Norman

13. Frank Koppelman, Department of Civil Engineering, Northwestern University
14. Gene Pound, California Department of Transportation, San Diego
15. Charles Purvis, Metropolitan Transportation Commission for the San Francisco Bay Area
16. George Janes and Edward Limoges, the Southeast Michigan Council of Governments
17. Greg Thompson and James Frank, Florida State University
18. George Largess, Attleboro, Massachusetts
19. Hal Maggied, Broward County, Florida Metropolitan Planning Organization
20. Kenneth Dallmeyer, Chicago Transit Authority
21. Prabhakar Attalun, Utah State University
22. Richard Stasiak, Florida Department of Transportation, Tallahassee
23. Bob Behnke, Consultant, Portland, Oregon

Census Data Use for Statewide Transportation Planning and Transportation Planning in Smaller Metropolitan Areas

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As noted in a May 1992 conference on transportation data needs, there is an increasing need for effective transportation planning to produce the information required by recent legislative mandates (*1*). With the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) requirement for the development of state transportation plans and management systems, and with increased attention given to analyzing the effectiveness of Clean Air Act transportation control measures, the transportation profession is being asked to provide better analysis and evaluation of proposed transportation policies and strategies. In addition to theoretically sound and robust analytical tools, a quality data base is critical for the transportation profession to provide the desired information.

The purpose of this paper is to examine the use of census data in statewide transportation planning and in transportation planning that occurs in small metropolitan areas. The focus is on the future use of census data given that, in the absence of a requirement for statewide transportation planning, few state departments of transportation (SDOTs) had aggressively used census data in their planning activities. However, the importance of statewide transportation planning has increased dramatically with passage of ISTEA. The following section briefly describes the characteristics of this new planning environment. The next section presents the results of a telephone survey of selected SDOTs that was conducted to assess past and future use of census data in statewide planning and in small urban areas. The final section provides an overview of the data needs of the future and the important role that census data can play in satisfying some of these data needs.

At least for statewide planning purposes, there is a paucity of information on, and in many cases experience with, the use of census data. Most of the SDOTs contacted in the survey are still awaiting the results of the 1990 census and have not yet had the chance to use the census data in real planning applications. In addition, the ISTEA requirements for a statewide transportation plan and the development of six management systems are creating great demands in many SDOT planning offices. These factors are making it difficult for many planning offices to focus on the use of census data in transportation planning. The following material is thus a combination of past practices, current thinking on the part of SDOTs (where such thought has occurred), and likely future requirements for quality data.

Changing Environment for Transportation Planning

A workshop report from the last national conference on census data for transportation planning purposes stated that "statewide planning is predominantly a policy-level activity and therefore is not a heavy user of detailed census data" (2). This may have been true before the passage of ISTEA, but post-ISTEA statewide planning must now satisfy specific requirements, many of which can be usefully addressed with census data. Most important, a statewide transportation plan is now required. The ISTEA-mandated statewide transportation planning process includes several elements: data collection and analysis, consideration of 23 factors, coordination with other agencies relevant to the planning process, development of a state transportation plan, and development of a state transportation improvement program.

The 23 factors that must now be considered as part of the statewide transportation planning process are summarized in the accompanying text box. Many factors that would presumably benefit from analysis based on census data are indicated in italics in the text box. For example, one could envision census data being used to show the social effects of transportation decisions, the effectiveness of traffic congestion reduction methods (especially in areas where congestion does not yet occur), or the effectiveness of expanded and enhanced transit services.

In states where serious statewide planning activities occurred before ISTEA, one sees a higher propensity to use census data in the analysis and evaluation process. Therefore, it seems reasonable to assume that the state planning activities now under way in each state could find great use for census data in better understanding the demographic and trip-making behavior of the state's population. In many cases, the SDOTs will be just beginning to use these data. The true effect of these data on statewide planning might not be found until after the next decennial

FACTORS TO BE CONSIDERED IN STATEWIDE PLANNING

(Factors in italics indicate high potential for use of census data in analysis and evaluation)

- Transportation needs identified through management systems
- Energy use goals, objectives, programs, or requirements
- *Bicycle and pedestrian considerations in projects*
- International border crossings, access to ports, airports, and so forth.
- *Transportation needs of nonmetropolitan areas*
- Metropolitan area plans
- *Connectivity between metropolitan planning areas*
- Recreational travel and tourism
- Plans for water quality and coastal zone protection
- *Transportation system management strategies*
- *Social, economic, energy, and environmental effects*
- *Methods to reduce traffic congestion and to prevent it where it does not yet occur*
- *Transit services*
- *Land use and development*
- Transportation enhancements
- Innovative financing mechanisms
- Preservation of rights-of-way
- *Long-range needs for person/goods movement*
- Efficient movement of commercial motor vehicles
- Life cycle costs
- Coordination of metropolitan transportation plans and programs
- Investment strategies for adjoining state and local roads that support rural economic growth and tourism
- Concerns of Indian tribal governments

census, when the states will have at least two reference points for comparing trends. ISTEA has thus created a potentially large new customer base for the use of census data.

In addition to the statewide plan, SDOTs are responsible for developing six management systems. The key characteristic of these systems is that they are to be integrally tied to the systems planning process. Although these systems have many characteristics that help define their role in the overall process, perhaps the most important is the use of performance measures as the basis for the identification of system deficiencies or opportunities. In essence, these six systems are adding a performance-based system monitoring element to the state transportation planning process. This is a potentially important issue for this conference because it raises the question of how system performance should be measured. The development of the congestion management system (CMS) is a good example of how this simple question could become complex and relate to the use of census data.

The purpose of the CMS is to identify and implement strategies that will reduce congestion and enhance the mobility of people and goods. The most traditional measure of system performance is some indication of network level of service or congestion. However, the second part of the definition of the CMS (that is, enhancing mobility) is not necessarily best monitored through level-of-service performance measures. In addition, some are arguing that the true measure of system performance is one that relates to the levels of accessibility provided by the transportation system (*3*). This might mean such things as the degree to which the transportation system provides access to job opportunities for low-income groups.

Figure 1 shows the evolution in thinking on measuring system performance from the traditional level of service concepts to the perspective of transportation accessibility. The different types of data needed to make the more complex performance measures operational are certainly related to the data that can be provided via the census. In taking a long-term perspective on how these management systems and systems planning are likely to evolve, we can see the importance that census data could have in determining how the performance of our transportation system is measured. Fundamentally, this means assessing how effective transportation officials are in accomplishing their goals and objectives. An example of this phenomenon is the questioning and assessment that followed the release of STF3A, which showed dramatic declines in carpooling and reduced market shares for transit and walking. After years of public policy incentives to encourage ridesharing, this very basic surrogate of transportation system performance, that is, average vehicle occupancy for the work trip, suggested that our best policy efforts were simply overwhelmed by market forces. Similar types of measures could be used in the CMS to gauge the level at which the transportation system is accomplishing its objectives.

This discussion has focused on the changing environment for statewide transportation planning. Another purpose of this paper is to examine the use of census data in small metropolitan areas. The environment for such planning, however, has not changed as dramatically as it has for statewide planning. Transportation planning remains an important activity simply because transportation investment has a relatively greater impact in smaller urban areas, where the transportation network might not be as ubiquitous as that found in larger metropolitan areas and the travel patterns are much more pronounced. In many cases, the most significant change in smaller urban area planning during the past several years has been in the relationship between transportation investment decisions and growth management policies that have provided policy and regulatory guidance on the types of urban form that are desired

System Capacity Operating Measures	**Mobility**	**Accessibility**
Delay	Mobility Index	% Employees Within 'X' Miles
LOS	Service Hours per Capita	
Volume/Capacity	Speed Weighted Person Flow	% Low Income Within 'X' Minutes
Congestion Index	Travel Time per O/D	

FIGURE 1 Various concepts of performance measures.

in a community. This guidance often relates to the decision-making process for investment in infrastructure. States such as Florida, Vermont, Oregon, and Georgia have pioneered some of the planning requirements that link community development and infrastructure expansion. In such cases, the use of census data can be critical for examining demographic and travel patterns that permit a community to assess appropriate development scenarios.

In summary, whereas past statewide transportation planning practice has not been widely based on state level analysis and plan development, this will soon change. In particular, a performance-based perspective on such planning, with a broad definition of performance, will rely even more on the type of data that is available through the census. Smaller urban areas will continue to rely on census data for very basic information that can be input into the planning process.

Uses of Census Data for Statewide Planning and Planning for Small Urban Areas

There are many reports and articles in the literature that discuss the use of census data in transportation planning. The Transportation Research Board, for example, has held several conferences that have examined the past and desired use of such data in transportation planning applications (*2,4,5*). In addition, several reports are available that use census data in analyzing the trends in key socioeconomic data that will likely influence travel behavior. Good examples of these reports include those of Pisarski (*6*) and Rosetti and Eversole (*7*). At the state level, several organizations have prepared reports examining county-level journey-to-work statistics (*8*). For smaller urban areas, the extent of the technical literature is more limited and includes such reports as a Federal Highway Administration case study report on applications of the UTPP to transportation modeling (*9*) and an informational report from the Institute of Transportation Engineers (*10*).

To assess the current and expected status of census data use in statewide planning, a telephone survey of 22 SDOTs was conducted that focused on three questions: What are the current uses of census data? What are the limitations in the use of such data? What other types of data would be useful for your planning process? The SDOTs included those of both large and small states, those of heavily urban and primarily rural states, and SDOTs with a reputation for having strong state transportation planning activities. Of the 22 states contacted, 17 responded.

One of the most important roles that SDOTs play in a state's use of census data is as a clearinghouse or purchaser of the data files for use by metropolitan planning organizations. In some cases, the clearinghouse role includes being a technical resource in the use of the Census Transportation Planning Package (CTPP).

For statewide planning, the primary uses of census data fall into three major categories—trend analysis/socioeconomic forecasts, model development and calibration, and corridor analysis. Each of these uses will be described.

Trend Analysis

The use for census data cited most often was in trend analysis. The purpose of trend analysis is to examine, over time, the changes of key socioeconomic data or travel characteristics that provide some sense of what has occurred in the state or its subareas. The states typcially compare results of the 1990 census with results from past years to identify high-growth areas and work trip interchanges. One state mentioned that it supplements trend analysis from the decennial census with similar information collected on a biennial basis to provide a more timely and useful trend analysis. The Maryland Department of Transportation, for example, used census trend data on population, mode split, travel time, and interjurisdictional travel to develop broad policy concepts for its corridor-based Commuter Assistance Study. The New York State Department of Transportation examined similar trends at the urban and county levels. Pennsylvania has likewise conducted trend analysis on key variables. North Carolina uses the demographic data for establishing statewide population/employment/travel trends. In addition, one other state specifically mentioned that trend analysis of travel data was a primary tool for projecting traffic volumes in rural areas.

The primary use of trend analysis is to better understand what is happening to variables of interest to planners, transportation officials, interest groups, and the media. An excellent example of the use of trend data in public discourse was the comparison of journey-to-work data on automobile occupancy. As noted earlier, the analysis of these data not only caused major debates among transportation professionals but also became the focus of media attention.

With the new requirements for statewide planning, the use of census data in trend analysis will likely increase. Not only will these trends provide useful contexts for transportation plan updates, but the trends will, over time, probably be examined on a trip pattern basis (e.g., county-to-county travel). Several states are already doing this. Given the emphasis on a continuous statewide planning process that will presumably continue for many years, such trend data could be very useful in gauging changing characteristics of travel between different areas of a state.

Model Development and Validation

Unlike the use of journey-to-work data for developing "observed" work trip tables for aggregate trip distribution and mode choice models in metropolitan areas as reported elsewhere in these Proceedings (see the paper by C. Purvis), very few states have statewide travel demand models. Ohio used the census data for all demographic forecasts in its statewide model. California has used housing, income, and employment data in regression equations to establish trip generation rates for a statewide journey-to-work model. Colorado, Connecticut, and Wisconsin are developing statewide transportation models that will use census and other data. California will be using census data in a geographic information system (GIS) context to analyze accessibility and demographic issues in applications of the ISTEA CMS management system. Maryland is also expecting to develop a model that uses census data within the context of the ISTEA management systems. Michigan has used census data for helping evaluate corridor-level improvements of the state highway system and is developing a statewide GIS approach to the management systems that incorporates census data.

Although several states in the survey indicated that census data would be used in a statewide model, in many instances the model is not yet developed. It appears likely that many of these "models" will turn out to be nothing more than the county-to-county travel trends discussed in the preceding section. One of the more interesting applications of census data at a state level is the use of GIS and the TIGER files to develop a comprehensive data base for the state. In particular, states that are developing a CMS on a GIS platform will find use for census data.

As in the case of trend analysis and socioeconomic forecasts, the changing environment for statewide transportation planning could provide greater use of census data in statewide planning. States such as Wisconsin and Michigan are developing statewide models for both passenger and freight movement that will require quality data. Other states will probably follow in years to come. The great burst of creative energy in metropolitan level transportation model building did not occur until after Congress, in 1962, required that a transportation plan be developed for every urbanized area. Similarly, we can anticipate that more states will develop a statewide modeling capability in the future. Census data could be important inputs into such models.

Corridor Analysis

A few states had novel approaches to the incorporation of census data in corridor and project analysis at the state level. Household-based information such as income level, ethnic background, and housing costs were found to be useful for impact analysis of right-of-way purchases. One state is developing a GIS for use with management systems and in corridor analysis. The GIS will incorporate significant census data at the tract level and can thus be used to determine potential socioeconomic effects of alternative highway alignments in a corridor. This example points out the powerful tools that can be developed for statewide planning by joining a robust data set with a new generation of spatial analysis software.

Small Urban Areas

Transportation planning in small metropolitan areas is often characterized by fairly straightforward analysis approaches that are not data intensive. Planning agencies for such areas do not have the resources to conduct large-scale data collection efforts, so the census data are an important source of information for at least a "snapshot in time" of the key variables. Unlike larger metropolitan areas, where extensive efforts are often made to estimate and validate numerous models, smaller urban areas usually use census data to determine three items of information: household income distribution, the distribution of households by number of workers, and the distribution of households by number of vehicles.

This information can be used in the development of market-segmented trip generation models or through sketch planning tools as input into small-area transportation evaluation. It is not likely, however, that we will see the census data being used extensively in small urban areas. They will continue to be a major source of sociodemographic data for the analysis zones in the study area.

Existing Limitations and Desired Data

The concern mentioned most often at the state level was the delay in release of census data, particularly the CTPP. Because of the looming deadlines for preparation of various elements of the ISTEA-mandated statewide plans and management systems, most states have moved ahead with planning efforts, relying on city- and county-level census data, older census data at more disaggregate levels, and other data sources.

Another major concern was the focus on journey-to-work trips in the census data. No information was provided on recreational trips, non–home-based trips, or freight movement. This concern reflects the significant growth trends that have been observed in all parts of the country in nonwork trips and in non–home-based work trips (or the trip-chaining phenomenon). These trips will become even more important in the analysis of trip making in metropolitan areas. Nonwork trips can be expected to be an important issue for statewide, intercity trip making. Indeed, as one SDOT official put it, "Our state is very rural, which makes journey-to-work data relatively useless." Some states have addressed this data gap by performing their own origin-destination studies and travel log surveys or by relying on data collected for local or private (freight) planning purposes.

Some states expressed concerns about the accuracy of census data. It was felt that wording on some questions on the census form was unclear, such as what constitutes a handicap or a trip. Other states have noticed major differences between census data and results from other local and statewide surveys. One state believed that the data are already "old" by the time they reach the states because of the previously mentioned delays; this could be a particular concern in rapidly growing corridors of any state.

The final category of limitations revolved around technical aspects of the census data. States relying heavily on GIS applications have mentioned that place of employment information is difficult to use in rural areas because the address ranges in the TIGER files are not very accurate in these areas. In addition, there are major discrepancies between census tract and jurisdictional boundaries, which can make GIS applications difficult. One state noticed differences between results obtained from STF-1 and those obtained from STF-3. Problems such as this have led another state to have doubts about any large-scale use of census data for its statewide planning.

Following up on the limitations mentioned previously, most states would like the census to continue collecting the information that is now being collected; however, it must be disseminated more quickly. One state suggested that summary information of major trip characteristics and demographic information be released at the county level shortly after completion of the census; the state believed that this would be most useful for statewide planning purposes. More detailed and disaggregated data could be released in ensuing years.

If census data collection were expanded, nearly all states would like to see travel data on nonwork trips, including recreational and shopping trips. However, concern was expressed that these data not be collected in a superficial manner, such as asking about "typical" trip-making patterns. Rather, a few states suggested that the census should ask long form recipients to track all travel activity on a particular day. If this level of information is not collected in the future, one state suggested that the census at least ask about trip chaining on work trips, especially considering the potential effects that it has on mode split and vehicle occupancy. The survey participants were also asked to identify additional census data that would be useful for transportation planning in the future.

CONCLUSIONS

This paper began by stating that the environment of statewide transportation planning has changed dramatically with ISTEA and that the changing environment will likely create a need for better data in the future. Thus, it was suggested, the types of data desired in the next decennial census should not be based on an assessment of what has occurred in the past. Except in the case of small urban areas, the survey lends credence to this approach. Only a few states had reached a point where statewide transportation planning was based on a strong modeling framework. However, this is likely to change. Future state transportation planning will rely more heavily on data about travel from one area of the state to another. Therefore, this conference should consider carefully what additional data might be necessary to make the county-to-county data more useful for state planning purposes.

In addition, given the changing characteristics of travel, serious consideration should be given to obtaining information on nonwork trips. Such information would be especially important for larger metropolitan areas but would also help smaller urban areas and rural states.

The use of census data in small urban areas was also discussed. In each of the telephone interviews and through an extensive literature search, no strong evidence was found to suggest major additions to the census data that are already collected. Given the primary importance of census data for establishing the demographic base for small-area studies, a consensus can certainly be reached on the need to continue collecting such data.

Let me end with a statement similar to the one I made at the Transportation Research Board conference on data needs. That statement was as follows:

> I worry that many of our public policies and subsequent policy requirements have gone far beyond the data base and technical modeling capabilities that exist in our profession. There is little doubt in my mind that we are about to play a catch-up game, due in part to many years of neglect and limited resources. However, I hope that our profession, and this conference, goes beyond simply looking at what is necessary to support the decisions of today. Because if we do, my fear is that once we finally have in place the data base and analysis methods that are needed for today, the decision-making environment will have changed again. In all of our discussions, we need to provide some strategic perspective on the importance of data and of the analytical capability it supports. Will they be useful 10 years from now? 20 years from now? 50 years from now? I know the answers to these questions are not easily forthcoming. However, by simply asking them, we might be able to put in place a data base that truly can support the decision-making process of the 21st century.

After having thought a great deal about statewide planning needs for census data for this conference, I believe that my statement is even more valid than when I made it 2 years ago.

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Use of Census Data for Transit, Multimodal, and Small-Area Analyses

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Journey-to-work census data have become an indispensable resource for tracking a host of megatrends that have had and continue to have a profound effect on how Americans commute. Among these have been suburbanization of jobs and the emergence of edge cities, increases in the number of multiple-earner and small households, steadily rising vehicle ownership rates, the growth in telecommuting and homeworking, increasingly automobile-dependent land use and settlement patterns, and the geographic spread of metropolitan boundaries. Collectively, these and related factors have brought about strong shifts in commuting behavior over the past two decades, most notably a sharp rise in drive-alone automobile commuting (*1*). Worsening traffic congestion, persistent air quality problems, and an apparently widening gap between levels of accessibility of different social classes have been by-products of America's growing dependence on the car for commuting. The public policy response to trends of the 1980s has been unprecedented. At the federal level, passage of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) and the Clean Air Act Amendments of 1990 (CAAA) have radically changed the process of transportation planning and decision making, requiring that proposed highway and transit investments be judged in broad societal terms. At the state and local levels, transportation authorities and private developers today have to cope with an imposing array of government mandates, including concurrency rulings, congestion management regulations, trip reduction requirements, and adequate public facilities ordinances, to name a few.

All of these regulations and imperatives have a need for better data and information to guide public policy making. The decennial census has become one of the most dependable and consistent sources of information for monitoring and evaluating not only how Americans get to work, but also for tracking trends in population and employment, household composition, industrial classifications, and metropolitan structure. For transportation planning purposes, the census provides the richest source of small-area geographic information on the location of people, housing, and employment within a metropolitan area. It also provides a basis for reassessing the validity of previously calibrated transportation models and for estimating new, updated ones.

For multimodal transportation planning purposes, the Census Transportation Planning Package (CTPP) is the crown jewel of census data because it provides flow (as well as trip end) data at a small geographic scale of analysis. The Urban Element of the CTPP, in particular, supports small-area analysis of commuting within metropolitan statistical areas (MSAs).

Prepared by the U.S. Bureau of the Census for metropolitan planning organizations (MPOs) to use in their long-range planning efforts, the CTPP/Urban Element comes in parts (2). Part 1 (CTPP-1) contains data tabulations by area of residence, and Part 2 (CTPP-2) contains data by area of employment (defined by workers in households). Zone-to-zone work trip interchanges, stratified by travel modes and times, are available in Part 3 (CTPP-3). For small-area analyses, records are usually identified by transportation analysis zone (TAZ), though data can also be obtained by census tract, block group, special study area, and central business district (CBD), when requested.

Other national data sources on journey-to-work, like the Nationwide Personal Transportation Study (NPTS) and the American Housing Survey (AHS), contain no flow data and use much coarser geographic identifiers than the CTPP. The most refined intrametropolitan spatial analysis permitted by NPTS is comparisons of commuting patterns between central city and non-central city locations. Except for a handful of metropolitan areas (New York–New Jersey–Connecticut, Los Angeles–Orange County, Hartford, Chicago, San Francisco–Oakland–San Jose, and Philadelphia), sample sizes from the 1990–1991 NPTS are too small (under 400) for in-depth intrametropolitan studies of commuting. The AHS likewise has too few cases and geographic coding that is too coarse to support intrametropolitan analyses of commuting behavior. Since NPTS and AHS only provide data by area of residence, it is not possible to carry out any corridor-level analyses or trip interchange modeling with either.

In its raw tabular or electronic form, the CTPP is often too voluminous to be easily analyzed. Summary statistics, thematic mapping, and GIS outputs are today commonly used to distill CTPP data to a more comprehensible and digestible form. With GIS, the physical features of transportation can be referenced to a coordinate system as points (a bus stop, park-and-ride lot), lines [highway segments, high-occupancy vehicle (HOV) lane], or polygonal areas (a two-block zone around a bus stop, a TAZ). Since spatial arrangements are central to most transportation activities, GIS has found a natural home within the transportation profession.

A number of possible uses of journey-to-work census data for transit and multimodal analysis and planning are outlined in this paper. The focus is on the use of data at a small geographic area (i.e., TAZs, census tracts, block groups). Both current and future small-area applications of census transportation data are discussed.

Multimodal Analyses

ISTEA encourages state and local authorities to act on transportation matters from a multimodal perspective. This does not simply mean that plans should weigh the investment needs of the highway, transit, rail, aviation, and maritime sectors, but rather that transportation itself should be looked at holistically, as an interdependent and integrated system.

All MPOs have some in-house capabilities for forecasting and evaluating travel demand within their regions. With the CTPP/Urban Element, multimodal analyses of commuting flows can be easily conducted. Characteristics of both the origin (place of residence) and destination (place of employment) can be statistically correlated with data on commute flows as a basis for building predictive models. Whereas CTPP allows a rigorous analysis of home-based work trips from zone to zone, one of its shortcomings is that it treats all work trips as if they were unlinked. Thus, non-work-related segments of a linked work trip are effectively ignored in CTPP tabulations. Ideally, transportation planners will use metropolitan travel survey data on linked trip making in parallel with CTPP data to enrich our understanding of the dynamics and complexities of contemporary commuting behavior.

Area-Specific Analyses

From Parts 1 and 2 of the CTPP, the journey-to-work can be examined with reference to characteristics of the residential and employment ends of the trip. Trip generation estimates can easily be derived from trip end data, though the census geography of the CTPP is not fine-grained enough to produce site-level rates, as found in the Institute of Transportation Engineer's *Manual on Trip Generation.*

From CTPP-1, work trip production rates can be estimated by indexing total daily vehicle trips in a zone to the number of households or total acreage. At place of employment, work trip attraction rates, expressed in terms of total workers or acreage, can be estimated for CBDs and large suburban employment centers (using CTPP-2). When pooled over all zones in a study area, trip rates (e.g., vehicle work trips per dwelling unit) can be cross-classified by such factors as vehicles per household and population density.

The CTPP also contains critical inputs into Urban Transportation Planning Systems (UTPS) modeling. Zonal-level regression models predict total counts of work trip ends produced by or attracted to a zone. Possible predictor variables available from CTPP-1 for estimating home-based work trip production models are numbers of persons, households, and employed residents, as well as such sociodemographic attributes as age, ethnicity, education, employment status, household size, household income, vehicles available, worker occupations, and occupational status. For home-based attraction models, CTPP-2 offers such possible predictors as numbers of workers by occupational class, employment densities, and median earnings. Of course, CTPP data might also be supplemented by other sources, such as local land use inventories that contain the square footage of building space and measures of land use heterogeneity within TAZs.

Flow Analyses

At the regional level, the CTPP is well suited to the task of estimating and validating trip distribution and modal choice models for journeys to work. Various kinds of multimodal studies of commuting flows, carried out across TAZs or other small geographic units, are outlined below.

Trip Distribution and Spatial Interaction Models

Zone-to-zone flow data from CTPP-3 can be used for simple visual displays as well as more advanced behavioral modeling. The following applications are possible:

- The easiest and perhaps most revealing use of flow data is to prepare point-to-point origin-destination (O-D) (desire line) maps. Since flow images can be undecipherable due to the large number of zonal pairs, some agencies present attraction-constrained desire line maps (i.e., flows to a subarea with large employment concentrations) for particular corridors and specific modes. Interactive mapping tools, such as FLOWMAP, can also be used to customize O-D maps to display variable-width directional flow arrows (*3*).
- The CTPP/Urban Element allows the calibration of conventional trip-interchange gravity models. Also, existing gravity models can be cross-checked using CTPP flow data. Part 3 of the CTPP provides the necessary trip interchange and travel time matrices for calibrating new models and validating existing ones. More sophisticated gravity formulations are also possible, such as stratifying interchanges by modes and trip end data by the occupation of employed residents (at the place of residence) and workers (at the place of employment). Once specified, new friction factors and other model coefficients can be estimated.

The CTPP-3 data are the most complete source of zone-to-zone travel times available for work trips. One limitation of CTPP data is that most cells in the interdistrict travel time matrix are empty. Techniques have been developed for imputing travel times for empty cells by extracting and synthesizing data from cells with current destinations (*4*). This allows zone-to-zone travel times in the CTPP to be cross-checked against zone-to-zone highway and transit travel time matrices generated from regional computerized highway and transit network data bases.

• During the past decade, census flow data have been used to study such public policy topics as jobs-housing balance, spatial mismatches, residential mobility, and intrametropolitan migration (*5,6*). Most spatial policy analyses use some variation of a constrained gravity model. Constraining the model at the workplace end of a trip can be used to study the correlates of spatial mismatches (e.g., between employment opportunities and low-income concentrations) and reverse commuting. Production-constrained models support studies of retail tradesheds and the market areas of health care centers and other institutional land uses (*7,8*). The U.S. Bureau of the Census itself uses interchange data from CTPP/State Element to define overlapping laborsheds as a basis for delineating the boundaries of a defined census region (e.g., the formation of a CMSA depends on a minimum threshold amount of inter-MSA "external" commuting). Flow data have even been used to guide theory. For example, a series of studies in recent years on the phenomenon of "wasteful," or excess, commuting has emerged. Researchers have applied linear programming algorithms to compare optimal work trip interchanges predicted by the "commute-cost minimization" model of residential location with actual commuting distances. Studies in metropolitan Baltimore (*9*), Los Angeles–Orange County (*10,11*), and other regions (*12*) have estimated excess commuting to be in the range of 11 to 85 percent. Such findings have led to a recasting of the traditional monocentric model of residential choice to account for the influence of polycentrism and nontransportation factors (e.g., quality of schools) on residential location decisions (*13*). In addition, 1980 census data have been used to estimate population and employment density gradients for multiple subcenters in Southern California in the study of how polycentrism influences commuting (*14,15*).

• CTPP flow data also allow for the cross-checking of screenline counts used to validate UTPS models. In addition, the State Element, which provides commute flow data between counties, small places (population exceeding 2,500), and regions, is sometimes used to validate work trip flows at external cordon lines and boundaries between metropolitan and nonmetropolitan areas.

Modal Split Analyses

Work trip modal split models are also frequently estimated from census commute flow data. Modelers face two trade-offs, however: unit of analysis and geographic resolution. The Public Use Microdata Samples (PUMS) provides 1990 census data for individual households (which completed the long census form), allowing for disaggregate utility-based modeling of mode choice for the journey to work. (For most metropolitan areas, PUMS provides approximately a 1 percent sample of households and the persons in them, with personal identifiers removed). The trade-off, however, is that the smallest level of geographic disaggregation is the PUMA (Public Use Microdata Area). PUMAs are amalgams of census tracts that represent 100,000 to 200,000 people (e.g., the PUMA for Bronx County, New York, contains three PUMAs). Thus, PUMAs are too coarse for pinpointing trip origin or destination. For many areas, sample sizes are too small for statistically reliable mode choice modeling.

With CTPP, the opposite holds. Unlike PUMS (or NPTS or AHS), CTPP allows the statistical association of work-trip modal flows between small geographic areas. (CTPP is also available for all MSAs, big and small; for NPTS and AHS, geographic breakdowns are only available for MSAs with a population exceeding 1 million.) However, CTPP only provides aggregate zone-to-zone flow data, so it does not allow for discrete choice modeling, such as is statistically possible with PUMS, NPTS, and AHS.

If there are sufficient data observations, modal split models can be developed for every modal option in a metropolitan area (e.g., car/truck/van, bus, streetcar/trolley car, heavy rail, commuter rail, bicycle, walking). An important predictor variable of any well-specified modal split model is the travel time differential between modes (e.g., transit versus automobile). For the zone of residence, possible predictor variables (from CTPP-1) might include median household income and vehicle availability, occupations of employed residents, residential density (households per acre), and perhaps even departure time. For the zone of work, predictors (from CTPP-2) might include variables on class/occupation of workers and employment density (workers per acre). To build more completely specified models, however, CTPP data should be supplemented with data from local surveys, such as information on the availability and price of parking at the workplace. Land use data from regional inventories (e.g., land use mixes) might also be merged with the CTPP. From a modal split modeling standpoint, one of the more serious limitations of CTPP is the availability of travel time data only for the elapsed portion of work trips. Since access, waiting, and transfer times are known to be more serious deterrents to transit commuting than elapsed times, modal split models estimated from the CTPP alone are unavoidably partial models. Supplementing the CTPP with travel time data for access and egress portions of trips from regional travel surveys would be one way of overcoming this problem.

More simplified trip end modal split models can also be estimated from the CTPP. At the destination end, for instance, the percentage of trips by carpool and vanpool could be estimated as a function of location within the MSA (e.g., CBD, central city, remaining area), employment density, and factors provided from other data sources (e.g., existence of HOV facilities).

Data Conversions

For integration of CTPP data into UTPS modeling, several types of data conversions are necessary for conducting small-area analyses. On the basis of 1980 journey-to-work data, Mann (*16*) recommended applying a factor of 1.96 for converting (one-way) journey-to-work data to (two-way, daily) home-based work trips. Also, since the 1980 and 1990 censuses compiled commuting data for the "usual" trip made to work last week, CTPP understates average vehicle occupancy (since occasional ridesharing and transit trips are not counted). Mann (*16*) suggests a conversion factor of 1.04 for estimating average vehicle occupancy, though the appropriate factor for 1990 might be different, especially given the sharp declines in vehicle occupancy levels during the 1980s. Daily work trips can also be converted to peak-hour work trips, using either tables from the National Cooperative Highway Research Program Report 187 or locally derived conversion factors.

TRANSIT SERVICE ANALYSES AND PLANNING

ISTEA strengthened the nation's commitment to public transportation, calling for the adoption of metropolitan planning "methods to expand and enhance transit services and to increase the use of such services" (Section 134d). Census data provide a backdrop for carrying out long-term strategic transit planning. Existing and potential markets of transit customers can be identified by tracing, over time, structural changes in a region's population and employment base and sociodemographic makeup. Regional travel demand models (UTPS), driven by census data inputs, can also be used to evaluate the likely cost-effectiveness of corridor-level transit projects. Census data even find application at the level of operations planning of bus services, such as quantifying population residing within 0.25 mi of a bus stop. For the most part, however, journey-to-work data are too coarse for detailed route-level transit planning or fine-tuning an existing service. Census data can be supplemented by on-board ridership surveys, on-off counts, and other sources to carry out finer analyses. Today, a number of U.S. transit agencies are combining census data with GIS to display existing and potential markets of transit customers, using successive overlay techniques.

Area-Specific Analyses

Census data, including CTPP-1 and CTPP-2, are increasingly relied on by transit planners for carrying out several kinds of market analyses at place of residence and place of work.

Study of Captive Riders

Census data at the tract level allow areas with large transit-dependent populations to be pinpointed. For example, planners at SamTrans, serving the western peninsula of the San Francisco Bay Area, merged census data with GIS to graphically display census tracts within their service district that have high concentrations of captive riders. Such thematic mapping techniques shade areas to highlight, in this case, zones with significant shares of residents who are dependent on transit services. In the case of SamTrans, transit dependency was defined by using a composite index of automobile availability, household income, age (stage of life cycle), and mobility impairment status. Overlaying route maps onto such displays of captive riders can also be used to evaluate compliance with Title VI requirements. All transit properties receiving federal assistance are required to submit an updated Title VI report every three years to ensure that Federal Transit Administration-assisted transit services do not discriminate with regard to race, color, or national origin. Successive overlays of sociodemographic census data are the best way to assess whether all segments of the population are receiving equal and adequate services.

Demand Projections

As inputs to both short-range and longer-range strategic planning, many transit agencies rely on census data for trend analyses of changes in population, age, fertility rates, and income within their jurisdictions. Factors like changes in ratios of jobs to employed residents can also be generated from CTPP-1 and CTPP-2, enabling transit agencies to project the likely work trip directional flows for specific areas. Zones with labor force deficits (housing rich/job poor) will experience predominantly out-commuting in the a.m. peak, whereas job-rich zones with a labor force surplus will experience more in-commuting. Such projections could guide transit agencies in route planning, such as in identifying areas where services might be efficiently interlined.

Demographic and Employment Profiles

Some rail transit agencies compile census data from CTPP-1 and Summary Tape File 3A (small-area summary) to draw sociodemographic profiles of residents currently living near stations. Planners with the Bay Area Rapid Transit (BART) district, for example, have created a data base containing 18 sociodemographic variables for neighborhoods around all 34 stations. They use GIS to interpolate census data for station areas that lie within a 1/4- or 1/2-mi ring of BART stations. By comparing station-area demographic profiles with 1992 survey data compiled from on-board ridership surveys (geocoded by residence), BART planners have been able to identify potential markets of rail commuters who live near stations. These data are also being used by BART's joint development office to screen neighborhoods that might be candidates for real estate ventures. An example is the leasing of land formerly used for parking to developers for building mid-rise apartments, as is currently being done at the El Cerrito Del Norte and Pleasant Hill BART stations.

Similarly, transit agencies can use CTPP-2 to identify employment concentrations within their service districts. Employment data can also be stratified by occupational and industrial class. For instance, premium subscription bus services might be aimed at areas with known concentrations of management and professional personnel as a market development strategy.

Transit Trip Rates

Trip end data can be used to estimate transit work trip rates. When produced over time, these rates provide a benchmark for gauging market penetration. A possible source of error in using census data for transit trip analysis is the confusion between subway/elevated, railroad, and even streetcar/trolleycar among some laypersons. For example, the 1990 CTPP/State Element showed that 2,125 residents of suburban Contra Costa County were "railroad" commuters heading to San Francisco, even though BART is the only fixed-guideway service connecting the two.

These "railroad" commuters were in all likelihood BART riders who consider BART a railroad instead of a subway/elevated (*17*). Similar miscoding problems also arise between Muni light rail service (which operates underground in downtown San Francisco but is a "streetcar/trolleycar" service) and BART. One way to reduce the confusion is to tailor census questionnaires so that they refer to popular names of transit services used by local residents in large rail-served metropolitan areas (*18*).

Performance Evaluation

Place of residence and employment data offer only a few opportunities for conducting transit performance studies and planning route-level operations. Many transit agencies use census population and household counts over time to study trends in service utilization (e.g., annual ridership per capita within the service district). Tract-level data can also be used to calculate the percentage of population within a district residing within a 1/4-mi walking distance of a bus route, another commonly used indicator of service effectiveness.

Commute Flow Analyses

Transit agencies can use zone-to-zone commute flows from CTPP-3 for route planning, identification of existing and potential markets of transit riders, and evaluation of transit accessibility.

Routing Planning

Desire line maps of transit commutes can be overlaid with maps depicting existing route configurations to evaluate how closely they match. Existing and forecast transit O-D patterns can be used to guide facilities planning and investment. Travel time ratios between transit and the automobile can also be computed for zonal pairs along major corridors. Such information can be used to modify routes with poor comparative travel times or excessive circuity and run segments that poorly align with travel desires.

For some transit properties, especially those in large metropolitan areas, CTPP-3 might be too big and unwieldy for transit planners to conduct TAZ-level travel flow analyses. MPOs will likely be called on to extract trip interchange tables from CTPP-3 that correspond to TAZs within the service boundaries of individual transit districts. From the local transit planner's perspective, this would be a much appreciated, valuable service.

Market Studies and Evaluations

CTPP-3 supports several kinds of transit market studies and evaluations. BART is currently combining CTPP-3 files and GIS to study the O-D patterns of rail versus nonrail commuters in BART-served Alameda, Contra Costa, and San Francisco counties. BART planners will concentrate on workers who reside near stations but who commute to San Francisco and other BART-served urban centers by a nonrail mode. BART planners are drawing sociodemographic profiles of these potential yet latent rail trips and are attempting to identify factors that might explain nonrail commuting in these instances, such as inadequate feeder bus services or the availability of free parking at the workplace. Census data allow fairly refined analyses, such as the ability to net out workers in sales occupations who likely need vehicles for midday business travel. BART planners are also using census data to project the additional rail trips, and the likely sociodemographic composition of new rail users, who might be priced over to BART following the introduction of congestion pricing on the San Francisco–Oakland Bay Bridge. O-D pairs along the transbay corridor are being used to estimate the potential ridership effect of peak-hour tolls on the Bay Bridge.

In Baltimore, transit planners are using CTPP-3 to compare O-D patterns of "streetcar" versus single-occupant vehicle trips along the central light rail line. By understanding the O-D patterns of their chief competitor, the drive-alone automobile, Baltimore's transit planners hope to improve feeder services at key stations and win over appreciable numbers of automobile commuters to the light rail mode.

Golden Gate Transit (GGT), serving the north counties of the Bay Area, used county-to-county flow data from CTPP/State Element to evaluate screenline crossings at the Golden Gate Bridge. GGT planners were concerned about the steady decline in bus commuters across the Golden Gate Bridge and wanted to determine whether this was due to an overall decline in commute flows or deteriorating transit services. Planners found that bus transit commutes fell at roughly the same rate (3.5 percent) as nonbus commutes along this corridor between 1980 and 1990. Thus, bus commuting trends paralleled overall intercounty commute patterns. GGT's fastest-growing bus commuting market was found to be reverse commutes from San Francisco and Marin counties to new, large-scale suburban employment concentrations in Sonoma County and the East Bay. GGT planners are responding by proposing a phased expansion of reverse-direction and cross-haul commuter bus runs. Some expect that the trend toward more balanced bus trip flows will improve GGT's operating efficiency by increasing revenue service hours and reducing back-haul and deadhead losses.

Intermodal Travel

ISTEA requires, for the first time, that state departments of transportation develop a statewide multimodal transportation plan. It also requires states to develop management systems for intermodal activities, including for goods and freight movement. New data sources will be required to inform policy makers which intermodal investments will do the most to improve goods movement and passenger interchanges.

Journey-to-work census data, as currently compiled, can only play a limited role in intermodal transportation planning. The absence of data on linked trip making and for nonwork purposes (e.g., to change travel mode) restricts the applicability of journey-to-work data to intermodal planning. Trip interchanges to major transportation hubs, such as an international airport, might suggest levels of intermodal activities. However, the CTPP-3 tabulations only record journeys by those working in the TAZ occupied by the airport. Correctly speaking, the purpose of a ground access trip from one's home to the airport to catch a flight is to "change travel mode." Whereas census data provide no help in this area, several recent metropolitan travel surveys provide data on linked trip making for multiple purposes, including those in the Chicago (1991), San Francisco Bay Area (1990), and Seattle (1991) regions.

Transportation Demand Management, Ridesharing, and HOV Services

It is widely accepted that cities will never be able to build themselves out of traffic congestion. Transportation demand management (TDM) techniques, like flextime and ridesharing, can increase the throughput of existing roadways by shifting travel demand by time and mode and over space. CTPP data on time of departure can be used to study the temporal distribution of work trips among zones. Stratifying O-D patterns by departure time intervals and occupational class might be one way to match potential ridesharers. Employment zones can also be classified in terms of the departure time characteristics of work trips that flow into them. Regional rideshare agencies might use this information to identify flows to large employment concentrations that are good candidates for targeting marketing campaigns.

For example, CTPP tables could be used to identify industries (e.g., manufacturing, wholesale) with fairly consistent work shifts (i.e., departure times by workers) that operate from a single fixed location. TAZs with large counts of workers in these industries can then be identified (CTPP Table 2-3). Employers in TAZs with large counts of targeted industries might later be approached about forming a transportation management association (TMA) to promote carpooling and vanpooling. Rideshare agencies might then identify the origins of trips that are destined to targeted TAZs. They can also check whether workers in the origin zones have jobs in the industries in the targeted TAZs (CTPP Table 1-18). Large numbers of trips originating from the same areas would identify prime locations for siting park-and-ride lots or timed-transfer depots. Attraction-constrained flow models (showing flows from all origin zones to major employment centers) could also be used to identify possible locations for park-and-ride lots. Flows might then be assigned to a network and scanned to identify junctures with large numbers of cross-flows, signifying possible locations for siting park-and-ride lots and transfer points.

Similarly, O-D flows might be used to identify corridors where HOV facilities are planned. Overlaying existing commute patterns, color coded by occupancy level, would be a good way to assess the market potential of a proposed HOV corridor. Any demand projections would need to be adjusted for the latent multioccupant vehicle trips that might be induced by the opening of a new HOV lane.

Other Small-Area Analysis Applications

A host of other possible small-area transportation-related analyses can be conducted with census data, including studies of traffic operations, alternative modes, neighborhood travel, and regional accessibility.

Traffic Operations

O-D pairs that might jointly use a section of a road can be assigned, either manually or using a computer algorithm, to that segment. This might be used to assess the traffic operational effects of future development at either end of the assigned O-D pairs. Census data on residential and employment densities can also be used for traffic planning, such as estimating the additional arterial lane and spacing requirements likely to be imposed by a major new traffic generator (e.g., shopping mall, industrial park) (*19*). As part of a network study, travel time data from CTPP-3 might be integrated with results from speed-delay studies to evaluate current and projected traffic levels of services. Commute flow and travel time data might also be used as input in confirming and validating skim trees. Whereas first-cut performance evaluations might be possible with census flow data, in general the geographic coding of CTPP data is too coarse to support any refined traffic operations analyses.

Telecommuting and Working at Home

The number of Americans working at home increased by more than 1 million, or 50 percent, from 1980 to 1990 (*1*). CTPP-1 data can be cross-tabulated by occupational and industrial classifications to identify work-at-home markets. Currently, however, it is difficult to distinguish telecommuters from independent business persons and sole proprietors who work out of their home.

Bicycle and Walk Commuting

As with automobile and transit commutes, census data can be used to compare existing O-D patterns of bicycle and walk commutes with current infrastructure provisions. Overlay maps can reveal the degree to which existing sidewalk networks and bicycle path systems align with O-D flows. For evaluating the demand for nonmotorized recreational and social trips, local travel survey data might be combined with census data. CTPP data might also be used to assess the level of internal ("within neighborhood") commuting by bicycle and pedestrian modes. High levels of internal nonmotorized commuting in specific TAZs or census block groups might suggest the need for targeting improvements in those areas (e.g., more pedestrian-actuated signal crossings, addition of dedicated bicycle lanes). Under ISTEA, bicycle and pedestrian improvements qualify as transportation enhancements that are eligible for National Highway System and Surface Transportation funds.

Neighborhood Travel Studies

Census data have also been used by researchers to study the commuting choices of residents from neotraditional versus conventional suburban, automobile-oriented neighborhoods. The central premise of this line of research is that those residing in relatively dense, mixed-use neighborhoods with traditional grid street patterns are likely to be less automobile dependent. Using 1990 census data at the block group level from Summary Tape File 3A and CTPP-1, researchers recently found that residents of traditional neighborhoods in the San Francisco Bay Area and Southern California averaged higher shares of transit commuting than their counterparts from nearby automobile-oriented neighborhoods with similar median household incomes and transit service levels (*20*). Transit-friendly neighborhoods in the San Francisco Bay Area averaged between 2 and 5 percent more commutes by mass transit than their matched-pair automobile-oriented neighborhoods. A comparable study of commuting by residents of traditional neighborhoods in Montgomery County, Maryland, using 1980 journey-to-work data reached similar conclusions (*21*).

Accessibility Studies

Accessibility indices have long been used to measure and compare the relative proximity of neighborhoods to employment centers, health facilities, and other urban facilities and services. Typically, an accessibility index is equivalent to the denominator of the gravity model. It is computed by multiplying the number of trip attractions by the interzonal friction factor (which declines with interzonal travel time) and summing the results over all attraction zones. Production-constrained gravity models are commonly used for measuring the geographic extent of laborsheds, where TAZs with large employment bases represent the constrained production end of interchanges. When census data are supplemented by other data sources, gravity-based accessibility indexes can be derived to, say, identify the number of child-care centers or restaurants/retail plazas within a 3-mi radius of an employment center. Attraction-constrained gravity models might likewise be estimated from journey-to-work data to study whether mismatches between worker occupational classes and housing prices have led to relatively long commutes (*5*). Recently, accessibility-based gravity models have also been used to compare how accessible different types of suburban communities (e.g., traditional versus automobile-oriented planned unit developments) are to employment and shopping opportunities in Southern Florida (*22*).

Conclusion

Census journey-to-work data have become increasingly vital to transportation planning and evaluation. These data are the most consistent and dependable source of information on where Americans live and work and how they commute. The CTPP is the most detailed source available for the study of intrametropolitan commute flows at a fine-grained level. It is finding its way to an ever-widening constituency of users—metropolitan planning organizations, state departments of transportation, public transit agencies, rideshare organizations, TMAs, market researchers, urbanologists, and others.

One of the most important applications of journey-to-work data for small-area analyses remains long-range multimodal transportation planning. The CTPP provides essential data inputs for long-range travel demand forecasting and can be used to cross-validate and update previously used transportation models for work trips. Many public transit agencies today rely on census data for both strategic long-range planning and ongoing service planning. Census data also provide background information from which to carry out link segment analyses, examine market receptivity to specialized facilities like HOV lanes, and compare the accessibility of residential neighborhoods to different employment opportunities.

The growing popularity of GIS has apparently elevated census data to a new height of usefulness. Since transportation is inherently a spatial phenomenon, GIS allows data on the characteristics of origins, destinations, and commute flows to be conveniently displayed, replacing what in the past were tabular presentations. The ease with which successive overlay maps can be produced from GIS bodes well for a future of strategic transportation planning that is grounded in rigorous analysis yet is accessible to a wider public. The marriage of GIS and journey-to-work census data has allowed transportation planners to push the profession in new and exciting directions. The litmus test of the benefits of these tools and data bases, of course, is the quality of decision making that results and ultimately how smoothly our streets, transit systems, and alternative commute programs operate.

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Census Data for Real Estate Decisions

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The changing demographics, economic attainment, and geography of the American population and workplaces will largely determine the nation's transportation needs in 2000, as they have since the first census was conducted more than 200 years ago. The use of census data in decisions on locating the buildings where we will live, work, shop, study, and play in 2000 and beyond, which will determine our needs for travel and communication, are examined in this paper. Many of the decisions are private decisions, those of builders and developers, companies, households, and institutions. On the other hand, they have an important public counterpart in regulation of the use of land. Such information probably plays an even greater role in decisions on development than the census commuting data do on transportation.

Acquiring, developing, and disposing of real estate is an important ingredient of an expanding economy. Often in the past such decisions were based on "gut feelings," rudimentary rules of thumb, or "back of the envelope" calculations. Increasingly, however, such choices are being made through careful analytical procedures and as part of a broad business strategy. A number of emerging trends that appear to emphasize the value of census data in development decisions are identified in this paper. The perspectives of three important participants in real estate—developer, planner, and lender—are examined, and recent case studies of how census data are currently being used for development choices are described.

Greater Need for Better Real Estate Information: Emerging Trends

A number of recent trends point to an increasing need for reliable information on small-area demography and economics:

- The fallout from commercial real estate overbuilding: When real estate values collapsed in the late 1980s and the 1990s, many investors—both private and institutional—experienced large losses. Hundreds of billions of dollars were lost. The response from the investment community generally is to attach a higher risk to commercial real estate and to demand greater documentation, including more careful market studies, to support proposed investments. Among other items, this will increase the need for good small-area demographic data.

Anthony Downs of the Brookings Institute points out that office space vacancy rates in 30 major markets hit 20 percent in 1985, yet bank lending continued (*1*). It must be admitted that the problem was not the quality of the market studies—if they were even done, no one looked at them. The reaction, however, is likely to increase their importance.

- Public information as the price of access to capital markets: The difficulty of obtaining bank financing in the aftermath of the savings and loan cleanup has caused many developers to go to Wall Street. One of the hottest new trends is the establishment of real estate investment trusts (REITs), publicly traded investments that own real estate. Such public offerings will demand better information on properties and markets.
- Finding hidden assets in corporate real estate: Real estate values are central to development decisions but are among the less well-managed assets of corporate America. A study of publicly traded companies (those listed on one of the major stock exchanges) estimated that in 1991, real estate holdings valued at cost accounted for $522 trillion. Those in the active real estate business (developers, brokers, etc.) had assets of just under $2 trillion, whereas passive investors such as REITs had holdings of $250 billion (*2*). A study of 60 leading companies by LaSalle partners found that it is possible to add significant value through reduced occupancy costs and more efficient use of capital—a significant opportunity in times of corporate downsizing, restructuring, and growing international competition (*3*).
- Growing sophistication and competitiveness among retailers: The rise of the "big box retailers," offering wide selection, low prices, and customer-oriented services, is killing off many of the "mom and pop" stores. These retailers can use computers not only for restocking the shelves but also for analyzing their markets.
- Increased regulation in the use of land: There is growing public involvement in what were previously considered private property rights. These take the form of state, regional, and local efforts to manage land use to achieve public goals. There is even a hint that federal regulations on metropolitan planning may focus greater concerns on development patterns. The only objective reading of such trends comes from the decennial census.

Real Estate Information From the Developer's View

Let's look at the process from the developer's point of view. There are eight steps common to the private real estate development process, shown in Figure 1. It is a creative, iterative process in which ideas are successively refined, discarded, fine-tuned, tested, and finally acted on. Information is crucial in the development process, beginning from data sufficient for "back of the envelope" decisions to extensive market studies in later phases (*4*). In the beginning stages, printed census reports may be adequate. Once significant commitments have been made, extensive computer manipulation of detailed census data may be needed.

A project begins with an idea, often the most difficult stage in real estate development and one that can occupy 20 to 30 percent of the time spent on a project. Ideas are generated in many ways. Developers often come upon a site looking for a use. For one reason or another, the owners of a particular parcel want the parcel to be developed. Alternatively, developers might find a use looking for a site, frequently the case when corporations want to expand. Finally, there may be capital-driven opportunities—an individual or group with money wishes to invest in a real estate project (not as likely these days).

The first screening the developer does is a "back of the envelope pro forma." Developers typically use their concept of the tenant to project the tenant's willingness to pay for a particular type of space with appropriate services in a particular location. The income per square foot is then reduced by operating costs per square foot projected over the project leasable square feet to calculate a net income stream. The present value of this income stream is calculated by applying a capitalization rate. The resulting net value is then compared with estimates of cost, including land plus site development plus costs per square foot of building. If value exceeds cost, the idea lives to the next stage. If not, back to the drawing board. This is

ONE: Inception of an Idea Not Feasible Feasible	Developer with background knowledge of the market looks for needs to fill, sees possibilities, has a dozen ideas, does quick feasibility tests in his head (legal, physical, financial).
TWO: Refinement of the Idea Not feasible Feasible	Developer finds a specific site for the idea; looks for physical feasibility; talks with prospective tenants, lenders, partners, professionals; settles on a tentative design; options the land if the idea looks good.
THREE: Feasibility Not feasible Feasible	Developer commissions formal market study to estimate market absorption and capture rates, commissions feasibility study comparing estimated value of project to cost, processes plans through government agencies.
FOUR: Contract Negotiation Cannot reach binding contracts Can reach binding contracts	Developer decides on final design based on what market study says users want and will pay for. Contracts are negotiated. Developer gets loan commitment in writing, decides on general contractor, decides general rent requirements, gathers permits from local government.
FIVE: Formal Commitment	Contracts, often contingent on each other, are signed. Developer may have all signed at once: joint venture agreement, construction loan agreement and permanent loan commitment, construction contract, exercise of land purchase option, purchase of insurance, and prelease agreements.
SIX: Construction	Developer switches to formal accounting system, seeking to keep all costs within budget. Developer approves any changes suggested by marketing people, resolves construction disputes, signs checks, keeps work on schedule, brings in operating people as needed.
SEVEN: Completion and Formal Opening	Developer brings in full-time operating people, increases advertising. City approves occupancy, utilities are connected, tenants move in. Construction lender is taken out, and permanent loan is closed.
EIGHT: Asset and Property Management	Owners oversee property management, including re-leasing; longer-term owners oversee reconfiguring, remodeling, remarketing space as necessary to extend economic life and enhance performance of asset; corporate management of fixed assets and considerations regarding investors' portfolios come into play.

FIGURE 1 Eight-stage model of real estate development (7).

clearly a data-intensive process to the developer, one in which information is as often picked up "on the fly" or even guessed at in the early phases. However, the ready availability of small-area census data is critical.

Real Estate Information From the Planner's View—Guiding Growth

Real estate from the developer's view is typically a profit-oriented, near-term, parcel-based, bottom-up exercise in finding the "highest and best use" for land. In contrast, the comprehensive planner's view is from a public-purpose, long-term, and community level. From this view, real estate is a top-down exercise in determining an appropriate pattern of uses. Such perspectives are not mutually exclusive. Many developers have projects requiring a long-term view, and planners need to recognize market realities. However, developers and planners often find themselves in opposition at the project level. In some cases this may revolve around factual data, including the demographic and economic characteristics available from the census bureau. There appear to be two significantly different levels of information use in planning, depending on whether the data are used as background for planning purposes or as input to growth models.

Comprehensive Planning

As described in the APA book on the planners use of information, decennial data from the census of population and housing fall into the category of information from secondary sources. Some are "tabulated for individual city blocks and for census tracts and are published in census tract and block statistics for the SMSAs and for a few smaller sites that made prior arrangements to pay for special publications" (*5*, p. 56). Since the original book was published soon after the 1980 census, it does not recognize the increasing data sophistication currently available.

Acknowledging the problems of a data source that only appears every 10 years, author Alan Feldt points out that "since there are prolonged periods during which no current information on population size and characteristics are available, other countries have mid-decade census and continuous registration systems" (*5*, p. 58). Apparently the availability of the special tabulations of transportation data was not widely known in the planning community outside of transportation specialists, since there was no mention of traffic zone data or the Census Transportation Planning Package. The lack of sophistication of many planning offices in using information is evident in the storage of many local records, which, although "technically open to the public, in practice . . . are inaccessible because . . . of how they are kept . . . ledger books, 3 × 5 cards, old cartons or footlockers filled with file folders" (*5*, p. 64).

Urban Growth Models

The difference in technical sophistication between planners who use models of urban growth and those who map data with colored pencils is the difference between data kept in geographic information systems and those in shoe boxes. It is for such computerized urban models that the lack of currency in census data is not a severe problem, since these tools take a longer-term perspective. Data on 1980 to 1990 trends, for example, are almost as good as data on 1984 to 1994 trends. Such models are voracious users of census data and in many cases are structured around these data.

One of the latest and most popular of these urban models includes a disaggregated regional allocation model for projecting residential location and an employment allocation model for projecting employment location. These two models are currently in use in 14 metropolitan areas, and 15 more are expected to be on line in 1993 (*6*). Just as retailers are depending on greater use of technical analysis of markets, planners are getting on board as well. Such information will also help inform private decisions. As an example of how such insights can offer a competitive edge, even without a model, North Carolina developer Will Thurow, unlike many competitors working in the Research Triangle area, viewed the cities making up the Research Triangle area as a converging market area, assuming office growth would spread beyond the Research Triangle Park along transportation corridors. Such insights made it possible to get out in front of an emerging market (7).

Real Estate Information From Buyer's and Lender's View

One aspect of real estate decisions not as well understood as development and corporate real estate management is appraisal—the valuation of real estate assets. Appraisers are the under-appreciated "bean counters" of real estate. They have been much criticized for their role in the commercial real estate collapse. Downs points out that in such an environment of low liquidity and future uncertainty over commercial property markets, appraisal has become extraordinarily difficult. The key issue, a particularly critical one for banks holding commercial loans, is how to value the assets on banks' books. In part this is a problem of whether the banks are forced to divest into a buyers' market or are allowed to hold on and hope for a cyclical recovery.

Even in more normal times appraisals are critical, if less visible, in the orderly transfer of real estate. This is important to families shopping for a home, businesses looking for a new location, and landowners looking for a developer. An appraiser must be aware of "the factors that contribute to urban growth patterns and . . . analyze the neighborhood or district where the subject property is located and . . . determine how the area affects the quantity, quality, and duration of the property's future income stream or amenities that create value." In analyzing a local market, a knowledge of trends in the formation of households and household characteristics is crucial. The age, size, income, and other characteristics of households must be considered to determine the demand for housing. The demand for commercial and industrial real estate is created by a population's demand for the goods and services to be produced and distributed at these sites. It is recommended that appraisers look to the census to provide detailed information on population and housing characteristics (larger statistical areas) as well as census tracts and blocks in metropolitan areas. It is further recommended that within neighborhood and district boundaries, if possible, the appraiser obtain accurate data on ages, occupations, incomes, and education levels of neighborhood residents. Appraisers also recognize that neighborhoods have a life cycle beginning with growth, then stability, decline, and eventually revitalization (8). Myers points out that the release of 1990 census data allows analysts to measures trends of the 1980s and recalibrate models for market analysis, emphasizing that census data are "ideal for use in appraisals and market analysis, where conclusions must be defensible" (9).

Census Data and Private Data for Real Estate Decisions

Just as demographic data are one of many types of information used in real estate decisions, census data are only one of many such sources. It is the Rodney Dangerfield of data sources—getting no respect when they are often embedded in other references. There is a story in Washington about members of Congress who criticize the costs of the decennial census and ask, "Why do we need the census? When I need information, my staff simply looks it up in the statistical abstract." Of course, the data they are referring to were reprinted from the census. Whereas there are many valuable private sources of demographic data, it is important to recognize the role of the census data as the original, unimpeachable, affordable source. It should not be a matter of choosing between census and private data sources, but rather understanding the advantages of each.

- The original source: Just as in the story of the members of Congress, there are many sources of demographic information that come from decennial census sources, either directly or as derivatives. Many local and state data sources generated sizable income from selling census data, and much research that used the information attributed it to the reseller rather than the original source. Other data sources key back to small-area census data. One private data source investigated for its use in transportation planning in the late 1970s used proprietary data to identify household structure type and automobile ownership but census tract data to develop an income model (*10*).

- The unimpeachable source: For both public and private sources, decennial census data carry the imprimatur of the U.S. Bureau of the Census. Despite some of the battles over the undercounted population, there is no more credible source of small-area demography. Census data are accepted by all levels of government for a variety of programs. Concerned about how much of a difference there can be in small-area estimates and projections offered by several of the nation's private data companies, the International Council of Shopping Centers decided to find out by comparing them with census tract data. Although generally all were close, the council calculated that a business considering targeting upper-income households in Baltimore County might go ahead if the high numbers were used but abandon the deal if the low set of estimates was chosen (*11*).
- The affordable source: As indicated, many private sources of demographic information are available, at a price. Paying premium prices for information may be possible for owners of high-cost projects with large profit margins. However, many others—local planning offices, nonprofit development corporations, interested citizens, and of course graduate students—are involved in real estate decisions, for whom such costs are prohibitive. Mark Kissel, a real estate consultant based in Washington, D.C., tells a story of a small project that did not justify a large expense in data but where tract maps were not publicly available. The day was saved when an employee found the information in the Library of Congress. It is for such individuals, with modest capabilities or finances, that Myers recommends keeping it simple—going first to printed census data, with computerized sources only as a last resort (*12*).

There are other data sources, many of them more current and richer in data, such as those described later. However, the census data have provided common ground for real estate decisions that generally have a mix of public and private interests. It is important that decisions on content and sampling recognize this history and preserve the essentials of a demographic safety net, which the decennial census of population and housing has traditionally provided.

Information for Real Estate Decisions—Case Studies

The following examples illustrate the range of census data and census-derived data in real estate decisions. They demonstrate a range of uses of census data.

- Multifamily: Memphis, Tennessee—This is an upscale, multifamily project that is part of a planned unit development in East Memphis. A market study was conducted for the first phase, 384 garden apartment units in 16 buildings, most located on a golf course. The characteristics of the neighborhood were identified as "entirely different from those of the larger MSA." Census data used in the study supported the statement that the area was "one of the most affluent and desirable in the area." Whereas the proprietary data base offered updated distributions of age and income, other detailed characteristics of occupation, educational attainment, households with seniors and children, housing tenure, and rents were based on the 1980 census, to support current data on rent levels collected by field surveys (Coldwell Banker, unpublished data, 1987).
- Retail: Bethesda/Chevy Chase, Maryland—This mixed use project is located at the hub of one the most desirable markets in the Washington, D.C., area. It has the highest concentration of mature, urbane, affluent households in the region. The project includes hotel, office space, and retail space. The market study completed in 1986 was particularly complex because retail sales were estimated to come from two sources: residents of the primary trade area and office workers and shoppers from outside the primary trade area. In addition, there was considerable

competition from current and planned retailers. Part of the demographic and economic analysis was drawn from the 1980 census tract data for parts of Washington, D.C., and Montgomery County, Maryland, as shown in Tables 1 and 2. Whereas some of the averages were updated to a current and short-range forecast period, the complete distributions from the decennial census were useful to contrast the market area with a competitive market (Coldwell Banker, unpublished data, 1986).

- Economic development: Long Beach—The composite of individual housing projects and retail, office, and industrial developments represents overall growth and economic development in a community. This public interest in economic development is illustrated in the third annual economic forecast of Long Beach, California. Not the arcane stuff that only an economist could love, there is an outlook section as well as sections on real-world issues, such as strategies for economic growth, reuse of an abandoned military base, and a shoreline development strategy (precipitated by the Walt Disney Company's decision to build a new theme park in Anaheim rather than Long Beach). Extensive use of 1980 and 1990 census data helped in understanding some of Long Beach's strengths and weaknesses compared with those of California and the rest of the country. Census data showed the changing composition of jobs and the work force, especially critical issues considering the sharp cutbacks at McDonnell Douglas. One insight available only because of the journey-to-work data was the finding that Long Beach residents are "a very different group of people than the Long Beach employees." Such insights derived from census data help public officials understand their communities and adjust to the economic realities of the 1990s (*13*).

These examples show a small cross section of how decennial census data have been used in real estate decisions, from both the private and public perspective. Some of these applications are not well known to those outside the Bureau of the Census, including those responsible for funding decisions. They clearly demonstrate the pervasiveness of census data in decisions on where America will grow.

SUMMARY

This paper has examined the use of decennial census data in private-sector decisions on real estate development as well as complementary public-sector actions involved. Such decisions affect a very large part of the American economy, going well beyond those actively involved in real estate to embrace real estate as an important tool of production. Seen in this context, it is an immense category, and there are a number of trends that indicate increased professionalism in real estate decisions, including those made by organizations that do not consider themselves to be in the real estate business.

Decisions on real estate were examined from the perspective of three principal participants—developers, planners, and lenders. Each requires access to information. In some cases the information is shared, and in some cases it is closely guarded. Census data play an important and pervasive role in all.

Supplements to census data are available through private sources, generally to those who can afford the higher prices. Some perspectives on the relationship of census data compared with the alternatives have been offered. The census is seen as the original, authoritative, and affordable source. This is not intended as a criticism of private data sources. It is a recognition of the standing of census information as an irreplaceable data base, an important message to those with control over the decennial census planning. Selected examples illustrate the range of applications of small-area census data.

This paper has demonstrated the immense role that real estate decisions play in growth and development in America and the pervasiveness of census information as a technical foundation of those choices. A number of trends suggest that this will be even more important in the future. The value of census data in such applications may have been underappreciated in the past, in part because the census is not given proper attribution or credit. However, as we look to planning for the 2000 census, it is important to keep these uses in mind, since decisions on real estate appear to be hooked on the census.

TABLE 1 Comparative Trade Area Socioeconomic Characteristics—Income Distribution, Property Values, and Age Distribution (National Decision Systems; Coldwell Banker Real Estate Consultation Services)

CHARACTERISTIC	BETHESDA-CHEVY CHASE PRIMARY TRADE AREA		WASHINGTON SMSA		TYSON'S CORNER, 5-MI RADIUS		FAIR OAKS, 5-MI RADIUS		INDICES OF RELATIVE DIFFERENCES, WASHINGTON SMSA = 100		
	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT	CHEVY CHASE PAVILION	TYSON'S CORNER	FAIR OAKS
Household Income Distribution—1979											
All households	52,296	100.0	1,115,400	100.0	57,922	100.0	35,259	100.0	100	100	100
$50,000 and over	14,622	28.0	125,817	11.3	12,129	20.9	6,266	17.8	248	186	158
$35,000 to $49,999	8,577	16.4	183,483	16.5	12,824	22.1	9,471	26.9	100	135	163
$25,000 to $34,999	7,719	14.8	212,930	19.1	11,521	19.9	7,873	22.3	77	104	117
$15,000 to $24,999	9,581	18.3	271,154	24.3	11,996	20.7	6,396	18.1	75	85	75
$7,500 to $14,999	7,185	13.7	192,853	17.3	6,371	11.0	3,395	9.6	79	64	56
Under $7,500	4,607	8.8	129,163	11.6	3,081	5.3	1,858	5.3	76	46	46
1980 Owner-Occupied Property Values											
All owner-occupied housing units	23,276	100.0	592,339	100.0	28,596	100.0	23,630	100.0	100	100	100
Under $100,000	3,368	14.5	413,690	69.8	14,124	49.4	13,318	56.4	21	71	81
$100,000 to $149,999	9,024	38.8	121,074	20.4	9,322	32.6	7,926	33.5	190	159	164
$150,000 to $199,999	5,563	23.9	35,244	6.0	3,005	10.5	1,836	7.8	402	177	131
$200,000 and over	5,321	22.9	22,331	3.8	2,145	7.5	551	2.3	606	199	62
Age Distribution											
14 and under	15,948	13.4	653,506	21.4	33,859	20.8	27,272	24.9	63	97	116
15 to 19	7,939	6.7	279,462	9.1	14,839	9.1	11,354	10.4	73	100	113
20 to 24	8,925	7.5	292,930	9.6	13,277	8.2	8,151	7.4	78	85	78
25 to 34	18,587	15.6	594,125	19.4	28,001	17.2	18,474	16.8	81	89	87
35 to 44	15,509	13.1	426,386	13.9	25,170	15.5	20,021	18.3	94	111	131
45 to 54	13,893	11.7	320,784	10.5	20,924	12.9	13,142	12.0	112	123	114
55 to 59	8,283	7.0	149,679	4.9	9,697	6.0	4,717	4.3	143	122	88
60 to 64	7,344	6.2	113,866	3.7	6,655	4.1	2,721	2.5	166	110	67
65 to 74	12,787	10.8	146,312	4.8	6,899	4.2	2,435	2.2	225	89	46
75 and over	9,864	8.3	84,481	2.8	3,384	2.1	1,338	1.2	301	75	44
Average		41.93		32.81		33.59		30.54	128	102	93

TABLE 2 Comparative Trade Area Socioeconomic Characteristics—Average Household Income Trends (National Decision Systems; Coldwell Banker Real Estate Consultation Services)

					INDICES OF RELATIVE DIFFERENCES, WASHINGTON SMSA = 100		
CHARACTERISTIC	BETHESDA-CHEVY CHASE PRIMARY TRADE AREA ($)	WASHINGTON SMSA ($)	TYSON'S CORNER, 5-MI RADIUS ($)	FAIR OAKS, 5-MI RADIUS ($)	CHEVY CHASE PAVILION	TYSON'S CORNER	FAIR OAKS
1979 actual	40,737	27,876	36,127	34,940	146	130	125
1985 estimated	57,583	40,658	48,557	52,453	142	119	129
1990 projected	76,833	55,696	62,125	73,568	138	112	132

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Using 1990 Census Data in National Policy Analysis

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Decennial census data on the journey to work from 1960 onward have been of critical importance in transportation planning at all levels of government. Census data on mobility and the journey to work are used in transportation planning, development and project impact analyses, and in supporting policy decisions at the federal, state, regional, and local/site level. The focus of this paper is on the use at the federal level, specifically, use by the U.S. Department of Transportation (USDOT) in developing, monitoring, and assessing transportation policies and service delivery programs, and on use by other federal agencies for a wide range of applications.

The paper begins with a short description of census products available for transportation policy at the federal level, summarizes the broad dimensions of federal use of decennial census data for policy assessment and development, and concludes with a summary of census data at the national level.

Census Products Used in Transportation Planning

Census Transportation Planning Package

USDOT has sponsored the preparation of special journey-to-work tabulations from the decennial census in 1970, 1980, and 1990. Of the more than 70 similar efforts conducted by the Census Bureau across a wide variety of program and topic areas, the Census Transportation Planning Package (CTPP) is the largest project. Through the American Association of State Highway and Transportation Officials, states and metropolitan planning organizations (MPOs) coordinated their needs to sponsor this special tabulation, resulting in the $2 million budget for the Census Bureau to prepare the tabulations. Even more will be spent in analyzing the data. This sponsorship reflects the level of demand for transportation and mobility data and the reliance on the census to provide this information.

Summary Tape Files 1 and 3

Summary Tape Files 1 and 3, which are standard data files reporting information for residence geography, are widely used. The Census Bureau, through the state data center program, was able to deliver tape copies and CD-ROMs relatively quickly to many levels of government analysts. The STF3 files, which include data from the "long" (sample) form, include tables on household vehicle availability, journey-to-work mode, trip length in minutes and departure time, and household income and housing unit tenure characteristics. Whereas tables in STF3 do not have the detailed cross-tabulations available in CTPP, the early release of these data gives analysts an early reading of what the detailed tables are likely to exhibit.

TIGER Files

Topologically Integrated Geographic Encoding and Referencing (TIGER) files are the geographic reference files, built in conjunction with the USGS. The TIGER files form a national coverage of roads, waterways, and political boundaries. Whereas their primary purpose was to assist the Census Bureau in collecting the census data, there have been many uses in the rapidly developing geographic information systems for transportation arena. These files, along with additional materials on employer addresses, were used in the workplace address coding portion of the CTPP.

Public Use Microdata Sample Files

The Public Use Microdata Sample (PUMS) files provide a sample of individual responses from the census questionnaire. Instead of tables where answers are grouped into ranges, the PUMS files have individual answers, such as the travel time to work in minutes or household income. To avoid disclosing information that can be traced to a specific person, the geographic detail is limited to large geographic areas called PUMAs, which have a minimum population of 100,000. These sample files are also available from the Census Bureau on CD-ROM, which much improves their use and access from the 1980 census.

Federal Use of Census Data

Decennial census data are used by USDOT in four general ways:

1. As a comprehensive demographic and mobility data base supporting development of new policies and programs,
2. As a statistical basis for setting program requirements and funding apportionment,
3. As a resource of "benchmark" data with which to evaluate the impacts and effectiveness of federal programs, and
4. As a travel behavior data base to support model development.

The journey-to-work data are used as an information resource by other federal agencies. In particular, employment location analyses are used by the Department of Labor and the Department of Justice.

Policy and Program Development

Census data constitute the primary data resource for establishing a profile of key population demographic and employment patterns as well as definable market segments. The profile provides a context and framework for identifying performance indicators with which to assess community livability and societal quality-of-life attributes and formulate effective policy actions.

Journey-to-work data assist in federal-level transportation policy and program development because they are consistent both longitudinally and cross-sectionally. That is, using standard census geography and geographic definitions and having the ability to report data for small geographic units allows the results to be compared over time. In addition, since all the data are collected in a consistent manner and at the same point in time, comparisons between areas can be made easily.

Although the trip to work (and the "usual" one at that) is only one part of everyday travel, the sample size of the census and the ability to compare socioeconomic characteristics of persons and households with this one trip provide a benchmark. Many large and medium-sized MPOs collect household travel survey data to get information on all trips, but there is no standard method or sampling design to permit results to be easily compared. These regional data collection efforts are conducted infrequently, and the time between data collection points may range from 7 to 15 years. Thus, the likelihood of all or even many metropolitan areas conducting a survey within the same time period is almost zero, and census data provide the only nationally consistent source for these areas.

The Nationwide Personal Transportation Study (NPTS) includes reporting for all trips. However, the small sample size (n = 20,000 households) prohibits its use for specific geographic areas and allows only comparisons such as by metropolitan area size or by census geographic region.

The CTPP is the only decennial census product that includes two geographies: residence and workplace. Whereas there may be other resources available to identify worker populations, these resources do not include characteristics of persons or households. Only census data allow analyses at the workplace location that include such variables as gender, industry, occupation, earnings, and hours worked, in addition to the journey-to-work mode and travel time variables.

Metropolitan Development and Access to Jobs

A current policy area being emphasized at the federal level is the relationship between emerging metropolitan development patterns and the social, economic, and intellectual well-being of the various population segments, including the inner-city poor. Census data provide both evidence and statistics on the sizable and growing employment base in suburban areas. The data can be further used to indicate the level of highway and transit access provided to these suburban centers from other suburbs and the central city. CTPP journey-to-work data have small-area data at both the place of residence and the place of work, as well as detailed information on commuter travel between the two.

There has been continuing debate on whether high unemployment rates among urban poor are due to a "spatial mismatch" between workers and jobs. Census data permit analysis of some of these characteristics with varying degrees of geographic detail. One study by Johnston-Anumonwo (*1*) analyzed PUMS data from the 1980 and 1990 censuses. She found that in Buffalo, New York, black women in service occupations had an average travel time to work of 20 min, compared with 15 min for white women. The difference was even more pronounced for women who commute to jobs outside the central city. Her study found little difference in travel time between black and white men, controlling for occupation, work location in or outside the central city, and income.

Both PUMS and CTPP provide detailed data on personal characteristics, such as race, Hispanic origin, gender, and occupation; household characteristics, such as household income; and travel characteristics to work that can be used to explore these issues and to measure trends over time. These analyses are possible for large geographic areas, such as counties, as well as small transportation analysis zones (TAZs) in metropolitan areas.

National Highway System and National Transportation System

At the federal level, TIGER files have been used to prepare nationwide geographic files to include state, county, place, and urbanized area boundaries, in addition to the very detailed census geography such as tracts and blocks. The boundaries have been incorporated into technical work for the National Highway System (NHS) and will likely be used in the development of the multimodal National Transportation System.

To some extent, the TIGER line files were used for mapping and analysis of candidate routes by states and local governments in developing NHS recommendations for submittal to the

Federal Highway Administration (FHWA). In turn, use of geographic information system-based mapping and analysis methods will enable FHWA to develop important accessibility and service measures to use in the upcoming congressional review and approval period.

Program Requirements and Fund Apportionment

As set forth in the Intermodal Surface Transportation Efficiency Act (ISTEA), USDOT uses population counts and basic socioeconomic data from the decennial census to support apportionment of funding for several grant programs among states. These include population counts for allocating funding from the Surface Transportation Program of ISTEA and urban planning grants under the Federal Transit Act Amendments of 1991.

Under the State Planning and Research Program, 50 percent of the program funds is made available to the Transit Cooperative Research Program. The remainder is apportioned to the states for grants and contracts consistent with the purposes of Sections 6, 8, 10, 11, and 20 of the act. Amounts are apportioned to the states in the ratio that the population in urbanized areas in each state bears to the total population in urbanized areas in all the states, as shown by the latest available decennial census, except that no state shall receive less than 1/2 of 1 percent of the amount apportioned.

In addition, census data are used as the basis for apportioning funds for the Airport Improvement Program, State Highway Safety Grants, Alcohol Program Incentive Grants, and the Congestion Mitigation and Air Quality Improvement grant program.

ISTEA recognizes the special challenges faced by large metropolitan areas in meeting the mobility needs of their population while improving environmental quality. The act established the concept of transportation management areas (TMAs), which are metropolitan areas having a population of 200,000 or more. Special program and funding provisions are contained in the law for TMAs, and the decennial census is the recognized source of this population information.

Nationally, the definition of metropolitan statistical areas is based, in part, on commuting patterns at the county level. Furthermore, urbanized area boundaries are used by FHWA and the Federal Transit Administration to allocate Surface Transportation Program and planning funds. MPOs are designated in urbanized areas of more than 50,000 population. By definition, the boundaries of the metropolitan area must include at least the existing urbanized areas and the contiguous area expected to become urbanized within the 20-year forecast period, and they may encompass the entire metropolitan statistical area or consolidated metropolitan statistical area.

Program Evaluation

Modal administrations of the USDOT use the household demographics and journey-to-work data from the decennial census to assess the impact of previously implemented policies. This is an important step in the refinement of policies or the development of new policies.

In addition, USDOT works in partnership with states and local governments to assess project/corridor-level effects of implemented plans, programs, and specific projects. In supporting ISTEA and the Clean Air Act Amendments of 1990 (CAAA), as well as other federal legislation such as the National Environmental Protection Act (NEPA), Title VI of the Civil Rights Act of 1964, the Uniform Relocation Assistance Act, and the Highway Safety Act, decennial census data facilitate a consistent level of responsible federal oversight and review of state and local plans and programs.

Furthermore, a consistent, reliable decennial census permits establishment and use of secondary sources for demographic and travel trends during the intercensal period. Maintaining the 10-year census survey cycle, however, is critical to providing periodic benchmarks of these indicators.

Information from the decennial census is used to evaluate the use, performance, and effects of implementation of the transportation program. Perhaps the most notable example is the environmental review process required under NEPA. Small-area demographic data are required to assess the potential effects of projects yet to be implemented. Detailed information is required on the age, race, and income characteristics of individuals likely to be affected, either directly or indirectly, by program initiatives. Both residential- and nonresidential-based information are obtained from census data to support this effort.

Beyond this, census-reported means of commuting travel, stratified by place of residence and work as well as by demographic level, provide an important barometer of the equity and cost-effectiveness of transportation programs. In consideration of CAAA, USDOT will need to rely on the 2000 census to continue the broad level of program assessment from past decennial efforts. With much of the nation actively promoting alternatives to the single-occupant vehicle throughout the 1990s, reported mode of travel from the 2000 census will provide important feedback on the overall effectiveness of today's national air quality agenda.

Nonmotorized Rates by Area

Bicycle and pedestrian access is a new focus expressed in ISTEA. Some transportation improvement programs (TIPs) around the country are making significant investments in bicycle paths and exploring pedestrian-oriented land use development. Whereas bicycling remains largely a recreational activity in the United States, bicycling is a major means of commuting to work not only in China but also in the Netherlands, Sweden, Denmark, and Germany.

With the CTPP, we can examine trip length and trip time by mode and by location. Bicycling represented less than 1/2 percent of all work trips in 1990, and walking represented about 4 percent. There was significant variation by area. The largest shares for bicycle commuting were in Sacramento, Phoenix, and San Francisco. For walking, the highest shares were in New York, Boston, Philadelphia, and Pittsburgh. As with other transportation investments, investments in nonmotorized travel modes will need to be evaluated with use over time.

Trends in Mode Use Across Metropolitan Areas

Reliable, comparable data for different metropolitan areas, even if limited to the journey to work, give policy analysts at the federal level the ability to evaluate how different areas reflect similar or differing travel patterns and trends. Repeating this data collection over time further enriches the effort by enabling these local area trends to be compared over time.

A dominant mobility theme to be addressed over the next decade will be whether the decline in transit and high-occupancy vehicle (HOV) shares of work trips will continue or be reversed.

Transit Share of the Work Trip

The CTPP shows that transit times often range from 50 to 100 percent longer than travel times by private vehicle for the same origin-destination pairs. With multiple-worker households, efficient use of time appears to be more valuable than (potential) cost savings from riding the bus or the social goal of reducing air pollution. Thus, the proportion of workers driving alone to work has continued to increase. Since most working Americans do not pay for parking, parking costs have not been a disincentive to private vehicle travel.

With census data, investments in fixed-rail systems and their effect on the journey to work can be reviewed. For example, San Francisco, Atlanta, and Washington, D.C., have built large fixed-rail systems with major funding through the Urban Mass Transit Administration (now the Federal Transit Administration). In San Francisco, the number of workers traveling by rail has increased from 13,000 in 1960 to 90,000 in 1990. In Washington, D.C., the number of workers traveling by rail has increased from 1,500 in 1960 to 148,000 in 1990 (2).

Still, New York remains the leader in workers using alternatives to a private vehicle for the journey to work. Washington, D.C., now has the third-largest percentage of workers using transit to work, following only New York and Chicago. In San Francisco and Atlanta, even with large increases in the number of workers using rail, the percentage of workers using rail remains less than 3 percent. (See the following table, where "total transit" includes bus, streetcar, rail, subway, ferry, and taxi.)

Metropolitan Area	*1990 Rail (percent)*	*1990 Bus (percent)*	*1990 Total Transit (percent)*
New York	18.8	8.0	27.8
Chicago	6.6	6.8	13.7
Washington, D.C.	6.7	6.7	13.6
San Francisco	2.8	6.3	9.3
Atlanta	1.0	3.5	4.7

The census data show the loss in the share of jobs in central counties and a corresponding increase in the proportion of jobs in suburban counties. For example, in Atlanta, there was a 9 percent decline in the share of jobs in the central counties. In Washington, D.C., there was a 5 percent decline. The continuing suburbanization of jobs is an essential issue in studying the transit ridership in any given metropolitan area. Since the census data provide mode of travel and location of both residence and workplace, they can be used to analyze trends in transit use for specific geographic areas.

More recent investments in transit have been in light rail systems, such as those in Sacramento, Miami, Baltimore, Portland, and Buffalo. There will also be significant progress in fixed-rail systems in the Los Angeles area. How these systems fare will be reflected in the next census results.

Carpooling Rates

Perhaps even more significant than changes in transit use for the journey to work has been the decline of carpooling over the last 30 years. Nationally, vehicle availability has increased tremendously, from 0.85 vehicles per worker in 1960 to 1.32 vehicles per worker in 1990. Vehicle occupancy rates have declined from 1.17 in 1970 (3, Table 6-3) to 1.09 in 1990 (2, Table 5-3A).

Vehicle occupancy rates showed more variation across metropolitan areas in 1980 than in 1990. By 1990, there is little variation, with nearly all metropolitan areas with POV occupancy rates between 1.07 and 1.13 (2, Table 5-3A). Even more dramatic is the lack of variation in occupancy rates between central county and suburban county residents. New York was the prime exception, where central county occupancy (1.25) was much higher than occupancy for suburban counties (1.10).

NPTS data for 1990 indicate that carpooling is most likely to be with other household members. The census data support this, since most carpools have only two members. Formal carpools and vanpools with more than four members are a very small proportion of vehicle pool trips. Nationwide, 12.1 million workers reported going to work in a two-person carpool, compared with only 1.3 million in a carpool of four or more persons.

As regional air quality improvement programs are implemented, many agencies are hoping that employer-based travel demand management programs will increase vehicle occupancy for the journey to work. Still, it is unclear how changing vehicle occupancies to work will affect daily and weekly travel behavior. Will there be fewer total trips, will trips be moved from peak to off-peak, or will people return home from their carpool trip from work, jump into their car, and run errands as they did before, effectively causing no change in the number of cold starts per vehicle per day?

Spatial Analysis

The CTPP data in combination with the TIGER files form a powerful tool for spatial analysis of travel patterns. Flows between both large geographic areas like counties as well as for small TAZs can be depicted easily for spatial analysis. This technology enables analysts to combine any number of other data sources, such as land use, transit routes, and assessed value of property with population, employment, and journey-to-work data from the census.

At the federal level, specialized software was developed to provide user-friendly data extraction of CTPP data. With this software, the user can select small amounts of data from very large files by pointing to areas on a map. Easy access to detailed journey-to-work data with a geographic component enhances the ability of federal analysts to compare areas on their desk-top computers. This data access capability was unheard of before this release of census data.

Americans with Disabilities Act

To respond to the requirements of the Americans with Disabilities Act (ADA) for transportation fully accessible to all segments of the population, the demographic and mobility measures traditionally included in decennial censuses provide an opportunity for USDOT to do a nationwide comprehensive assessment.

In summary, the decennial census provides for sufficient consistency nationwide in field data collection to permit consistent evaluation on a programwide basis.

Travel Model Development

Extensive research is being sponsored by USDOT to develop improved tools and methods of analyzing travel impacts and to project future trends. One of the significant uses of census data at the national level is in establishing and maintaining a robust data base for forecasting. The CTPP provides an empirical base of work trip data to support calibration and validation of travel demand models. In addition, the basic worker and employment characteristics, including trip length to work, can be used in developing land use allocation models.

Short-Term Improvements

At the federal level, short-term improvements through the Transportation Modeling Improvement Program are likely to include better estimates of transit ridership, improved procedures for estimating and forecasting participation in ridesharing programs, and support for the development of models to determine automobile ownership. Especially as HOV lanes and bicycle paths are added to TIPs, operational models must account for these choices in daily travel. Another short-term model improvement may be to use 1980 and 1990 PUMS files for improving forecasting of vehicle availability by such characteristics as immigration, household size, housing type, education, or other proxies for income and length of residence.

Long-Term Improvements in 1980s

The journey-to-work question in the 1990 census allowed workers to select only one mode for their journey to work. The question requested the mode for the longest portion of the trip. Whereas this is sufficient for the many people driving alone to work, transit trips often combine multiple modes: for example, drive to park/ride and rail trip for remainder, or drop off at kiss/ride and bus trip for remainder. We also do not have sufficient information on walk access for transit trips. Since intermodal transportation has been of increasing interest, the interfaces between these multiple modes are likely to be included in new travel demand models.

In the 1980s there was discussion but little formal encouragement of flexible work times to spread peak travel. The data indicate little evidence of spreading peak. Current models generally limit their time-of-day component to two cases: a total daily travel and a peak travel period (defined as period of 2 to 4 hr). Census data on departure time for work remains a large, nationally consistent data base on time-of-day of travel for at least one trip.

Nontransportation Uses

Federal agencies other than USDOT use the journey-to-work and mobility questions from decennial censuses. The Department of Labor used mode to work to analyze socioeconomic and demographic characteristics of the work-at-home population. Tabulations of work force characteristics by tract of zone of work are key inputs for emergency response planning, public health studies, and other purposes. Tabulations by place of work provide key inputs to analyze residential opportunities by race and income relative to work locations (equal housing opportunities) and job market access (equal employment opportunities).

National Commuting Trends

Data from the 1990 census indicate that between 1980 and 1990, nationally, driving alone to work gained 13.7 percent, and the proportion of workers using carpooling or transit declined. Overall, average vehicle occupancy declined from 1.15 to 1.09. Vehicle availability increased dramatically, with the number of vehicles available to households increasing faster than the number of workers or population. Nationally, these figures are used to direct policy decisions to enhance all modes of transportation. At the local and regional levels, these trends are used to develop transportation control measures and travel demand management programs in efforts to reduce congestion and improve air quality.

Commuting-Related Changes from the 1970s

- Rapid growth in vehicular travel: The number of households grew 26 percent between 1970 and 1980, whereas the number of household vehicles grew 64 percent. The number of vehicles per household increased from 1.25 to 1.61 between 1970 and 1980; at the same time, average household size was declining.
- Growth in population and workers: By 1980, the baby boom generation was fully of working age, with both men and women participating in the labor force. Labor force participation rates for women of all ages increased from 43 percent in 1970 to 51 percent in 1980, an increase of 14 million women. In the same period, labor force participation rates for men of all ages declined from 80 to 77 percent but increased in number by 10 million (*4*). Thus, the increase in the absolute number of workers was as critical as the labor force participation rate and the change in mode choice for the journey to work.
- Suburb-to-suburb/intercounty commuting: Between 1970 and 1980, employment in suburban areas and suburb-to-suburb commuting were increasing rapidly, portending changes for the next decade.
- Decline in use of transit: Given the rapid increase in vehicle availability, declining household size, and suburban residential development, perhaps the decline in the use of transit for the journey to work was not unexpected. Not only did transit use decline as a proportion of work trips, it declined in absolute number as well. In 1970, 6.5 million workers used public transit for the journey to work; this figure declined to 6.1 million in 1980.

Driving alone became more and more dominant, taking shares away not only from transit but from carpooling as well. In the major metropolitan areas, average automobile occupancy declined from 1.17 in 1970 to 1.14 in 1980.

Commuting-Related Changes from the 1980s

- Dramatic growth in drive alone: Continuing the trend from the previous decade, driving alone was even more dominant. In 1980, 64 percent of workers reported driving to work alone. By 1990, the figure increased to 73 percent, representing more than 84 million workers in the United States.
- Decline in carpooling and transit: Nationally, 13 percent of workers reported carpooling to work, representing about 15 million workers. This was a significant decline from 1980,

when the share was 19.7 percent. In 1990, the share of carpooling was relatively stable across metropolitan areas, ranging from 10 to 15 percent in each area with a population of 1 million or more.

Whereas the share of workers using transit to work declined from 6.4 percent in 1980 to 5.3 percent in 1990, the number using transit remained about the same (6.17 million in 1980 and 6.07 million in 1990) (*5*).

Only in the New York metropolitan area does rail/subway make up a large proportion of commuters (20.9 percent in 1980 and 18.8 percent in 1990). Despite the drop in share between 1980 and 1990, the number of rail/subway commuters increased from 1.4 million in 1980 to 1.5 million in 1990.

- No change in commute time: Average travel time to work showed little change between 1980 and 1990, averaging 21.7 min in 1980 and 22.4 min in 1990. Increases in "reverse" commuting, increases in suburb-to-suburb commuting, shifts away from travel modes like bus (which tend to have long travel time over short distances), and increases in driving alone (the most "convenient" mode) are considered to be directly related to the stability of travel times.

Using the 1980 UTPP and the 1990 CTPP Urban Element, we will be able to compare travel times by mode for small area TAZ pairs between 1980 and 1990. This work is in progress at the Texas Transportation Institute. Each TAZ is assigned to one of five land use types, resulting in 25 possible combinations. Preliminary work using data from Houston shows that, overall, travel times remained the same, with small but significant increases in travel speed for five combinations.

- Less intracounty commuting: Historically, planners have assumed the development of the radial city, where employment was concentrated in major centers. Now, modern technologies permit expansion to vast areas. New concepts of metropolitan areas as a "string of varying-size beads," information superhighways, and telecommuting technologies allow people to communicate more quickly across wide distances, perhaps without face-to-face interaction. These changes affect location decisions of both businesses and households.

Suburban "bedroom" communities have developed into major regional employment centers. By 1990, for large metropolitan areas, 57 percent of the workers lived in suburban counties. About 60 percent worked in the same suburban county, and another 15 percent worked in another suburban county. These changes are reflected in the changing mix of commuting patterns between central cities, suburbs, and exurbs.

Summary

Policy analysis applications of census data at the federal level have expanded with the completion of each decennial census. With the completion of the 1990 census and preparation of the CTPP, policy analysts can track trends in metropolitan growth and development over the past 40 years while assessing how this growth has been translated into access and mobility needs. With the 1980 and 1990 transportation planning packages (UTPP and CTPP), the subject and data reporting content was expanded to include indicators not only of the use of the transportation system but also of the performance of the system in meeting the demand.

The broad scope and topic content of census data, as well as their consistency over time and across regions, define an extensive range of applications in national policy analysis. Whereas many of these applications involve federal program investment decisions, the most extensive uses involve identifying and interpreting national trends, both in the aggregate and on a disaggregate level.

With completion of each decennial census effort, policy analysts are better able to distinguish between short-term issues and trends of a longer-term nature. Furthermore, the census data give us the ability to associate development trends with emerging patterns of transportation system usage. For these reasons, future censuses will prove useful in providing even greater opportunity to leverage past efforts in further enriching the national profile of demographics, development, travel demand, and system performance.

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WORKSHOP REPORTS

Introduction

The purpose of the workshops was to develop recommendations for the role, use, and products of the census for transportation planning purposes. Through the workshops, the attendees discussed current and future transportation data needs and how census data can and should support those needs. Example questions that guided the discussions are given here.

The workshops were oriented to the following breakout groups of professionals:

- Statewide Planning and Small Metropolitan Areas,
- Planning for Large Metropolitan Areas, and
- Transit and Traffic Applications.

The format was as follows:

Contents and products—Discuss, comment on, and summarize from the standpoint of the user the overall census products developed for 1990. This should include questions relating to transportation, sample size, media and methods of distributing census information, the Census Transportation Planning Package (CTPP) in relation to other census products, administrative arrangements for receiving and processing the census data, and the relation of census to other data sources.

From experience with (or knowledge about) the 1990 census data as produced, consider the following:

- What recommendations do you have for the 2000 census products?
- What additional (different) questions would you need to better support your transportation program?
- What minimum set of transportation questions would you need?
- Could you live with a smaller sample size? If so, what minimum sample size?
- What would make it easier to use the census data?
- What recommendations do you have for the format and media use for distribution of the CTPP?
- How useful is the CTPP in relation to other census products (e.g., PUMS, STFs, etc.)?

Applications—This workshop session should focus on the problems and successes of applying the census data within the context of your transportation program and in conjunction with other transportation data sets. The emphasis should be on how census data are planned to be applied in response to the Intermodal Surface Transportation Efficiency Act and the Clean Air Act Amendments of 1990.

Consider the following:

- What are the issues and requirements facing state and metropolitan planning organization planners and transit operators that can benefit from the census data? What cannot be, and why?
- How are data needs coordinated at the state, regional, and local levels? Are census data coordinated?
- What technical capabilities are needed to take full advantage of the census products? Staff? Computer programs?
- Can census data support air quality analysis; congestion, intermodal, and public transit management system development; or major investment studies?
- How are census data being integrated with transportation data from other sources (e.g., household survey, employer survey)?
- Are there uses to which census data cannot be applied? Why?

Needs for the future—On the basis of findings and conclusions in the previous workshops and your estimate of future transportation data needs, what data can (should) the 2000 census provide to support these needs? Consider the following:

- What are future comprehensive data needs?
- On the basis of the material presented and your workshop discussions, will census data meet these future needs?
- If the census is conducted differently in 2000, what is your assessment of the alternatives proposed so far?
- What recommendations do you have for census product needs in 2000?
- Are there state, regional, or local institutional changes that would enhance census data applications?
- Are there technical changes or improvements?
- Do you have any research recommendations?

Statewide Planning and Small Areas

COCHAIRS: Mary Lynn Tischer, Ronald Tweedie

RECORDER: Andrew Meese

PARTICIPANTS: Tim Baker, Robert Ball, J. Bronter, Robert Finkelstein, Osvaldo Garcia, Keith Golden, Jared Goldfine, Zachary Graham, David Grier, Edward Hocker, Walter Kondo, Larry Kopfer, Cameron McGough, M. Ming, John Pascoli, Michael Sanders, Donald Wells, Stephen Williams, Linda Wilshusen

The use of the 1990 census data for statewide planning was not found to be extensive. Several states had some experience with the information for policy analysis, whereas others used the more detailed census data as the basis for modeling and corridor planning. General trend analysis and the identification of travel flows were cited applications, as well.

The workshop addressed small-area use of census data as well as statewide application. Whereas there was general agreement on most of the topics discussed, several differences in needs were noted. Most areas, particularly small areas, generally do not have other sources for origin/destination flows or the detailed sociodemographic data associated with travel. Second, the sample size issue was key to the utility of the data.

Workshop participants in general supported the continued collection of all the socioeconomic and journey-to-work information. For many, the data were essential for their transportation planning. It was recognized that the census could not be relied upon to supply all the information necessary for transportation planning purposes, but it was deemed to be essential for the geographic and sociodemographic data and as the framework for other information.

There were several uses for the data.

Several problems in the 1990 study were noted, particularly the delay in releasing the information, which was due in part to the inadequacy of resources directed to the coding and processing of the data. There was unanimous agreement that the most important change that should occur in the next census is the more timely release of information, and several recommendations were made to ensure that end.

Other general recommendations and opinions were as follows:

- The 1990 census was an improvement over the 1980 census, particularly in the creation of the statewide element in the geocoding of the origin/destination data.
- The involvement of the various levels of government and other institutional actors enhanced the product of the census. They should be encouraged to continue to cooperate in preparation for the 2000 census.

The American Association of State Highway and Transportation Officials (AASHTO) facilitated the geocoding of the place of work data and the special tabulations, the state data centers facilitated the interpretation and distribution of data, and the metropolitan planning organizations (MPOs) assisted in the development of the destination addresses.

- The Bureau of Transportation Statistics can be a resource for technical support and ongoing analysis of census data and methods and can represent the transportation community's interest to the Bureau of the Census.
- There is a need to provide software for the interpretation of data, since the end user is not technically sophisticated and the turnover of staff knowledgeable in census data is a problem. The Bureau of Transportation Statistics can help ensure development of software and coordinate the sharing of software.
- The data requirements of small areas suggest that the current sample size represents a minimum for transportation planning activities and should not be reduced.
- The census should avail itself of the most recent technology in producing materials for states and MPOs. The distribution of the 1990 census on CD-ROM was helpful and is illustrative of the developing technologies that can simplify the distribution process.
- There was agreement that census data provide essential origin/destination information. These data are universally useful, especially in conjunction with GIS packages.
- New requirements of the Intermodal Surface Transportation Efficiency Act (ISTEA) and the Clean Air Act Amendments (CAAA) will provide additional incentives to use census data.
- The census questions need to recognize the changes in the nature of the workplace, the structure of households, and the location and time of trips.
- There is a continued need to supplement travel data to meet the requirements of ISTEA and CAAA.
- The importance of the geocoded data was universally acknowledged. It was believed that any additional resources should be directed toward improving the data coding rather than providing additional questions or software.
- The transportation community should investigate funding for methods to speed up delivery through the Bureau of Transportation Statistics and AASHTO.
- If the Bureau of the Census determines that an alternative methodology will be used in the 2000 census, another conference should be held to provide advice regarding content.
- For statewide and small area planning, the current census methodology is considered appropriate. Furthermore, the alternatives are not acceptable from a technical perspective. The workshop recommends use of the same procedure in 2000.
- The 2000 NPTS should be made as consistent as possible with the census.
- It was unclear to the workshop participants why the census date would be changed from March to April. The group was concerned with the implications of the date change.
- The transportation community needs to establish coalitions with other users of the census (for example, business groups, NARC, etc.) to ensure that our needs for the next census are met.
- AASHTO needs to take a stronger role in supporting availability and use of census products. The Committee on Planning should be charged with this responsibility.

Planning for Large Metropolitan Areas

COCHAIRS: Elaine Murakami, Keith Lawton

RECORDER: Gene Bandy

PARTICIPANTS: Kenneth Campbell, Ed Christopher, Robert Donnelly, Trish Duncan, Leo Estrada, Jack Jernigan, Konstantinos Koutsoukos, Edward Limoges, Robert Marx (Day 2), Michael Rossetti, Phillip Salopek (Day 1), Cheryl Stecher, Todd Steiss

The large metropolitan planning organizations (MPOs) represented were Baltimore, Detroit, Chicago, San Diego, Sacramento, Dallas–Fort Worth, Portland, and the Port Authority of New York. MPO staff were experienced with travel demand modeling and demographic forecasting. Additional participants were U.S. Department of Transportation staff, household travel survey data collectors, and traffic safety staff. All of the MPOs represented had a 1980 Urban Transportation Planning Package (UTPP) file.

APPLICATIONS

The predominant applications of census data for transportation planning were in trend analysis, air quality planning, corridor studies, major investment studies (alternatives analysis), and model development and calibration. Air quality concerns are currently a critical element. Submissions for State Air Quality Improvement Plans are required, and items on MPOs' Transportation Improvement Programs (TIPs) must be evaluated with regard to air quality effects. Census data are used as a "known" quantity. Trends using census data, despite the 10-year gap between data points, have more credibility than data from smaller sample surveys.

Large MPOs had, at a minimum, experience with the 1980 UTPP, and some had experience with the 1970 UTPP. All the MPOs in this working group had the capability and resources to incorporate census data with a variety of other data, from both primary and secondary sources. Most often mentioned in this group was household travel behavior via household surveys and land use, employment, and freight data.

Major Issues

Workplace Location Coding

This was the most critical issue of discussion over both days. To address this issue, we identified several areas of concern.

The communication and the working relationship between the Census Bureau and the MPOs should be improved. The MPO Cooperative Assistance Program was a start in the right direction, but for the 1990 census there was misunderstanding and a lack of communication in several areas. The MPOs welcome the opportunity to be more closely involved in the workplace coding process and would like to be "sworn Census agents" to help resolve coding where there may be incomplete addresses, local names, and other business name or address problems. In 1990, as part of the program, MPOs formally agreed to conduct this type of assistance, but they were never asked to participate. The Census Bureau never conveyed to the MPOs the decision that this assistance had been disallowed because of interpretation of Title 13. Therefore, the MPO staff kept waiting to be asked.

Commercial and business addresses need to be included in a "continually updated" Master Address File (MAF). From discussions during the conference, we understand that the current intent at the Census Bureau is that the MAF include only residential addresses. This is not sufficient for transportation purposes. Because workplace location is a critical component of our data needs, whether the Census is conducted at one point in time or on a continuous basis, workplaces, not just residences, will need to be geocoded.

To conduct this geocoding, the commercial and business addresses also need to be incorporated into TIGER. TIGER files need to be maintained under many venues—there are roles for the U.S. Postal Service, the Census Bureau, and MPOs. The MPOs would like the geographic reference files that are continuously maintained and often used for E911 dispatch to be incorporated into the TIGER files. There is much disparity among MPOs in the amount of TIGER file maintenance that is currently in place. There should be clear communication between the Census Bureau and the MPOs on mechanisms and methods for sharing these geographic data.

There should be a formal evaluation of workplace responses, coding, and allocation from the 1990 census.

Timeliness of Data Delivery

The flow data at large and small geographic levels should be delivered in a more timely manner. This issue was similarly discussed 10 years ago at the last conference. The MPOs would like to see a local review built into the process—even with heavy involvement in workplace geocoding, we know that there will still be some allocation because of poor written responses on Census forms.

The STF S-5 (county-to-county flow tape) was of immense value to transportation planners despite large geography and lack of detail on mode, trip time, trip departure time, and so forth. Its greatest asset was that it was released much earlier than any Census Transportation Planning Package (CTPP) product.

It was agreed that a staged approach to data delivery is a good idea (statewide ABC, then Urban 123, then statewide DEF, . . .). We believe that a few basic tables delivered in a timely manner are more useful than many tables delivered later and would be a further improvement. We will probably need a survey on which tables were used most often to help define tables for 2000.

Organization and Administration

There was consensus that the American Association of State Highway and Transportation Officials (AASHTO) contract was a good mechanism for MPOs to get CTPP. This was a great improvement over the 1980 process.

There was consensus that the State Data Center program, operated through the Census Bureau Data User Services Division, was effective in getting timely delivery of standard Census products such as PL-94-171, STF1-2-3-4, TIGER files, and Public Use Microdata Sample (PUMS) data. The State Data Center program was a good model for shared development of report writers for STF files.

We should continue to improve communication via the "information highway." People who use the Census Bureau EBB like it, but many people do not know about it. MPOs need access via Internet so that costs (long-distance telephone charges) can be reduced.

Having national coverage of CTPP was a positive step, despite delays in data delivery. The large MPOs are using the statewide element, particularly as metropolitan areas expand and need to incorporate areas that are more distant into their regional models. The MPO is unlikely to have detailed travel data or to have conducted regional household surveys for these outlying areas.

National coverage of TIGER files was another significant improvement from the 1980 census, despite the preceding problems. TIGER files have been used for creating digital line and polygon files used by many MPOs for mapping and GIS applications. The TIGER files have been invaluable for displaying the data to more easily understand geographic patterns of demographic characteristics for both residence and workplace geographies, to examine trends over time, and to understand home-to-work travel patterns. Several MPOs prepared sophisticated displays of census data for the "show and tell" session on Monday evening. The displays included trends in mode choice between 1980 and 1990, flow data between counties and places, and comparisons of census data with modeled travel forecasts for 1990 for travel demand model validation.

Content

The following topics were identified as those most needed by MPOs:

- Household—income and vehicles available;
- Housing unit—structure type, tenure, year built, telephone available, vacancy rate/occupancy status, and value of home/rent;
- Person—household relationship, age, race, Hispanic, education, school enrollment, disability, language, migration, and work status; and
- Place of work—accurate location, number of hours/days last week, departure time, mode, occupation/industry, class of worker (government, self-employed, etc.), and trip length (min).

The group was primarily concerned with identifying questions from previous censuses that needed to be included in the next census rather than identifying new questions. It was stressed that several topics are critical for the population forecasting that MPOs conduct in conjunction with travel forecasting and that we should not lose sight of these topics by focusing too closely on the journey-to-work questions.

If the matrix sampling alternative is selected for the 2000 census and there is the possibility of adding a few questions, the following two issues were identified as the most important:

1. Stops on way to and from work (include "to second job"): Trip chains and, in particular, the number of links related to the work trip have become a focus in improving travel demand models. Total trips have increased, but home-based work trips have declined as a proportion of total trips. However, using a new definition of trips that includes these stops can improve existing models.

2. Usual mode, number of days used last week and alternative mode, number of days used last week (include "work at home" as answer)—The question of different modes used over the course of a week addresses such issues as carpooling and transit usage. Many employer-based travel reduction programs have goals that can be met only if alternatives to driving alone are used part of the time. The ability to ask for multiple modes gives analysts more information on less frequent, but regularly used, modes.

There was much discussion of other items, but the group did not resolve them specifically. For example, on the topics of telecommuting and "primary" and "secondary" jobs, there was concern that questions would cause more confusion among respondents. These items were believed to be more appropriate for other surveys with direct probing (e.g., telephone surveys).

Products

PUMS

The MPOs would like more disaggregate information like PUMS. Instead of trying to define all combinations that anyone might want for a product like CTPP, we would prefer the development of mechanisms to allow data users to request custom tabulations that can be run quickly. There should be ways to access the "whole file" without seeing individual records. The data user should be able to make a tabulation request, and the output would provide detail only when an appropriate geographic level is reached. That is, if a four-way cross-tabulation request is made for block groups but the data do not support this level of geographic detail, the output would restrict itself to tract reporting. Similarly, the users should be able to define reporting groups, such as income or age ranges, rather than relying on standard definitions.

Questions are as follows: Can a PUMA have a population of less than 20,000 without violation of confidentiality? Where did the 100,000 level come from? Is there a statistical basis for it?

CTPP

The primary concern was to trade off the number of tables for more timely delivery. The group believed that there were a small number of tables that warranted inclusion but that many of the tables were likely to be used only by a few areas. These needs should be addressed through special tabulations and should not interfere with basic journey-to-work tabulations. Specifically, Statewide Element Parts D, E, and F and Urban Element Parts 4, 6, 7, and 8 should be carefully evaluated to determine whether anyone used them. Also, the tables for residence end (Statewide Element Part A and Urban Element Part 1) should also be evaluated, since STF3 already provides much of the detail.

Having the same tables in the Statewide and Urban Element packages makes sense, keeping in mind the desire to reduce the number of tables. As previously mentioned, a standard procedure to request special tabulations on a more ad hoc basis for multiway cross-tabulations for individual agency needs is a better approach than trying to define all tables for all uses and creating a plethora of tables, a majority of which will almost never be used.

The current geography reported in the urban package includes place, county, and state detail for all areas. For example, small numbers of workers who live in California and worked in New York are reported by place geography in the 1990 CTPP. We recommend that beyond adjacent states (or other geographic unit to be determined), the place detail be eliminated.

In conjunction with recommendations to improve the workplace address geocoding, there should be a formal review of the allocation procedures. Because the responses submitted on census forms will never be perfectly accurate or complete, an allocation procedure will still be needed for the 2000 census. The 1990 allocation procedures should be formally documented. The documentation should include comparisons with the allocation procedure used in 1980.

TIGER

Many must cooperate to maintain TIGER files, but in metropolitan areas there is a need to work with MPOs. The Census Bureau should not be given a file that the bureau does not use with no one being told why it was rejected. Assuming long form for method, as late a date as possible is wanted for update before use in census.

Incorporate TAZ boundaries into TIGER. The group forecast that all MPOs would have access to GIS for the next census and therefore would use GIS to submit TAZ boundaries instead of "equivalency files." The equivalency file process has had problems with submissions of discontinuous areas, water blocks, and other mistakes not easily checked without a GIS.

PL 94-171

These data are legislatively required to be released 1 year after census. Early release of the data makes the data useful for comparing population and housing counts with local and regional short-term forecasts.

Pre- and Postcensus Local Review

As we understand current plans for the Census Bureau's MAF, local review of housing unit counts should be easier for the 2000 census than in previous decades. The MPOs are concerned that the MAF should include commercial/employer addresses, to be used in conjunction with TIGER file updating.

STF1 and STF3

The demographic data from the Census are the backbone for population forecasting. Transportation forecasting by MPOs is integrated with population and employment forecasting, and we need to remember that the journey-to-work questions from the census are not the only important items.

Media

The group assumed that there would continue to be a reduction in standard printed reports from the Census Bureau. However, we believed that we could not predict what the best machine-readable medium would be. Whatever medium that allows for quick delivery of multiple copies is recommended. The data should be provided with user-friendly software developed by the Census Bureau. This public domain software should be for basic extraction and tabulation. "Glitzy" software should be left to private-sector vendors.

CENSUS COLLECTION ALTERNATIVES

Matrix Sampling

The concept, as we understand it, is that the decennial census would consist of a short form plus rotated parts of a long form to subset samples. The sample would be conducted every 10 years as part of the decennial census. "Medium-length" forms would be mailed to 75 percent of sample households, and 25 percent would receive a complete long form.

As we understand it, under matrix sampling, questions would be grouped into three categories: economic, social, and housing. To create the medium-length forms, three combinations would include two categories each, and one would have all three. Thus, 1 in 24 households would receive each of the four forms. For economic data alone, by combining three of the samples, we would end up with one in eight households. However, for economic and social data combined, the sample would be only 1:12.

This 1:12 sample would likely limit the flexibility of cross-tabulations needed from PUMS or CTPP. A smaller sample size would reduce the detail that could be reported for small geographic units and would increase variance. This is a problem for MPOs.

The group understands that the current political perception of this alternative is that it would reduce the burden on respondents and, therefore, might improve response rates and lower the overall costs of conducting the census. We did not have enough information to evaluate whether these perceptions are supportable.

We addressed potential questions that might be added to these medium-length forms under the "Content" area.

Continuous Measurements

There were both guarded optimism and skepticism about this alternative. It could be an advantage to have annual updates for data at large geographic levels (state, metropolitan areas, and large counties). This is a better approach to tracking trends than having data only once every 10 years. Some of the group believed that the 3- to 5-year rolling average for reporting small geography could be used, particularly if a new average were available each year. However, there are many concerns about its implementation:

- How can residential and business address file maintenance be ensured? How will workplace addresses be coded under this alternative?
- There is a potential loss of information for small governmental units.
- There will be less publicity—how will this affect response rates?
- If long form "as usual" is canceled—this is far preferable to matrix. At least one person prefers this to the existing long-form process—continuous is ideal for tracking trends.
- A commitment to continued funding is needed. There is a danger of being nibbled away over time to contain costs.
- A rolling average of more than a 5-year cycle for small area data may not be acceptable. Already in its short life, continuous measurement has gone from a 3-year to a 5-year rolling average.
- More results are needed from CB research, with full involvement and communication with the MPOs, states, and so forth. There is concern that the time frame for decision on funding of full continuous measurement would go before Congress in 1997 (for implementation in 1999), but the pilot test is currently scheduled for 1995 to 1996. What results and evaluation are going to be available for making this decision? Evaluation should include people outside the Census Bureau.

Transit and Traffic Applications

COCHAIRS: Darwin Stuart, Peter Stopher

The discussion was conducted generally in four parts:

1. Summary of current uses of the Census Transportation Planning Package (CTPP) by group members,
2. Recommended changes for the next decennial census if conducted in a fashion similar to 1980 and 1990,
3. Special concerns regarding use of a continuous measurement approach for the 2000 census, and
4. Suggestions for research to develop a better understanding of and to promote further improvements in the census effort.

A summary of each discussion follows.

CURRENT APPLICATIONS OF THE 1990 CTPP

Because of delays in release of the 1990 CTPP, group members generally had little experience in working with the data. Only 4 of the 15 group members had experience in applying the CTPP to planning issues.

Limited Application to Traffic Operations

On the basis of this limited experience and early understanding of the CTPP content and format specifications, questions were raised concerning the applicability of the CTPP to traffic operations analysis. Insufficient geographic detail, use of average measures of travel time, and infrequent (decennial) update were the principal reasons behind this. As a result, most of the discussion focused on transit applications of the CTPP.

Title VI of Civil Rights Act

One of the early uses cited for the CTPP with regard to transit was support for Title VI (Civil Rights Act) equity-of-service analysis. Zonal data in the CTPP relating level of service to racial and socioeconomic characteristics were identified as particularly useful.

Benchmark for Surveys and Enrichment of CTPP

The CTPP was recognized for its role as a "benchmark," or validation point, upon which to develop more detailed regional travel surveys. Beyond this, points of correspondence between CTPP tables and the results of more detailed surveys provide an opportunity to leverage and expand the usefulness of the CTPP. Examples include analyses to identify relationships between the detailed reporting of travel patterns from separate surveys and aggregate measures from the CTPP. For example, correlations between detailed survey parameters (such as access mode and time-of-day and day-of-week trip frequency) and the kind of aggregate statistics reported in the CTPP would be evaluated. This would be a means of synthesizing additional detail within CTPP for use in other study corridors for which detailed surveys do not exist.

Transit Market Identification

Demographic and travel data from the CTPP, both at the block level and grouped into analysis districts, provide a comprehensive information resource for transit operators—principally in prescreening analyses. The CTPP tabulations support more detailed ridership analyses at the route and corridor levels as well as in station areas. Again, whereas the CTPP is not a substitute for detailed ridership surveys or field counts, it offers significant benefit in identifying promising ridership markets at the corridor, activity center, or demographic subgroup level. CTPP-reported indicators of transit dependency, such as automobile ownership and household income, provide additional information on current and prospective user markets and can provide a basis for more focused and detailed investigation.

It was also noted that CTPP transit data can be validated with relative ease. The reliability of the CTPP data for use in transit market analysis can be determined by accumulating CTPP-reported zonal flows for comparison with ridership counts on transit lines within the corridor.

Prescreening Demand Management Strategies

To the extent that transportation zones or analysis districts in the CTPP may correspond generally to major activity centers, the CTPP may be used for first-level, sketch-plan identification of promising markets for demand and systems management strategies. Commuter profiles and worker flow data may be used to identify population and employment concentrations, with employment and demographic profiles appropriately suited to these strategies. This preliminary market identification would form the basis for detailed follow-up market research.

Recommended Changes to 2000 Census (In Its Current Form)

Background

As a preface to outlining future research needs, the group developed an extensive list of issues and questions related to the 1990 CTPP, with implications for future decennial census efforts. In these discussions it was assumed that future census efforts and journey-to-work products would be similar to those of 1980 and 1990.

Whereas the CTPP is useful for identifying commuter markets in general, it was clear to group members that there is no substitute for local surveys and data collection for transit and traffic analysis applications. As indicated previously, the CTPP was found to be extremely useful in setting a corridor context and preview of potential transit and demand management user markets, yet insufficient geographic and modal detail is provided on commuter and commuting profiles to support operational analysis.

Recommended Changes to Census/CTPP Content

The wording associated with selected topics and the design of some parts of the census questionnaire elicit responses that are not particularly suited to travel analysis and research. The content needs cited by group members include the following:

- Question restructuring is needed to request multiple work locations and modes for multiworker households.
- New questions are needed requesting information on multiple purposes of travel en route to work (trip chaining).
- Question restructuring is needed to request arrival time, instead of the total travel time as in 1990, as a means to correct for the "lumpy" nature of reported travel times.
- New questions are needed that include school trips and school location.
- Question restructuring is needed to allow reporting of locally used transit operator names.
- The disability-related questions should be modified to incorporate more detail on disability type, and the questions should be asked of the entire population.
- Questions are needed to enable the respondent to identify all access and egress modes, not just the primary one.
- The work-at-home option should be treated as a location rather than a mode, and telecommuting should be added as a separate travel mode.

The following revisions to the census and CTPP products were suggested:

- Tabulations are needed to establish the relationship between workplaces for individuals in multiworker households and the location of the household.
- Census processing needs to be improved to enhance workplace designation/coding accuracy and coverage within GIS, and there should be provisions for involvement of states and MPOs in the address coding process.
- Factoring methods should be developed to correct reported transit usage for the "differential undercount" inner-city areas in 1990. An increase in the sampling rates in inner-city areas should be considered in future decennial census efforts.
- CTPP tabulations can be streamlined by reducing the number of vehicle occupancy classes reported in tables.
- County-level geography provides insufficient geographic detail in external areas. Coding of these workplaces to finer geography is desirable in future census efforts.
- Preparation of future census journey-to-work (CTPP-like) products should consider development and early release of a small group of "core" tabulations, with more elaborate tabulations available as optional reports, perhaps through "point/click" interactive network interface.
- Trend data over two or three decades should be prepared by the Census Bureau and provided with the next CTPP release.
- The user friendliness of data products should be improved, particularly for local and regional transit and transportation planners.

Future Needs—Research Issues and Opportunities

- A review of the processes followed by states and MPOs in distributing the CTPP data within their communities is needed.

- Research is needed to identify confidentiality issues associated with the census and the possibility of making block-level data available for users to regroup into analysis districts, new zones, and so forth, as needed, to support transit line and station area studies.
- An assessment of CTPP users is needed to identify tabulations most (and least) frequently used.
- An evaluation of the feasibility of privatizing the survey/data tabulation effort, leaving the congressionally mandated "count" to the Bureau of the Census, is needed.
- Research efforts are needed to assess the utility of the CTPP in supporting a variety of policy initiatives, such as (*a*) providing a basic standardized measure of community access and mobility as a means of identifying and quantifying the benefits of transit and (*b*) providing advice in ways of using the CTPP to assess the potential for market-based transportation strategies such as congestion pricing, parking pricing, and so forth.
- A study is needed to assess the complementarity of various federal and regional travel and demographic surveys in relation to census products, with an eye to opportunities for data integration.

Future Needs—Implications for Continuous Survey Census

Group members were unanimous in recommending a comprehensive study of the implications of continuous measurement for data quality and analytical robustness, as well as cost to users. Particular attention should be paid to the following:

- The impact of a 5-year moving average on trend analyses;
- The potential for receiving annual last-year "snapshot" as well as annual updates to the moving average;
- The implications of the moving average or annual "refreshment" on availability of public use file, data confidentiality, and so forth; and
- Potential for incorporation of longitudinal (panel) surveys within the sample frame.

APPENDIX A

Highlights from 1994 Transportation Research Board Annual Meeting Sessions on 1990 Census

Christopher R. Fleet, *Federal Highway Administration*

The following is a summary of the major discussion topics from CTPP—Products and Applications (Session 190A) and Data Needs—A Look to the Future (Session 190B) of the 1994 Annual Meeting of the Transportation Research Board (TRB). It was prepared as a presentation to the National Conference on Decennial Census Data for Transportation Planning, Irvine, California, for the following purposes:

1. To lend consistency and continuity between the TRB sessions and the conference,
2. To provide a broader base of support for consensus recommendations for the 2000 census when considered in conjunction with the conference, and
3. To provide an opportunity to document input from presentations made by participants at the TRB sessions.

The comments that follow are posed more as questions or discussion points than conclusions. The points raised at the TRB sessions are, however, similar and add support to the recommendations contained in this proceedings.

It was difficult to condense 3½ hr of presentations and discussion into a short overview and, thus, the material from the TRB sessions has been filtered to arrive at the most critical points in the view of the author. It also includes some of the author's interpretations and observations.

Themes

There were four major themes throughout the two sessions. The following list is in no particular order of priority, nor is there any attempt to follow the order of the TRB agenda. The themes were as follows:

1. Application: problems and solutions,
2. Local perspective and implications for the user,
3. A view from the other side, and
4. Adapting to change.

Application: Problems and Solutions

Both positive and not so positive aspects to application were apparent from the discussion. On the negative side, for example, it was clear that few, if any, applications of the statewide Parts A, B, and C had been accomplished by the time of the TRB sessions. The statewide package had been out since April/May (8 months at TRB time). Also 37 sessions of the Census Transportation Planning Package (CTPP) training course had been presented by the Federal Highway Administration to more than 1,200 users across the nation since early 1991. Yet, no one in the audience or that we could find (except for Ron Tweedie and Chuck Purvis) had used the package. Why was this? Several reasons were voiced, among them the following:

- The package is too hard to use in the media distributed by the Census Bureau (nine-track tape),
- The CTPP for state use is new, and
- States assumed that the package was purchased for metropolitan planning organizations (MPOs) and did not want to process it.

Although not explicitly raised at the TRB sessions, these reasons pose a critical question: Is the wrong message (of apparent noninterest) being sent to the Bureau of the Census and the Office of Management and Budget?

The problem with distribution of CTPP on nine-track tapes was discussed with an implied question: How to do better next time? The CD-ROMs developed by the Bureau of Transportation Statistics had just become available. To some users, nine-track tape is an old medium; desk-top computers are easier to use and there is no "corporate knowledge" of mainframes available on state or MPO staffs. To other users it is easier to work with the extremely large files of the CTPP (MTC's Part 3 is 260 MB). This assumes that states or MPOs have programmers or someone with knowledge of SPSS or SAS on staff.

On the more positive side, a recent survey conducted by George Wickstrom indicated state use (or planned use) of the 1990 CTPP to be double that of the 1980 Urban Transportation Planning Package.

Local Perspective and Implications for the User

Despite the value of the census, it was recognized that it provides only part of the data needed for transportation planning, particularly for model updates. Supplemental surveys are needed, such as automobile use surveys or home interview, truck, and taxi surveys, to obtain a complete picture of travel in the region. In the broadest context, states and MPOs need to know what data they have and what data they need. They may have to perform a complete inventory of data sources, availability, and their relevance to transportation planning. George Wickstrom reported on such an inventory done for the Metropolitan Washington Council of Governments.

There is continual need for MPO and state involvement in and support for the census program. For example, the census block-traffic zone equivalency development program required close coordination between the future CTPP data users and the Census Bureau. More of this close cooperation is needed. The question was raised, however: Will the Census Bureau continue this close association? The possibility that the Census Bureau will abandon its "grass roots" association with the users was of real concern to the audience.

Concern was expressed about the methodological reform for the 2000 census and what this will mean for transportation planning. States and MPOs need to be heard before decisions are made about census methods and content.

A need was expressed for "heads up" alerts to the states and MPOs when relevant topics are about to appear in the *Federal Register* or other media where the content will affect the users or users are being asked to supply input (e.g., census proposals).

In the general transportation data context, data users and suppliers need to develop and maintain good coordination. In particular, attitudes against data sharing need to loosen up.

There are many data sources at local governments and agencies, and these need to be tapped. This carries with it, however, the need to establish compatibility among local and regional data formats and content.

Coordination is needed between the states, their MPOs, and local governments and others in making data available. For example, Chuck Purvis reported on an aggressive outreach program that MTC has for disseminating census products.

View from the Other Side

Susan Miscura provided the Census Bureau perspective and a preview of plans for the 2000 census. The Census Bureau has an interest in accuracy but a mandate to hold costs down. The 1990 census cost $2.6 billion. The cost of the same type of census for 2000 is estimated at $4 billion or more. Twenty percent of the cost of the 1990 census was attributable to collecting and tabulating data beyond that needed for apportionment and redistricting. This has implications for the content and methodology that the Census Bureau may use in the 2000 census.

A critical concern of the Census Bureau is how to improve the accuracy of the census count. The Census Bureau will be focusing on methodology, sampling, and statistical estimation to improve accuracy. The 1995 test will focus on methodology; choice of questions (content) will be considered later.

Several questions at the TRB session concerned how real the methodological change is. One, for example, asked: "Is the Census Bureau budget sufficient to test alternative designs?" This year the Census Bureau reallocated resources. It is unclear for future years.

One comment from the user community placed the cost burden in perspective. If there is no journey-to-work question in the 2000 census, the cost of obtaining this information will be shifted

- To other federal agencies if federally supported,
- To other levels of government (states/MPOs) if pooled funded, or
- To other programs (SPR funds) for home interview surveys or NPTS add-ons.

Alternatively, the cost could be deferred to later years or not collected at all. So there may not be a net savings, but there likely will be a net increase in cost.

Adapting to Change and External Forces

One of the most far-reaching provisions of the Intermodal Surface Transportation Efficiency Act and the Clean Air Act Amendments of 1990 is the requirement of conformity between transportation plans and programs and the state implementation plan for attaining air quality standards. Air quality conformity is a driving force behind the need for good travel data and models.

Do census data have a role in transportation planning for air quality analysis? Do external forces and institutions have a stake in the census? If so, do they know it? For example, does the Environmental Protection Agency realize that, at least indirectly, it should have an interest in the success of the census as a key data source for transportation planning—and, thus, air quality planning?

Consideration is being given by the Census Bureau to alternative methods of collecting data: matrix sampling and continuous measurement. This will affect the methods used by states and MPOs for applications of the census data.

Questions for the 2000 census have been categorized into four groups: (*a*) required by law from a decennial census, (*b*) required by other agencies from the decennial census but can come from a sample, (*c*) estimates required by other agency statutes that the Census Bureau has determined would best be filled by a sample of the decennial census questionnaires, and (*d*) questions asked in 1990 for which there is no federal legislation to require their collection. The journey-to-work and place-of-work questions are currently in the third category. What are the chances that this category, or parts of this category, will not be included in the next census?

Conclusion

The Census Bureau is going about "designing a different census." Change will undoubtedly come—the question now is how can the states and MPOs react and plan for it.

- What will the 2000 census include for transportation planning?
- What method will be used to collect it?
- Will the data be comparable with data from past decennial censuses?
- What is the best way for states and MPOs to adapt to the new methodology?

These are the questions raised or implied at the TRB Annual Meeting sessions on the 1990 census and the questions that participants at this national conference had to address.

APPENDIX B

Census Transportation Planning Package

The 1990 Census Transportation Planning Package (CTPP) is a set of special tabulations oriented toward transportation planning but also useful for other professionals engaged in urban and rural planning and analysis. It is based on the place-of-work data collected in the 1990 census and is produced by the Bureau of the Census on a cost-reimbursable basis. The 1990 CTPP is a continuation of the transportation planning program that began after the 1970 census. The 1980 Urban Transportation Planning Package (UTPP) was usually purchased by individual metropolitan planning organizations (MPOs) contracting with the Bureau of the Census. In contrast, the 1990 CTPP is being funded by the states through the American Association of State Highway and Transportation Officials (AASHTO). The states all committed funds to AASHTO for this project, making the package truly national in scope for the first time.

The 1990 program is sponsored by AASHTO, the National Association of Regional Councils, the Federal Highway Administration, the Federal Transit Administration, and the Bureau of the Census.

A working group was established to develop the specifications for the CTPP for both a metropolitan data set and a statewide data set. This ad hoc group included members from the sponsoring agencies and experts in the field from states and MPOs.

Two types of products will be produced in the 1990 CTPP: a set of statewide tabulations and a set of urban tabulations. The statewide tabulations provide data for persons who live *or* work in the state. Data are tabulated for the state, each county, county subdivision (only available for nine states for workplace data), and place of 2,500 or more persons. Totals for state parts of MSAs, CMSAs, and PMSAs will also be provided, as will urbanized area totals (place of residence only). The statewide tabulations will consist of six parts:

- Part A, tabulations by place of residence;
- Part B, tabulations by place of work;
- Part C, tabulations of place of residence by place of work;
- Part D, tabulations by place of residence for areas of 75,000 or more persons;
- Part E, tabulations by place of work for areas of 75,000 or more persons; and
- Part F, tabulations of place of residence by place of work for areas of 75,000 or more persons.

Urban tabulations will be produced for the MPO in each area where the Census TIGER/Line files contain address ranges. This generally includes all urbanized areas except some of those most recently defined. Data will be tabulated for either standard census geography, such as census tracts or block groups, or for locally defined, custom geographic areas, such as traffic analysis zones. Subtotals for study area, CTPP region, MSA, CMSA, PMSA, and urbanized area (place of residence data only) will also be provided. The urban tabulations will consist of seven parts:

- Part 1, tabulations by small area of residence;
- Part 2, tabulations by small area of work;
- Part 3, tabulations of small area of residence by small area of work;
- Part 4, tabulations by large area of residence;
- Part 6, tabulations of superdistrict of residence by superdistrict of work for regions with 1 million or more persons;
- Part 7, tabulations by census tract of work; and
- Part 8, tabulations of small area of residence by small area of work for regions with 1 million or more persons.

(There is no Part 5 in the urban element in the 1990 CTPP.)

A set of subject locators for the 1990 CTPP, detailing the content of both the statewide and the urban products, follows.

1990 CENSUS TRANSPORTATION PLANNING PACKAGE

SUBJECT LOCATOR

PART A -- TABULATIONS OF RESIDENCE AREA DATA FOR STATES, COUNTIES, MCDs, AND PLACES OF 2,500 OR MORE; STATE PORTIONS OF MSAs/CMSAs, PMSAs, AND URBANIZED AREAS

1990 CENSUS TRANSPORTATION PLANNING PACKAGE

SUBJECT LOCATOR

PART B -- TABULATIONS OF WORKPLACE AREA DATA FOR STATES, COUNTIES, MCDs, AND PLACES OF 2,500 OR MORE; STATE PORTIONS OF MSAs/CMSAs, AND PMSAs

1990 CENSUS TRANSPORTATION PLANNING PACKAGE

SUBJECT LOCATOR

PART C -- TABULATIONS OF AREA OF RESIDENCE BY AREA OF WORK FOR STATES, COUNTIES, MCDs, AND PLACES OF 2,500 OR MORE

1990 CENSUS TRANSPORTATION PLANNING PACKAGE

SUBJECT LOCATOR

PART D -- TABULATIONS OF RESIDENCE AREA DATA FOR STATES, COUNTIES, MCDs AND PLACES OF 75,000 OR MORE POPULATION

ITEM	TABLE NUMBER
Industry:	
All workers	D-19
By means of transportation to work	D-19
By occupation	D-19
Labor Force--See Employment Status	
Means of Transportation to Work:	
All workers	D-6,D-7,D-13, D-16,D-19,D-20
By age	D-6,D-13
By class of worker	D-20
By earnings of workers	D-7,D-13, D-16,D-20
Median earnings	D-8,D-14, D-17,D-21
Mean earnings	D-9,D-15, D-18,D-22
By Hispanic origin	D-6,D-7
By industry	D-19
By number of hours worked last week	D-16
By occupation	D-19
By race	D-6,D-7
By sex	D-6,D-13,D-16
Workers in households	D-27,D-28,D-31
By household income	D-28,D-31
Median household income	D-29,D-32
Mean household income	D-30,D-33
By number of persons in household	D-31
By number of workers in household	D-27,D-28
By sex	D-27
By vehicles available	D-27,D-28,D-31
Workers who did not work at home	D-23,D-34,D-35
By number of hours worked last week	D-23
By time leaving home to go to work	D-23,D-34,D-35
By travel time to work	D-34
Median travel time	D-36
Mean travel time	D-37
Mobile Homes--See Units in Structure	

ITEM	TABLE NUMBER
Workers (continued):	
By occupation	D-10,D-19
By race	D-6,D-7
By sex	D-6,D-10, D-13,D-16
In households	D-24,D-27, D-28,D-31
By Hispanic origin	D-24
By household income	D-24,D-28,D-31
Median household income	D-25,D-29,D-32
Mean household income	D-26,D-30,D-33
By means of transportation to work	D-24,D-27, D-28,D-31
By number of persons in household	D-31
By number of workers in household	D-27,D-28
By race	D-24
By sex	D-27
By vehicles available	D-24,D-27, D-28,D-31
Who did not work at home	D-23,D-34,D-35
By means of transportation to work	D-23,D-34,D-35
By number of hours worked last week	D-23
By time leaving home to go to work	D-23,D-34,D-35
By travel time to work	D-34
Median travel time	D-36
Mean travel time	D-37
With earnings	D-7,D-10,D-13, D-16,D-20
Median earnings	D-8,D-11,D-14, D-17,D-21
Mean earnings	D-9,D-12,D-15, D-18,D-22

1990 CENSUS TRANSPORTATION PLANNING PACKAGE

SUBJECT LOCATOR

PART E -- TABULATIONS OF WORKPLACE AREA DATA FOR STATES, COUNTIES, MCD'S AND PLACES OF 75,000 OR MORE POPULATION

ITEM **TABLE NUMBER**

ITEM	TABLE NUMBER
Vehicles Available:	
For workers in households	E-15
By household income in 1989	E-15
Median household income	E-16
Mean household income	E-17
By means of transportation	E-15
Worked At Home--See Means of Transportation to Work	
Workers:	
Total	E-1,E-2,E-5, E-8,E-11,E-12
By age	E-1
By class of worker	E-12
By earnings of workers	E-2,E-5,E-8, E-11,E-12
By Hispanic origin	E-1,E-2
By industry	E-11
By means of transportation to work	E-1,E-2,E-8, E-11,E-12
By number of hours worked last week	E-8
By occupation	E-5,E-11
By race	E-1,E-2
By sex	E-1,E-5,E-8
In households	E-15
By household income	E-15
Median household income	E-16
Mean household income	E-17
By means of transportation to work	E-15
By vehicles available	E-15
Not working at home	E-18
By time of arrival at work	E-18
By travel time to work	E-18
Median travel time	E-20
Mean travel time	E-21
By means of transportation	E-18
With earnings	E-2,E-5,E-8, E-12
Median earnings	E-3,E-6,E-9, E-13
Mean earnings	E-4,E-7,E-10, E-14

1990 CENSUS TRANSPORTATION PLANNING PACKAGE

SUBJECT LOCATOR

PART F -- TABULATIONS OF AREA OF RESIDENCE BY AREA OF WORK FOR STATES, COUNTIES, MCD'S AND PLACES OF 75,000 OR MORE POPULATION

ITEM	TABLE NUMBER
Average Vehicle Occupancy--See Workers Per Vehicle	
Carpool--See Means of Transportation to Work	
Carpool Occupancy--See Workers Per Carpool	
Departure Time--See Time Leaving Home to Go to Work	
Means of Transportation to Work:	
Workers who did not work at home	F-1, F-2
By time leaving home to go to work	F-1, F-2
Mean travel time	F-4
Median travel time	F-3
By travel time to work	F-2
Mean travel time	F-4
Median travel time	F-3
Public Transportation--See Means of Transportation to Work	
Time Leaving Home to Go to Work:	
Workers not working at home	F-1, F-2
By means of transportation to work	F-1, F-2
Mean travel time	F-4
Median travel time	F-3
By travel time to work	F-2
Mean travel time	F-4
Median travel time	F-3

1990 CENSUS TRANSPORTATION PLANNING PACKAGE

SUBJECT LOCATOR

PART 1 -- TABULATIONS OF RESIDENCE AREA DATA FOR CTPP REGIONS, MSAs/CMSAs, PMSAs, URBANIZED AREAS, STUDY AREAS, CBDs, AND TRAFFIC ANALYSIS ZONES OR CENSUS TRACTS OR BLOCK GROUPS

ITEM	TABLE NUMBER
Mobility Limitation Status:	
Persons 16 years and over	1-9, 1-10
By age	1-9
By employment status	1-10
Workers 16 years and over	1-44
By means of transportation to work	1-44
Not at work--See Employment Status	
Not in Labor Force--See Employment Status	
Number of Hours Worked Last Week:	
By means of transportation to work	1-32
By sex.	1-28
Number of Persons 16 Years and Over in Household:	
By vehicles available	1-19
Number of Workers in Household:	
All households	1-13, 1-14, 1-18
By household income	1-14
Median household income	1-15
Mean household income	1-16
By household size	1-13
By vehicles available	1-18
Occupancy status, housing units	1-62
By units in structure	1-62
Occupation:	
Workers 16 years and over	1-25
By sex	1-25
Part-time--See Number of Hours Worked Last Week	
Persons:	
Total	1-1, 1-5, 1-6
By age	1-6
By Hispanic origin	1-5
By race	1-5
By sex	1-6

1990 CENSUS TRANSPORTATION PLANNING PACKAGE

SUBJECT LOCATOR

PART 2 -- TABULATIONS OF WORKPLACE AREA DATA FOR CTPP REGIONS, MSAs/CMSAs, PMSAs, STUDY AREAS, CBDs, AND TRAFFIC ANALYSIS ZONES OR CENSUS TRACTS OR BLOCK GROUPS

ITEM	TABLE NUMBER
Hispanic Origin:	
Workers 16 years and over	2-1
By means of transportation to work	2-1
By race	2-1
Industry:	
Workers 16 yearas and over	2-3
By sex	2-3
Means of Transportation to Work:	
Workers 16 years and over	2-1, 2-6, 2-7, 2-9, 2-10
By earnings of workers	2-10
Median earnings	2-11
Mean earnings	2-12
By Hispanic origin	2-1
By number of hours worked	2-9
By race	2-1
By sex	2-6
Workers in households	2-17
By vehicles available	2-17
Workers not working at home	2-18, 2-19
By time of arrival at work	2-18
By median travel time	2-25
By mean travel time	2-26
By standard deviation of travel time	2-27
By travel time to work	2-19
Median travel time	2-20, 2-22, 2-25
Mean travel time	2-21, 2-23, 2-26
Standard deviation of travel time	2-24, 2-27
Number of Hours Worked Last Week:	
Workers 16 years and over	2-5, 2-9
By means of transportation to work	2-9
By sex	2-5
Occupation:	
Workers 16 years and over	2-2
By sex	2-2

Part-time--See Number of Hours Worked Last Week

Public Transportation--See Means of Transportation to Work

1990 CENSUS TRANSPORTATION PLANNING PACKAGE

SUBJECT LOCATOR

PART 3 -- TABULATIONS OF AREA OF RESIDENCE BY AREA OF WORK FOR CTPP REGIONS, MSAs/CMSAs, PMSAs, STUDY AREAS, CBDs, AND TRAFFIC ANALYSIS ZONES OR CENSUS TRACTS OR BLOCK GROUPS

1990 CENSUS TRANSPORTATION PLANNING PACKAGE

SUBJECT LOCATOR

PART 4 -- TABULATIONS OF RESIDENCE AREA DATA FOR CTPP REGIONS, MSAs/CMSAs, PMSAs, URBANIZED AREAS, AND STUDY AREAS

ITEM	TABLE NUMBER
Units in Structure:	
All households	4-1
By household income in 1989	4-1
Median household income in 1989	4-2
Mean household income in 1989	4-3
By household size	4-1
By vehicles available	4-1
Vehicles Available:	
All households	4-1
By household income in 1989	4-1
Median household income in 1989	4-2
Mean household income in 1989	4-3
By household size	4-1
By units in structure	4-1

1990 CENSUS TRANSPORTATION PLANNING PACKAGE

SUBJECT LOCATOR

PART 6 -- TABULATIONS OF AREA OF RESIDENCE BY AREA OF WORK IN CTPP REGIONS OF OVER ONE MILLION PERSONS FOR CTPP REGIONS, MSAs/CMSAs, PMSAs, STUDY AREAS, AND SUPER DISTRICTS

1990 CENSUS TRANSPORTATION PLANNING PACKAGE

SUBJECT LOCATOR

PART 7 -- TABULATIONS OF WORKPLACE AREA DATA FOR STATES, COUNTIES, MCDs, PLACES OF 2,500 OR MORE, AND CENSUS TRACTS; STATE PORTIONS OF MSAs/CMSAs, AND PMSAs

ITEM	TABLE NUMBER
Age:	
Workers 16 years and over	7-10
By sex	7-10
Armed Forces--See Industry or Occupation	
Automobiles Available--See Vehicles Available	
Arrival Time--See Time of Arrival at Work	
Armed Forces--See Industry or Occupation	
Average Vehicle Occupancy--See Workers Per Vehicle	
Carpool--See Means of Transportation to Work	
Carpool Occupancy--See Workers Per Carpool	
Class of Worker:	
Workers 16 years and over	7-3,7-11
By Hispanic origin	7-3
By race	7-3
By sex	7-11

ITEM	TABLE NUMBER
Earnings of Workers:	
Workers 16 years and over	7-4,7-13,7-17
By Hispanic origin	7-4
Mean earnings	7-6
Median earnings	7-5
By means of transportation to work	7-17
Mean earnings	7-19
Median earnings	7-18
By race	7-4
Mean earnings	7-6
Median earnings	7-5
By sex	7-13
Mean earnings	7-15
Median earnings	7-14
Full-time--See Number of Hours Worked Last Week	
Government Workers--See Class of Worker	
Hispanic Origin:	
Workers 16 years and over	7-1,7-2,7-3 7-4,7-7
By class of worker	7-3
By earnings of workers	7-4
Mean earnings	7-6
Median earnings	7-5
By industry	7-2
By means of transportation to work	7-7
By occupation	7-1
By race	7-1,7-2,7-3 7-4,7-7
Household Income in 1989:	
Workers 16 years and over in households	7-21
By number of workers in household	7-21
Mean household income in 1989	7-23
Median household income in 1989	7-22
Industry:	
Workers 16 years and over	7-2,7-9
By Hispanic origin	7-2
By race	7-2
By sex	7-9

1990 CENSUS TRANSPORTATION PLANNING PACKAGE

SUBJECT LOCATOR

PART 8 -- TABULATIONS OF AREA OF RESIDENCE BY AREA OF WORK FOR CTPP REGIONS OF OVER ONE MILLION PERSONS, THEIR STUDY AREAS, CBDs, AND TRAFFIC ANALYSIS ZONES OR CENSUS TRACTS OR BLOCK GROUPS

Glossary

AASHTO: American Association of State Highway and Transportation Officials.

BTS: Bureau of Transportation Statistics, U.S. Department of Transportation.

Continuous measurement: Census alternative being explored. Under a continuous measurement design, the decennial census conducted in 2000 would collect only the basic short-form data on a 100 percent basis. The long-form sample characteristics—place of work and the other journey-to-work items, the number of vehicles available to each household, persons with mobility-related disabilities, and the whole range of social, economic, and housing data collected on the long form—would not be collected. Instead, the long form would be replaced by an Intercensal Long-Form Survey. The Intercensal Long-Form Survey would comprise a monthly 250,000-household sample that would be cumulated to produce rolling averages over some period of time. For the smallest areas (the level of sample data used to produce data for census tracts or to aggregate in traffic analysis zones), the estimates would be 5-year moving averages. For medium-size areas (probably states, metropolitan areas, large urbanized areas, and large cities) annual average estimates would be produced. National estimates could be monthly or quarterly.

CTPP: Census Transportation Planning Package.

GIS: Geographic information systems.

ISTEA: Intermodal Surface Transportation Efficiency Act of 1991.

JTW: Journey to work.

MAF: Master Address File.

Matrix sampling: Census alternative being explored. The decennial census would consist of a short form and rotated parts of a long form to subset samples. Sample would be considered every 10 years as part of the decennial census.

MPO: Metropolitan planning organization.

NARC: National Association of Regional Councils.

NPTS: Nationwide Personal Transportation Study.

PL 94–171 (Public Law 94–171): Geographic areas covered and subject content.

PUMS: Public Use Microdata Sample.

STF 1–4 (Summary Tapes 1–4): Each STF contains a particular set of data for specific types of geographic areas.

TAZ: Traffic analysis zone.

TIGER: U.S. Bureau of the Census's Topologically Integrated Geographic Encoding and Referencing. TIGER provides a digital (computer readable) geographic data base for the location and referencing of mailing addresses for small geographic areas for the nation.

TIP: Transportation Improvement Program.

UTPP: Urban Transportation Planning Package.

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