APPLICATIONS AND USES OF THE CENSUS URBAN TRANSPORTATION PLANNING PACKAGE

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Urban transportation planning studies must have data. In the past emphasis was placed on obtaining detailed data on travel and socioeconomic conditions at one point in time, but today emphasis has turned toward obtaining travel and transportation-related data that are more timely and less costly and time consuming to collect and that can be incorporated into the planning process on a continuing basis.

The 1970-census Urban Transportation Planning Package (UTPP) represents a minimum common data set intended to be useful to urban transportation planning studies for continuing planning purposes. The package provides a useful supplemental base data source to aid studies in routine review of changing socioeconomic and travel conditions. It also provides a source of data that can be incorporated into the maintenance and updating of an urban transportation plan and program. This paper discusses 2 main issues: (a) how and where the UTPP can be applied in the continuing urban transportation planning process and (b) how the data can be used for transportation model development.

APPLICATION IN THE CONTINUING PLANNING PROCESS

The maintenance of both long-range and short-range transportation plans is critical for continuing urban transportation planning and for providing a timely basis for up-to-date capital improvement programs. Urban form and activity are undergoing continual change (quite often change that was not expected several years ago), and the maintenance of transportation plans must include a periodic review and evaluation to determine the effect of these unanticipated changes. If the effect is significant, then an updating of the existing future plan may be called for.

Because a wide range in the magnitude of urban change can occur, we can reasonably expect that such change, manifested in alterations of future travel demand estimates, will also require that a wide range of reviews be made of the existing long-range and short-range transportation plans.

Because land use activity and travel may also change quite rapidly, a cyclic time frame has been developed for the periodic review of existing plans. Levels of review (or reappraisal) have been characterized as routine review, major review, and complete plan reevaluation (1). This continual reappraisal activity is shown in Figure 1 by the various routes that lead to decisions about the necessary level of reappraisal effort. The cross-hatching indicates the steps in which the UTPP might be applied.

Routine review is a continual appraisal of the effects of changes in the location and magnitude of growth relative to that forecast. Its application is keyed to the existence of upcoming projects in the plan implementation stream. If a project is imminent, then early decisions must be made concerning the significance of possible differences in travel stemming from growth changes in the corridor in which the project is to be constructed. Depending on the degree of significance, the project may be processed normally, the project may need revision, or other affected projects may need to be revised. This process is shown in Figure 2.

The application of census socioeconomic data might supply valuable input to the evaluation of the effects of growth changes on travel demand in proposed project corridors. For example, the socioeconomic information contained in Parts I and III (residence zone tabulations and zone of work tabulations respectively) could provide a benchmark against which growth and development could be measured since the initial transportation study surveys were made. The first step shown in Figure 2 indicates this application.

The conversion of current socioeconomic data to trip ends (second cross-hatched box) could draw heavily on the contents of the package. Where there are growth differences, the census data could be input to trip generation relations to obtain updated trip ends. At this stage, simple trip generation rates, possibly drawn from other studies or based on the base-year origin-destination data rather than on traditional zonal regression equations would be more useful and more easily applied.

An ongoing surveillance program should also supply the data necessary for assessing the impact of growth changes on changes in travel demand. The census socioeconomic data could be used as a yardstick to evaluate the effectiveness of the surveillance program. An updating of selected census items from 1970 to the current year would probably be necessary, however.

For those studies just starting a surveillance program, the UTPP offers a good base. This is particularly true for most studies because it will have been 5 or 6 years since any substantial form of transportation and socioeconomic data were obtained in the study area. This is perhaps one of the major uses of the special package data.

If the current trip ends obtained in the routine review (second cross-hatched box, Fig. 2) indicate that trip-making is not growing as originally expected, a more extensive investigation is warranted. Here, output of the surveillance program or the census data or both in the corridor of interest are used as input to a revision of the land use forecast and will result in a more complete determination of changes in travel demand to include trip generation, trip distribution, and assignment of traffic to the future transportation system. Here, the interest lies in whether the growth changes will result in significantly different future design volumes and, if so, the geographic extent of the differences (i.e., in the corridor of interest or more widespread).

Depending on how different geographic extent and magnitude of changes in growth are from those anticipated, a more intensive assessment of the consequences may be necessary. If growth changes are significant, then either a major review or a complete plan reevaluation, including a full-scale application of the forecasting models, may be required.

There are 2 phases to a major review: (a) an evaluation of the forecasting procedures and (b) a reevaluation of the future transportation plan. In the first phase (Fig. 3) the technical adequacy of the forecasting procedures must be ascertained.

In the major review process (Fig. 3), data from the UTPP can be applied

1. As a basis for using current socioeconomic data to generate current trips with existing models;
2. In the development of new trip generation models (more discussion follows);

Figure 1. Reappraisal activity.

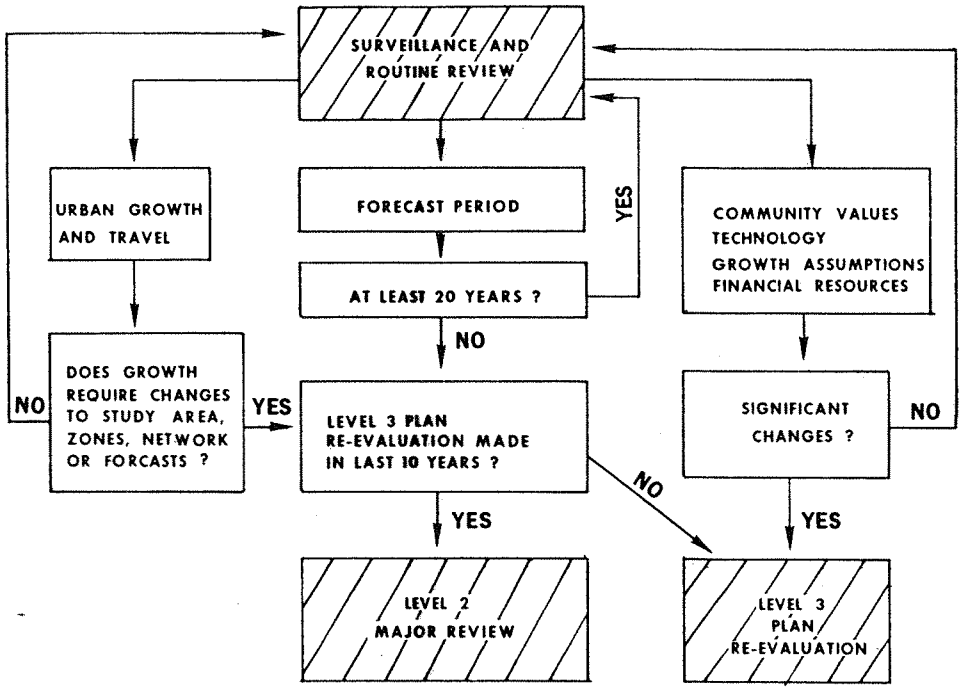
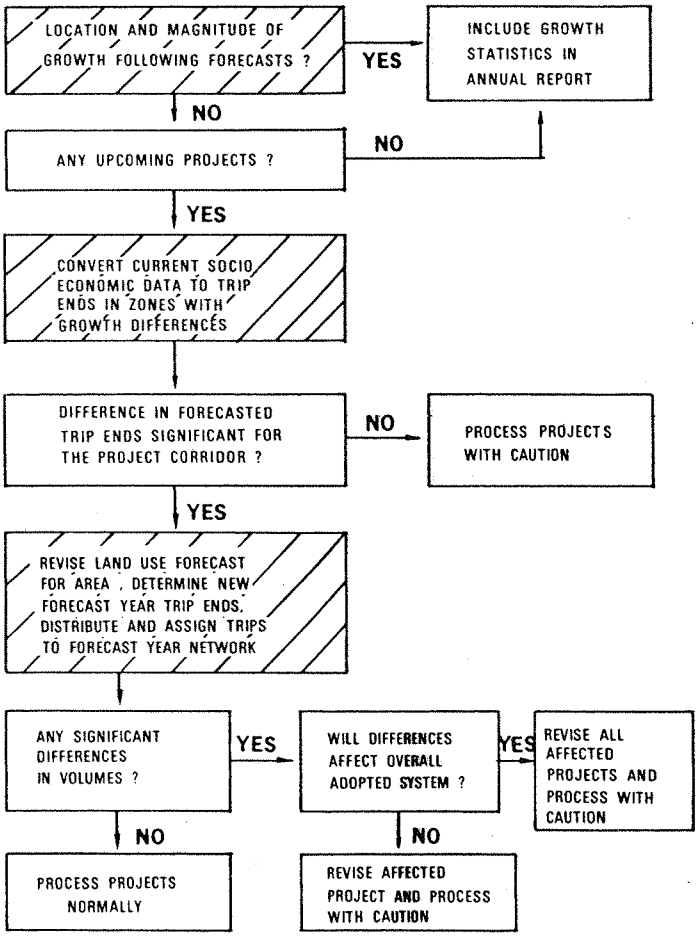


Figure 2. Routine review.



3. In the refinement of old trip generation models;
4. As a benchmark against which new updated long-range and short-range land use and socioeconomic data may be checked; and
5. As a secondary source (information from the journey-to-work question) to check trip-length frequency distribution, trip ends, and work-trip tables.

In applications 2 or 3, thought might be given to developing new trip generation relations from previous origin-destination data and census information, such as that shown in Figure 4. The foundation for the approach is the premise that there is a basic relation between household income, automobile ownership, and number of trips made by the household. Household size might also be incorporated in the relations. The independent variables are available from the UTPP, and the models can easily be applied in the current year.

Although trip generation relations can be developed without automobile ownership, this variable is a basic ingredient in the trip generation process, primarily because of the built-in sensitivity of the approach to automobile ownership saturation levels. Plots of household income-automobile ownership distributions show a characteristic shape and marked similarities in the urban areas shown in Figure 5.

Given an estimated income level by zone and the total dwellings in that zone, the relation (Fig. 5) can be applied to determine the number of households by automobile ownership category. If the number of households owning 0, 1, 2, or more automobiles is known, the total trips generated in the zone can be derived from relations similar to those shown in Figure 4. Total trips per zone by each income class can then be stratified by purpose by using a relation similar to that shown in Figure 6. Such an approach to trip generation using cross-classification analysis has considerable merit in that it is simple to use, is conceptually easy to see, and employs easily obtainable data.

The estimation of long-range and short-range land use and socioeconomic activity is difficult at best. Comparisons, therefore, between the existing conditions during the base year and the activity in 1970 available from the census (possibly updated to a current year) can provide the forecaster with a broader base of knowledge for updated forecasts. This application is shown in the bottom cross-hatched box in Figure 3. For example, analysts making new 1995 forecasts have the benefit of comparisons between original estimates for 1970 and what actually happened between the base year and 1970. Overly optimistic forecasts back in the mid-60s are evident in many studies now that socioeconomic data are available from the 1970 census.

In summary to the first point of this paper, the data in the UTPP may be used for any of several purposes in an ongoing urban transportation planning process. Many of these applications are essential to surveillance and reappraisal elements.

MODEL DEVELOPMENT

Transportation studies have traditionally forecast travel demand in terms of total average daily travel. In most studies, existing models and forecasting techniques are based on the daily trip definition. Consideration has been given to the application of peak-hour models both because peak-hour volumes are ultimately needed for design purposes and, more recently, because census journey-to-work information is available. Because the census work trip constitutes only one trip purpose, some scheme must be developed to convert the census work trips to either total daily trips or peak-hour trips.

If the decision is made to use the census journey-to-work data, less error will be introduced in converting from census work trips to peak-hour trips than to total daily trips simply because work trips constitute such a large percentage of peak-hour trips (70 to 80 percent) (2). It has, however, been demonstrated that 92 percent of the variation (i.e., $R^2 = 0.92$) in total daily trip volumes (origin-destination trips assigned to a network) can be explained through statistical analysis by daily work-trip link volumes (3). There has also been considerable research into peak-hour factors by type of facility, area of city, and orientation of facility (4).

The several suggested methods of using the census data for travel model development

Figure 3. Major review.

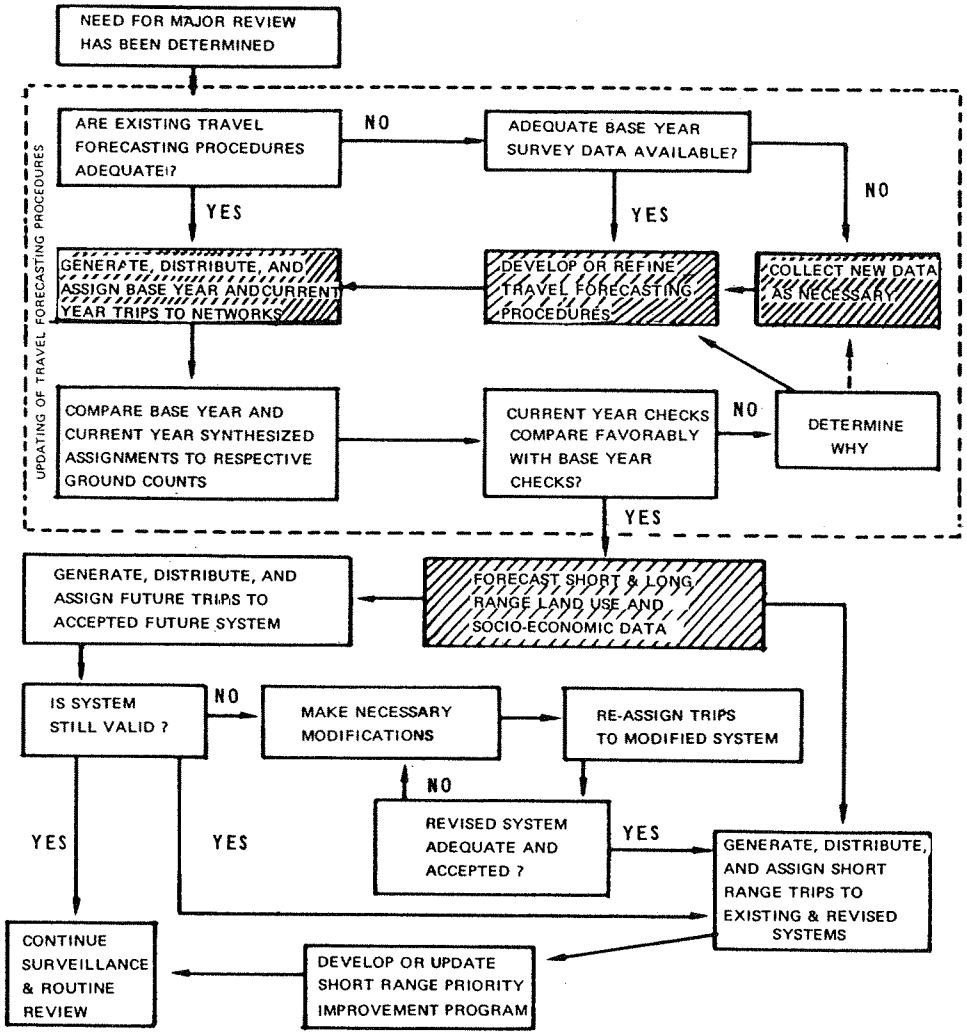


Figure 4. Income, automobile ownership, and trips.

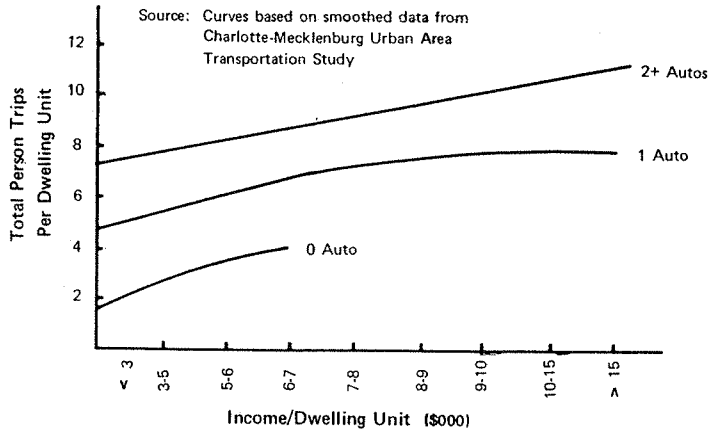


Figure 5. Income, automobile ownership, and households.

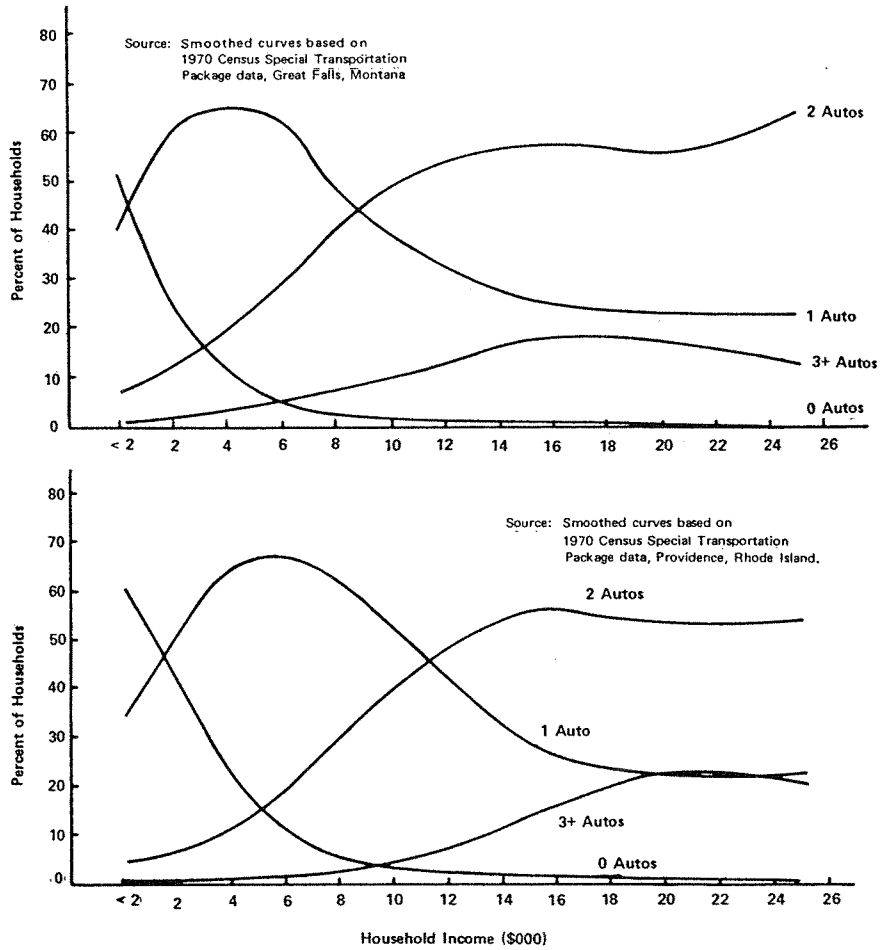
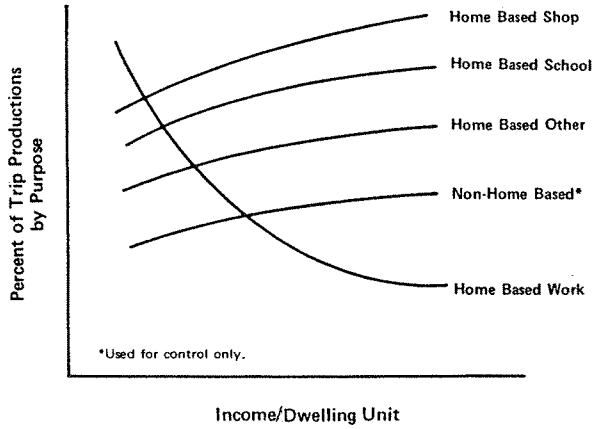


Figure 6. Income per dwelling unit and trips.



can be divided into trip-end or trip-volume models, depending on the point at which the factors are applied (before or after assignment) and further categorized by the resultant trip definition (ADT or peak hour). Other approaches to this problem are possible, and research under way at the present time will shed more light on the subject (5, 6, 7).

Trip-End Models

Four methods of using the UTPP can be classified as trip-end models. Three are oriented to the zonal definition of the study area. The fourth is based on employment density and trip length. All use trip ends in developing conversion factors. In all cases except one, the trip ends are derived from the base-year origin-destination survey data, so some consideration will have to be given to the stability of relations over time.

Zonal Peak-Hour Factors

Factors (work-trip ends and peak-hour trip ends) are developed by zone for both origins and destinations (Fig. 7). Inputs to the factor development are the base-year origin-destination data and the output from program PEAKHOUR. This program (in the FHWA-S/360 urban transportation planning battery) is designed to separate the peak-hour trips from the total daily origin-destination work-trip file by using the "trips-in-motion" concept.

The factors (in terms of trip ends) thus developed can then be applied to the census work-trip table by using the program FRAT to obtain a 1970 peak-hour trip table. To have some judgment about the adequacy of this trip table, one should assign the trips to a 1970 network and compare them with 1970 peak-hour ground counts. Based on existing or updated trip generation models, or new models developed from census data, forecasts of work-trip ends are made. Application of the previously developed factors results in forecast peak-hour trip ends, which can then be distributed and assigned to a future network. This technique assumes that some provision has been made for models capable of distributing and assigning peak-hour trips rather than the traditional daily trips.

Zonal Daily Trip-End Factors

Figure 8 shows essentially the same approach as that above, but the trip-end conversion factors are based on the relation between work and total daily trips. Existing distribution and assignment models may be used in this case.

In the second ADT model approach (Fig. 9), census socioeconomic data are applied to existing or updated trip generation models to obtain 1970 trip ends by zone for all trip purposes. Census journey-to-work trip ends by zone are applied to the previously developed trip ends to develop the factors shown in Figure 9. These factors may be developed for the entire study area or for smaller geographic units, depending on the level of aggregation of the data from which the factors were developed.

Forecast work-trip ends are obtained through existing or updated trip generation procedures. The work-to-total trip-end factors are then applied to obtain total future trip ends. The remainder of the forecasting process involves the application of normal estimating techniques. These approaches, of course, assume that work trips as a percentage of total trips will remain constant over time, an assumption that can be argued.

Employment Density and Trip Length

The rationale of the peak-hour relations based on employment density and trip length developed by Mann (2) is that, as employment density at the destination of the trip increases, the ratio of peak-hour trips to work trips decreases (i.e., work trips become

larger in proportion to total peak-hour trips). Similarly, as trips get longer, trips for work will constitute an increasing percentage of total peak-hour trips. These 2 relations are shown in Figure 10. Application of the concept involves a combination of both relations, shown at the bottom of the figure. A matrix of zone-to-zone work trips can be factored by using the ratios based on the employment at the destination and the travel time (skim tree) between the zones. This approach has the advantage of recognizing changes in the character of development in a zone over time; the previous approaches assume that factors are stable by zone through time.

Trip-Volume Models

There are 2 possible approaches presented here, although there may be others. The first (Fig. 11) uses some rather extensive research that was conducted on peak-hour travel (4). In this research the percentage of average daily traffic in the peak hour by functional class, area type (CBD, suburb), and orientation (radial, circumferential) was studied by using data from 7 representative cities. The development of census-based models can take advantage of this research as shown in Figure 11.

In the first approach, factors are developed for trip volumes rather than for trip ends. The program PEAKHOUR can be used to develop trip-volume factors for use converting from average daily primary work-trip volumes to peak-hour trip volumes for links in the system classified by the categories mentioned above. After the census work-trip table is assigned to a 1970 network, these factors may be applied to the resulting link volumes, giving peak-hour trip volumes by links in the system. Factors, based on the research mentioned above relating peak-hour volumes to total daily volumes, are applied to the peak-hour trip volumes from the census trip assignment. The result is total daily trip volumes on each link in the system.

Given future trip ends, based on existing or updated work-trip generation models (either developed from the census data or existing origin-destination data), future daily trip volumes can be obtained through application of the appropriate factors.

The second trip-volume approach can be classified as a peak-hour model and is being investigated under a research contract at the Georgia Institute of Technology (6). The concept of the model is shown in Figure 12 (9) and is based on peak-hour link volumes being a function of assigned work-trip link volumes. The independent variable (assigned work-trip volumes) is estimated from work-trip generation and distribution models. The distribution model can be developed by using base-year origin-destination data or possibly the census journey-to-work trip data.

Given design-year work-trip link volumes, the basic peak-hour model is applied to obtain peak-hour volumes directly by link. This model is developed from base-year assigned origin-destination data and base-year ground counts.

The above described techniques quite probably do not cover all possible approaches to using the UTPP information. They do, however, constitute a broad spectrum of probable applications and suggested strategies for developing new models.

SUMMARY COMMENTS

This paper has presented suggestions for incorporating data from the 1970 census into the continuing urban transportation planning process. In the continuing plan and program review process, census data can be applied as a basis for current socioeconomic data for generating current trips with existing models, in the development of new trip generation models, in the refinement of old trip generation models, as a benchmark against which new updated long-range and short-range land use and socioeconomic data may be compared, and as a beginning base or a benchmark to check an ongoing surveillance program.

In the second and third applications, consideration might be given to using the census variables of income and automobile ownership to develop relations at the dwelling unit level. An example was presented in this paper.

Figure 7. Peak-hour-model trip ends.

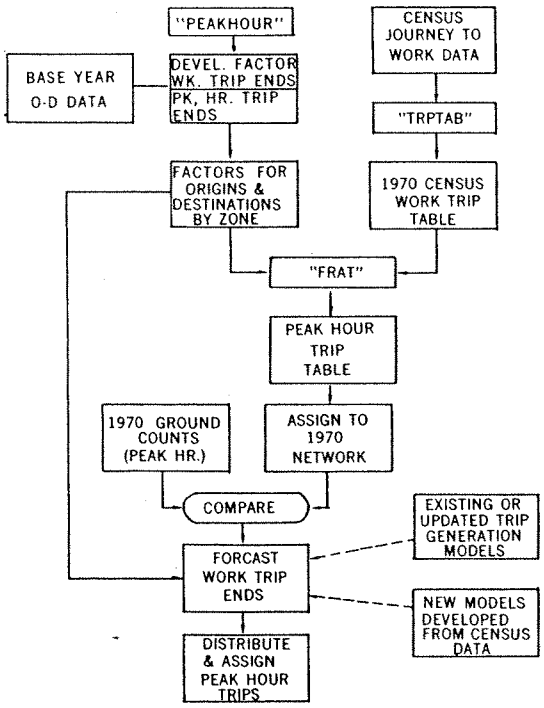


Figure 8. ADT-model trip ends.

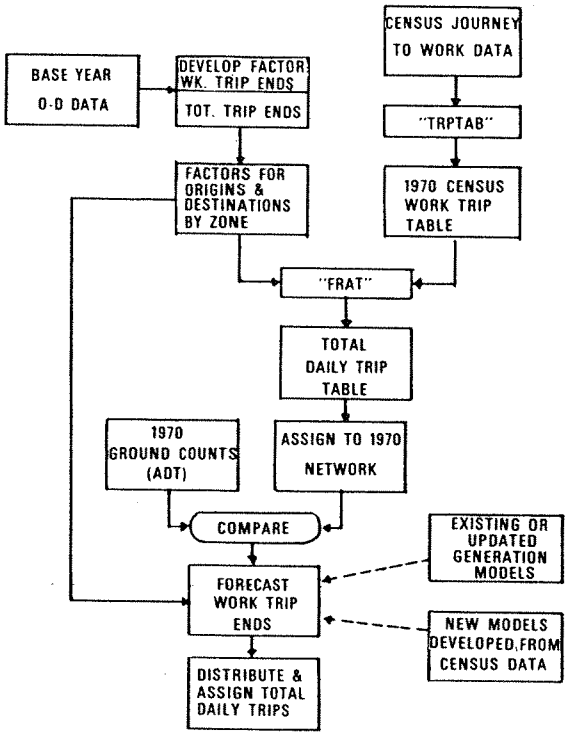


Figure 9. ADT/work-trip-model trip ends.

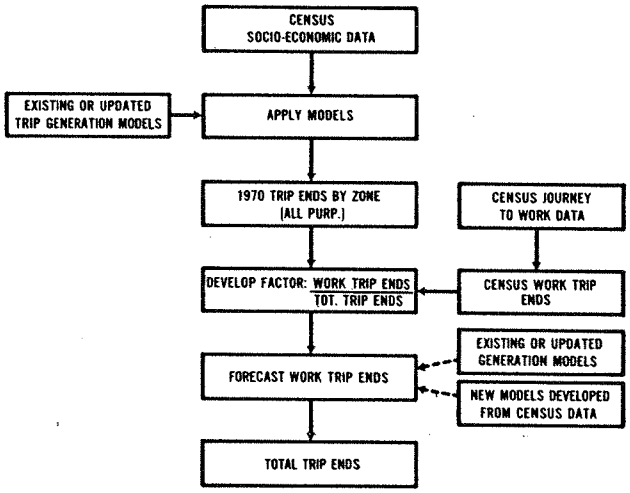


Figure 10. Peak-hour factors related to employment density and trip length.

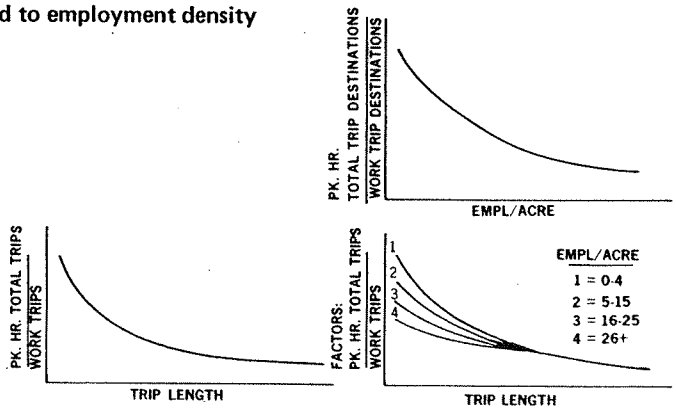


Figure 11. ADT-model trip volumes.

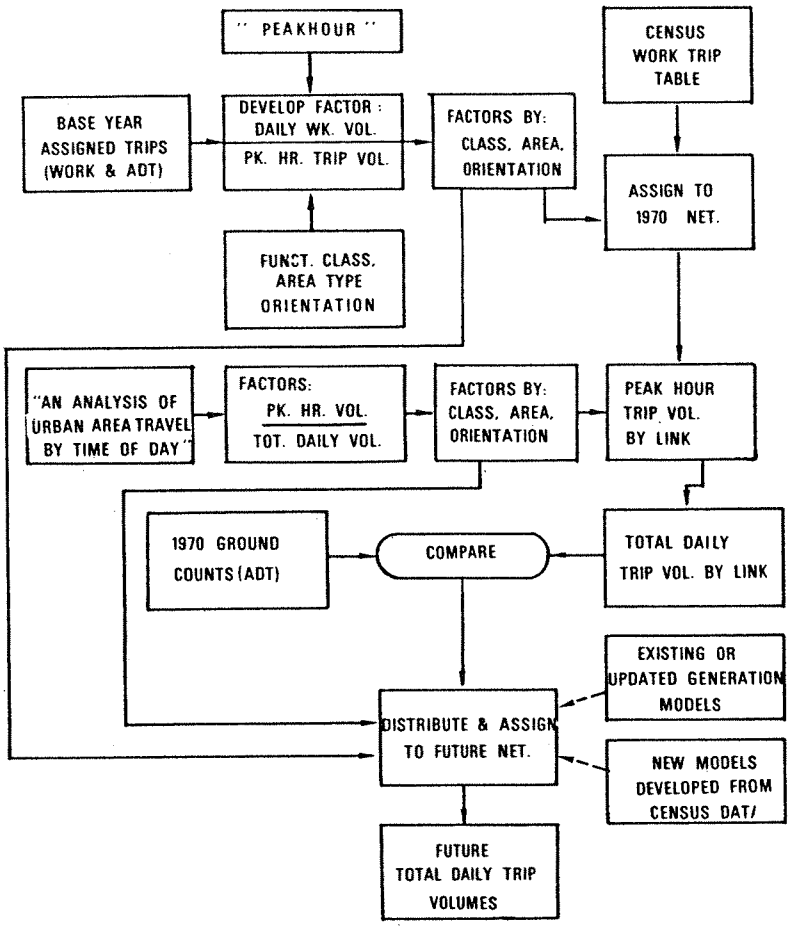
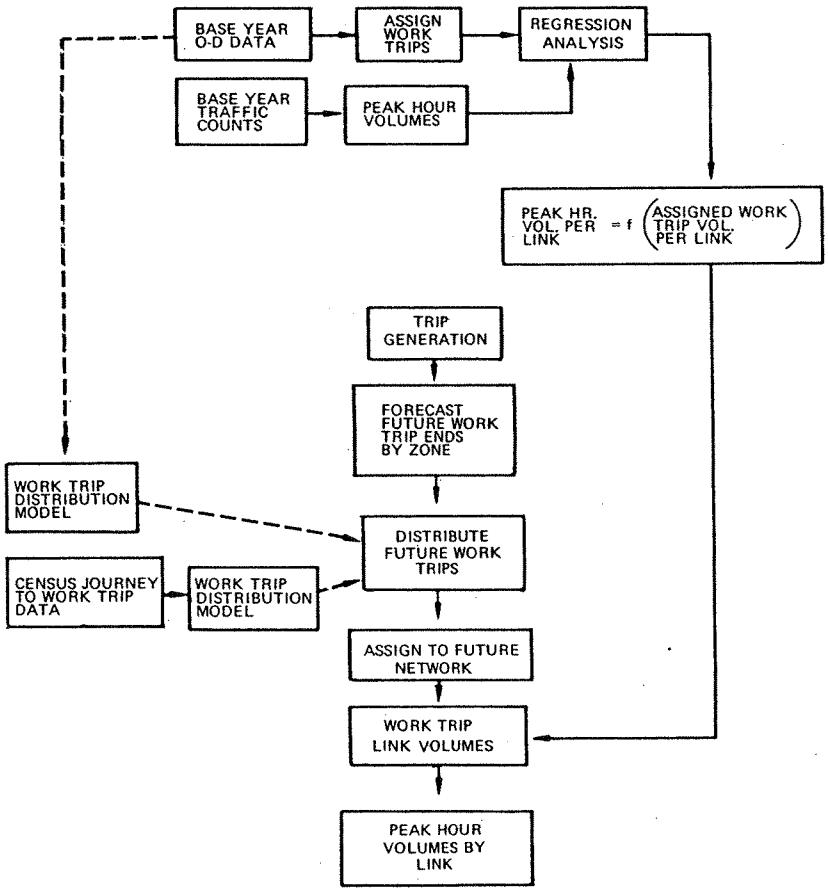


Figure 12. Peak-hour-model trip volumes.



In essence, the UTPP offers a supplemental data source that may be used for a number of purposes in the urban transportation planning process. Application of the package is not without some limitations, however, and these must be considered carefully in a practical sense, for example, the degree of coding of the place-of-work to block level, differences in definition between census journey-to-work data and the typical origin-destination trip data, timing of the census data in relation to the continuing transportation planning needs, geographic area coverage of the UTPP data, and sampling and method of expansion of the census data.

Even with the above considerations accounted for, experience to date indicates that census data can be used in urban transportation planning. As a result of some early tests and applications, the Middle Rio Grande Council of Governments (Albuquerque) concluded that UTPP data can be used in the reappraisal portion of the transportation planning process to provide a direct check on work-trip productions and attractions. Agreement was generally favorable with locally developed data in describing the socioeconomic characteristics of the area. The data were also considered to be an adequate base for trip generation analysis (5, 8).

The Delaware Department of Highways and Transportation was able to refine parts of the package and will use census data to provide independent variables for person-trip generation equations and to provide data for developing a modal-split model (8).

Although these early applications provide indications, more extensive testing and investigation are under way. These include research by Parsonson on the development of an urban peak-hour traffic model based on the 1970 census and concurrent ground counts (6) and a study sponsored by FHWA on the use of census data for updating urban transportation studies (7). The objective of the first study is the development of a peak-hour travel model for estimating 20-year design data.

As an additional guide to state highway departments and transportation studies, FHWA issued a report (9) that presents in more detail than has been included in this paper a rationale for incorporating the census data into the urban transportation planning process. It includes additional discussion on the use of the UTPP and the details that must be considered in its application.

As results of these studies and more practical application of the package become available in urban areas, the utility of the census data will be further demonstrated. The indications are that the census transportation data are an excellent data source for continuing urban transportation planning.

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