EXPERIENCES IN USING CENSUS DATA FOR TRANSPORTATION PLANNING

The Rhode Island Project

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Comprehensive urban transportation planning has been legally required since the passage of the Federal-Aid Highway Act of 1962. Comprehensive transportation planning, which is a requirement for every city having a population of more than 50,000, requires the collection and processing of a great many data. Data collection and processing is required not only to establish base-year data but to update traffic volume projections, improvement recommendations, and other information important to the community. For many years the primary source of data has been expensive and time-consuming inventories.

In recent years, an increasing amount of discussion and activity has centered on the feasibility of using the dicennial national census as a transportation planning data source. The 1970 census included questions concerning journey-to-work trips. The Bureau of the Census and the Department of Transportation have collaborated to produce the 1970-Census Urban Transportation Planning Package (UTPP) for various areas of the country. The question remains, Do the census data provide a valid source for use in updating urban transportation studies? To answer this question, the Federal Highway Administration awarded the Comsis Corporation a contract to investigate the use of these data. The project is being accomplished in conjunction with the state of Rhode Island and the Office of the Secretary of Transportation. The intent of the project is to run a series of comparisons between data obtained in the census and data obtained in origin-destination surveys conducted by the state of Rhode Island in 1961 and 1971. The project includes 3 tasks: to investigate and report on the feasibility of the project and detail the remaining tasks, to develop assignment volumes by using the 1970-census journey-to-work data, and to evaluate the methods used for developing assignment volumes. At the time this paper was presented we had completed the first task.

The products expected to result from the project include: a

report of the accuracy achieved by using census data to update the base-year data in developing average daily traffic by link via traffic assignment; a report of how the 3 methods tested for obtaining network loads compare with the average daily traffic resulting from a new origin-destination survey; and a report of the problem areas uncovered in using the census data to develop network loads, solutions to the problems, and guidelines to other users.

OBJECTIVES OF TASK 1

The objectives of task 1 were to investigate whether the methodology structured for this project was valid and feasible from the standpoint of data requirements. Specifically, the following work elements were included in task 1:

1. Design the actual processes involved in the project including techniques to be used and expected results;
2. Detail and estimate the cost of each element of work in the project, develop a critical path schedule to show the structure of the project, and provide a progress plan;
3. Investigate the feasibility of the 3 main comparison processes in task [these include a review of the previous work (1, 2, 3, 4, 5) and methods of trip generation model development].
4. Identify all data items required by the project and determine whether the required data items actually exist in an available, usable form;
5. Document the manipulations of data involved in the various processes and comparisons;
6. Indicate what software, if any, would have to be developed to complete the requirements of the project;
7. Discuss what problem areas, if any, are expected, what impact these problem areas will have, and what recommendations and actions are required for their alleviation;
8. Define what areal units can best be used as a basis for the work in the project; and
9. Make recommendations concerning any phase of task 2 that will assist in producing a better report at the end of the project.

DEVELOPING TRAFFIC ASSIGNMENT VOLUMES

Three methods were evaluated for developing traffic assignment volumes by using census data.

The first method involves using primary work automobile-driver trips as an indicator of total peak-hour automobile-driver trips and then relating the peak-hour trips to total ADT for automobile driver. (All trips discussed in this paper are automobile-driver trips unless otherwise indicated.) In this method, 1961 data are used to create primary work and peak-hour trips, a network, trees, and loaded networks. The relation developed between primary work and peak-hour trips is applied to the 1970-census journey-to-work trips to create 1970 peak-hour trips. This work is based on similar work by Parsonson (1, 2, 3) on using primary work trips as forecasters of peak-hour trips. After 1970 peak-hour volumes are developed, 1970 ADT is developed by using factors developed by Peat, Marwick, Mitchell and Company (4). These factors allow for the development of ADT by expansion factors, which vary depending on the characteristics of each link in the network.

The second method is based on the concept that primary work trips are predictors of total ADT. Armbrister (5) showed this to be a valid appraoch, and this project will further test his hypothesis. Once again, 1961 information is used. Networks loaded with primary work and average daily volumes are used to develop relations between these 2 volume types. The relations produced are used to generate 1970 ADT from the census journey-to-work trip volumes.

The third method is based on trip ends rather than trip volumes. 1961 socioeconomic

data and a trip generation procedure, such as cross classification, are used to show that total trips are related to primary work trips as a function of the socioeconomic makeup of the traffic generator and attraction areas. The results will be applied to journey-to-work productions and attractions to develop 1970 ADT productions and attractions. Finally, ADT volumes will be developed through the use of gravity model trip distributions, directional splits of gravity model trips, and the subsequent loading to the 1970 network.

EVALUATION OF CENSUS DATA AND METHODS

Task 3 will evaluate the adequacy of each method employed to generate 1970 automobile-driver link volumes (task 2) and to assess the adequacy of census journey-to-work data for transportation planning purposes. The assessment will include checks of link volumes stratified by functional class, area, and volume; volume checks across grid lines and cut lines; and vehicle-miles of travel by various areal and facility-type groupings. Seven major comparisons are currently proposed.

1. 1970 primary work automobile-driver link volumes generated from census journey-to-work data and 1970 primary work automobile-driver link volumes generated by 1961 travel models. To generate 1970 volumes, 1961 models will require the use of 1970 socioeconomic data and the 1961 trip generation, distribution, and assignment models.
2. 1970 total automobile-driver link volumes generated by 1961 travel models and 1970 ground counts factored to eliminate trucks. Again, the development of the 1970 link volumes will require the use of the 1961 trip generation, distribution, and assignment models.
3. 1970 internal automobile-driver and internal total person primary work-trip interchange volumes generated from census journey-to-work data and similar values obtained from the 1971 origin-destination survey. The 1971 trip interchange volumes will have to be factored to portray 1970 interchanges and provide a direct one-to-one comparison. These comparisons will be made on an areal basis yet to be determined and will identify any apparent differences in travel.
4. 1970 primary work automobile-driver link volumes generated from 1970 journey-to-work data and 1970 primary work automobile-driver link volumes developed from the 1971 origin-destination survey and stratified by functional classes and area types. The 1970 primary work automobile-driver trip matrix developed from the 1971 data will be assigned to the 1970 highway network before this comparison is made.
5. The generated 1970 ADT (method 1) and the 1970 ADT ground counts.
6. 1970 ADT developed from the relation between ADT and primary work trips (method 2) and automobile ground counts.
7. ADT (method 3) and automobile ground counts.

DATA REQUIREMENTS FOR PROJECT

Successful completion of this project is dependent on the acquisition and processing of various data. A study of the project requirements concerning data and the processing programs was part of task 1. The 1971 study interviewed 0.44 percent of the state's population. For the purpose of this project, the 1971 information will be modified to reflect conditions as they existed in April 1970, the time of the census. These data will be used as the basis for some of the comparisons.

1. 1961 travel models, consisting of trip distribution, generation, and assignment models, will be used in conjunction with 1970 socioeconomic data to develop 1970 link volumes for comparison with ground counts.
2. 1961 socioeconomic data, including dependent variables such as population, dwelling units, and employment used in creating the 1961 trip generation model, will be used in method 3 to develop a relation between primary work trips and total trips as a func-

tion of socioeconomic characteristics.

3. 1970-census socioeconomic data will be used in the relation developed above to create 1970 ADT volumes from primary work volumes and also with the 1961 models to create other 1970 volumes.
4. 1970-census journey-to-work information will be used to build the journey-to-work trip table and the production and attraction summaries.
5. 1970 highway network will represent the transportation network in Rhode Island at the time of the census in April 1970.
6. 1961 trip records were obtained from the origin-destination survey of 1961 and include the dwelling unit information and trip information on origins, destinations, purpose, mode, and time of travel.
7. PMM factors were created by Peat, Marwick, Mitchell and Company (4) to reflect the portion of ADT that occurs during the peak hours for various classifications of network links.
8. 1970 ground counts, which are obtained from the city of Providence and the state of Rhode Island, show actual traffic movements over selected highway links and will be the basis for several of the project comparisons.
9. 1961 productions and attractions of all trips and primary work trips reflect the total trip ends for each zone in the 1961 study area and will be analyzed by using method 3 to develop a relation between ADT and primary work-trip productions and attractions. Zonal socioeconomic characteristics will be used in the analysis.

In addition to these data sets, several other data items will be required during the study:

1. 1970 independent data sources for use in verifying census information;
2. Rhode Island codes for zones;
3. 1961 and 1970 network and zone maps from state;
4. 1961 trip generation and distribution reports for use in reviewing the validity of the models and providing input to portions of task 2;
5. 1970-71 growth factors for use in adjusting the 1971 survey results to the time of the census;
6. Write-up of the 1971 project;
7. Census-tract to traffic-zone conversion file for use in working with 1970 socioeconomic data;
8. 1970 primary work link volumes generated by the 1961 models; and
9. Total link volumes generated by the 1961 models.

PROCESSING

The project was designed to make maximum use of FHWA PLANPAC software, and the need to develop any major computer software is not expected.

One of the major elements for task 1 is to translate the conceptual design, as shown in Figure 1, to a detailed practical process in a manner such that PLANPAC can be of maximum assistance. The following describes the processing required to accomplish task 2.

Method 1

The method 1 comparison is designed as a 2-phase process (Fig. 2). First, a relation between 1961 peak-hour and primary work trips will be established according to Parsonson's methods. That relation will be applied to the 1970-census journey-to-work trip table to develop 1970 peak-hour trips. The second phase will use factors established by Peat, Marwick, Mitchell and Company to expand the 1970 peak-hour trips to ADT volumes. These ADT trips will then be compared for accuracy to the 1970 ground counts and to the generated 1970 peak-hour ground counts. The following steps are included in method 1.

Figure 1. Study design.

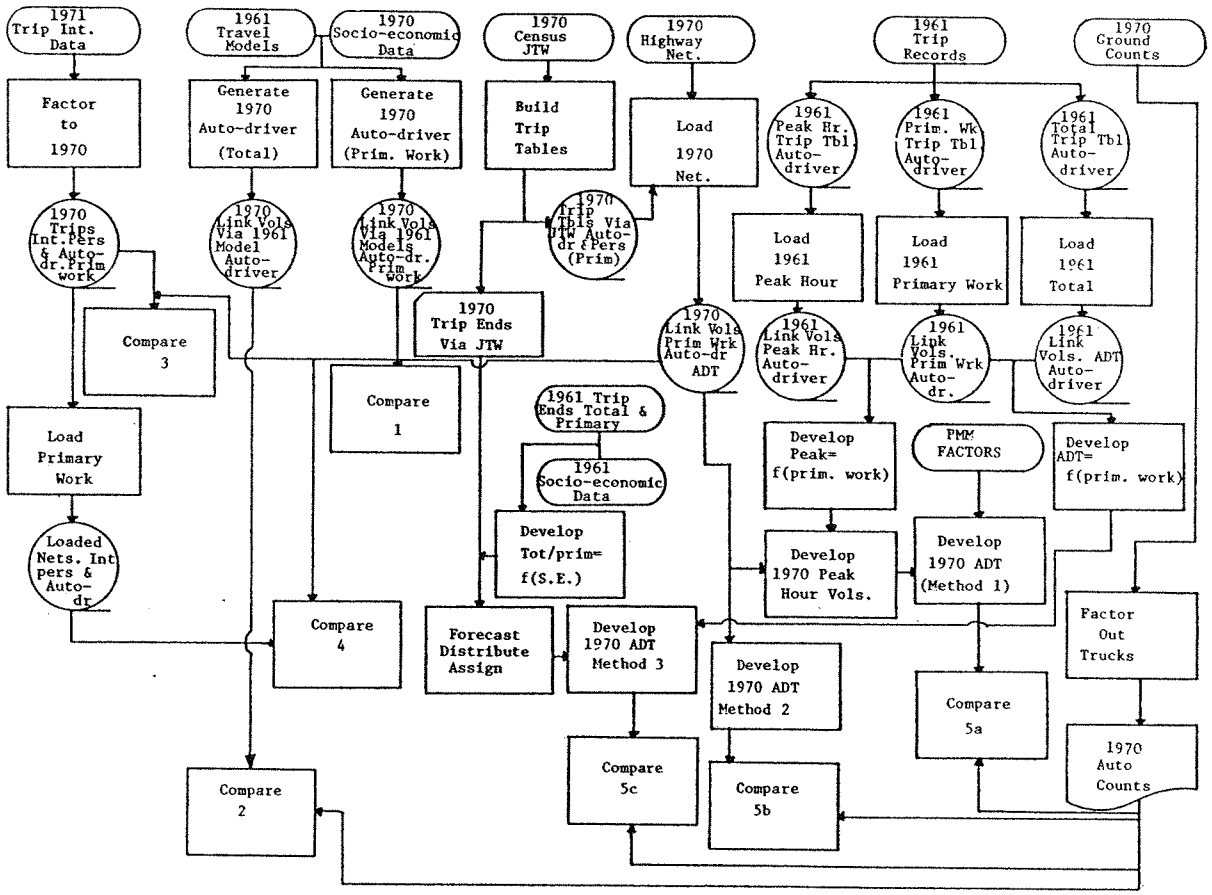
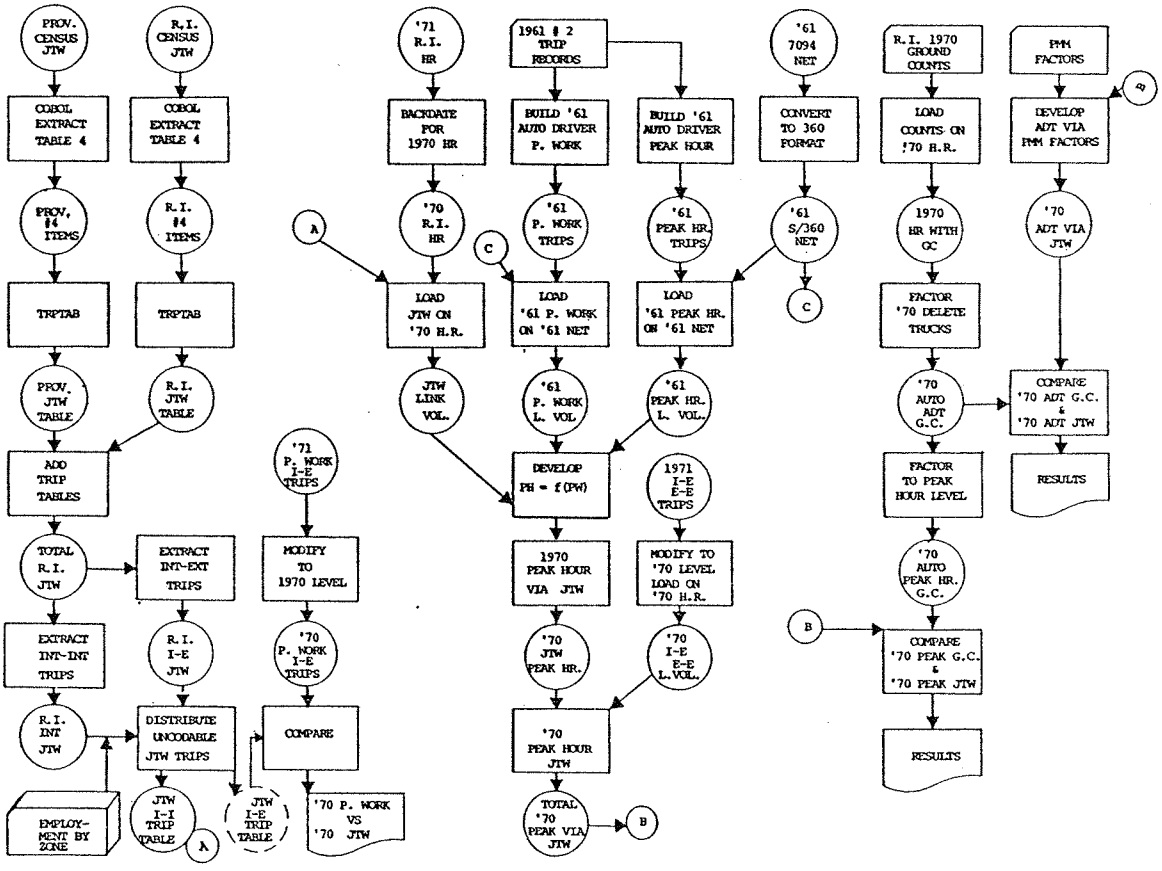


Figure 2. Method 1 process.



1. Create the 1970 journey-to-work trip table with all origins and destinations within the state boundary line:
   a. Tapes of the UTPP are processed by using program FILSYS or a similar program to create a separate file of each of the census tables;
   b. The fourth table is manipulated to create a journey-to-work trip table;
   c. The trip tables are adjusted to allow for absentees and similar errors on the file;
   d. The state trip table and the Providence trip table are added to create a total study area trip table; and
   e. The study area trip table is adjusted by using zone equivalencies supplied by the state and a trip table compression program such as TRPVERT so that no zones are located outside the state.
2. Build 1970 historical record and trees:
   a. Link card images of the 1971 historical record are supplied by the state;
   b. The state supplies delete cards to adjust the 1971 historical record to an April 1, 1970, level;
   c. The 1971 historical record is undated to create the April 1, 1970, historical record; and
   d. 1970 trees are built by using program BUILDVN.
3. Create 1970 journey-to-work link volumes: The program LOADVN and the 1970 historical record, the 1970 trees, and the journey-to-work trip table are used to assign the journey-to-work trips to the 1970 historical record.
4. Build 1961 network and trees:
   a. The state supplies a 1961 network in 7094 format;
   b. The 7094 link card images are obtained from the 1961 network;
   c. The 7094 link card images are converted to 360 link card format;
   d. The 1961 historical record is built with program BUILDER; and
   e. Program BUILDVN is used to build 1961 trees.
5. Build and load 1961 peak-hour and primary work trips on 1961 historical record:
   a. The 1961 trip record No. 2 and No. 3 cards are used as input to program PEAKHR to build the 1961 peak-hour trip table;
   b. The peak-hour trips are loaded on the 1961 historical record by using program LOADVN;
   c. A trip table of 1961 primary work trips is built from the 1961 No. 2 and No. 3 cards with program TRPTAB; and
   d. The primary work trips are loaded on the 1961 historical record by using program LOADVN.
6. Develop a relation of the form, peak hour = f(primary work), by comparing and analyzing the 1961 peak-hour and primary work link volumes.
7. Use the relation developed in step 6 to generate 1970 peak-hour trips from the 1970 journey-to-work trip table.
8. Develop 1970 ADT by using PMM factors:
   a. The 1970 historical record is set up to carry classifications of links that can be used with the PMM factors; and
   b. 1970 ADT link volumes are created by applying the PMM factors to the generated 1970 peak-hour link volumes.
9. Load ground counts and factor for trucks:
   a. 1970 ground counts are obtained from the state;
   b. Ground counts are inserted into 1970 historical record; and
   c. Link volumes are factored to eliminate trucks.
10. Make ADT comparison of ground counts and those generated by using journey-to-work trips:
   a. Ground count link volumes are compared to those generated by using journey-to-work trips; and
   b. Comparison results are analyzed and interpreted.
11. Make peak-hour comparison of ground counts and journey-to-work volumes:
   a. Ground counts of automobile drivers are factored to peak-hour link volumes;
   b. Ground count link volumes are compared to those generated by using the journey-to-work trips; and

c. Results of comparisons are analyzed and interpreted.

Method 2

The comparison of method 2 (Fig. 3) is based on a relation between primary work trips and ADT as discussed by Armbrister (5). The steps are as follows:

1. Use program TRPTAB and input from the 1961 No. 2 and No. 3 cards to build an ADT trip table;
2. Load the 1961 historical record with 1961 ADT trips;
3. Analyze and develop a relation between 1961 ADT link volumes and 1961 primary work trips of the form, ADT = f(primary work trips);
4. Develop 1970 ADT link volumes by using the developed relation and the 1970 journey-to-work link volumes;
5. Compare 1970 link volumes and ground count link volumes; and
6. Analyze and interpret the results of the comparisons.

Method 3

Method 3 (Fig. 4) is based on zonal trip ends rather than trip tables as are methods 1 and 2. The steps are as follows:

1. Use total automobile-driver 1961 productions and attractions, 1961 primary work productions and attractions, and 1961 socioeconomic data to develop the relationship, TOTAL/PW = f(socioeconomic);
2. Obtain journey-to-work trip ends from journey-to-work trip table by using program PTSUM;
3. Develop 1970 total automobile-driver trip ends by applying the relation above to 1970 journey-to-work trip ends and 1970-census socioeconomic data;
4. Distribute the 1970 ADT productions and attractions by using the gravity model distribution technique;
5. Split the gravity-model-generated trip table by using program SPLIT and state directional factors;
6. Load the split trips on the 1970 historical record, and use program COMPARE to check the synthesized link volumes by the gravity model against the 1970 ground count link volumes; and
7. Analyze and interpret the comparison results.

CENSUS CODING

Some preliminary work has been done on summarizing the census journey-to-work information. The UTPP covers the Providence SMSA, which includes most of Rhode Island and parts of Massachusetts and Connecticut. The distribution of the 384,600 workers who lived in the SMSA is as follows:

Item	Workers
Living in SMSA	384,601
Working in Rhode Island	289,574
Working in Massachusetts and Connecticut	93,243
Working outside Rhode Island, Massachusetts, and Connecticut	1,784

Figure 3. Method 2 process.

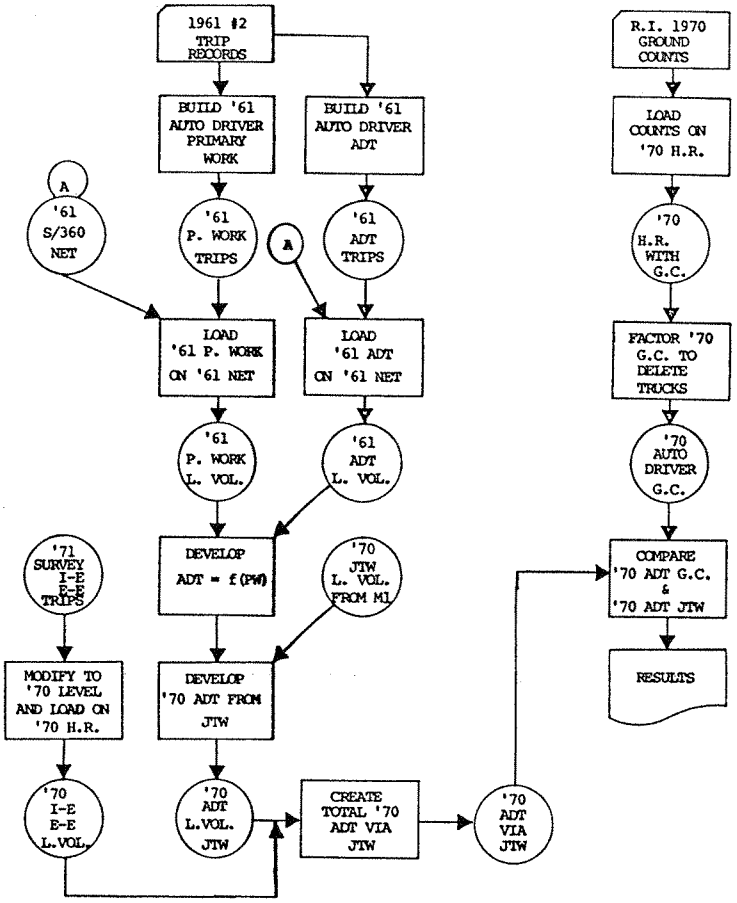
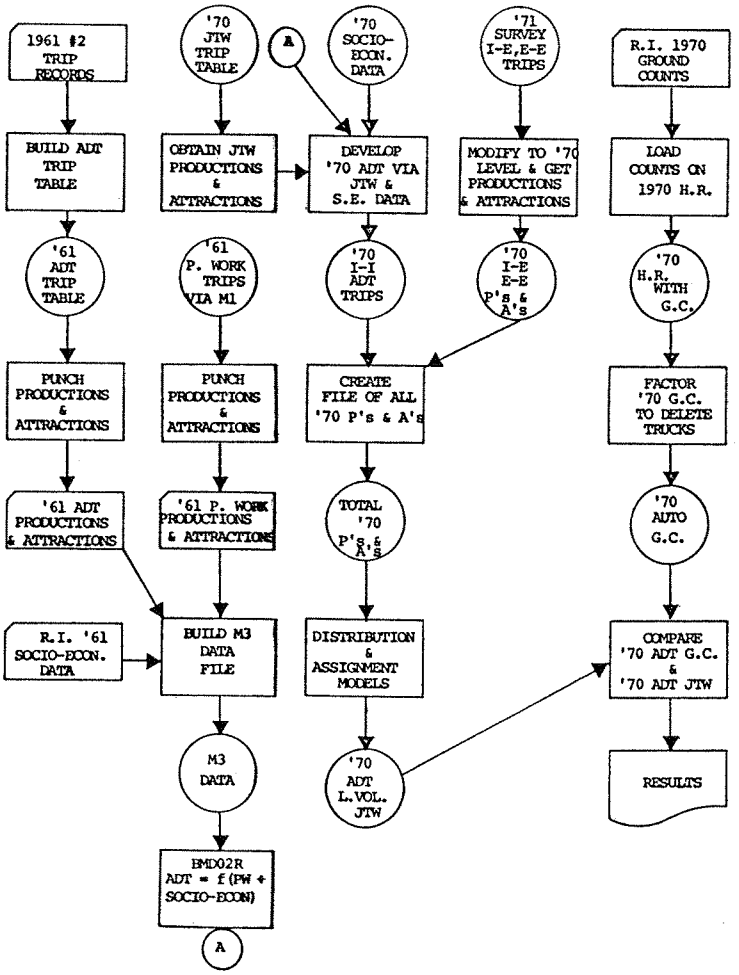


Figure 4. Method 3 process.



If the entire SMSA is considered, 52.3 percent of the workers were coded to block, 39.9 percent were coded by the Universal Area Code (UAC), 7.3 percent were not coded, and 0.5 percent worked outside the SMSA. If the urbanized area is the limit of study, 77 percent of the work places can be coded to block and 23 percent to the UAC. These percentages are of the 231,335 workers whose work places could be coded to the Providence urbanized area. If we assume that the work places that could not be coded for the urbanized area are the same proportion as urbanized area workers are to SMSA workers (about 60 percent), then we can estimate the total urbanized area residents as being 249,000. If we use this as a control, the percentage of workers coded is as follows:

Item	Providence SMSA	Urbanized Area
Block	52.3	72
UAC	39.9	21
Not coded	7.3	7
Outside SMSA	0.5	—

As mentioned previously, work places coded by the UAC and those not coded are allocated to zones. In New England, UAC covers towns or cities. In the Providence urbanized area there are 18 such areas and 3 rest-of-county areas to which work places were coded when they could not be coded to city or town. The 3 rest-of-county codes have only 5,585 coded journey-to-work trips. There are 403 traffic zones for the 1971 origin-destination survey in the urbanized area.

Some comparisons of the census data with state employment figures have been made. The average monthly employment for the entire state in 1970 was 342,750. This compares to the 289,574 workers in the Providence SMSA who worked in Rhode Island. The difference is about 15 percent, which is about what was found in other areas. Most of the difference can probably be accounted for by the fact that state employment data include multiple jobs held by a single worker and that some workers lived outside the SMSA and worked within. Comparisons of the census employment with the state data are made by town. Currently only "covered" employment is available by town (this accounts for 264,000 employees). Allocations of total employment are made for comparison with the census data.

PROBLEM AREAS

Boundaries

Different study area boundaries were used in the 1961 and 1971 Rhode Island studies. The state line was used as a boundary in the 1961 study. Portions of Connecticut and Massachusetts were included in the 1971 study. For this project, the state line will be used. In addition, the zones in the 1971 study include a set of stations placed on the state boundary. Therefore, the trips that are assigned to the Connecticut and Massachusetts segments of the study area will have to be assigned to given external Rhode Island stations. This will require that an equivalency file be established to provide for the compression of trips to the given area.

Journey-To-Work Trips That Cannot Be Coded

A portion of the census journey-to-work trips did not have sufficient response information to obtain the traffic zone of origin or destination or both. The number of trips involved is not large. Approximately 1,800 trips do not provide any usable information, and some 30,000 trips have been coded by UAC and other levels but are not now at a traffic zone stage. These trips should all be included in the journey-to-work trip table so that the information is as complete as possible. The 1,800 trips will probably

be distributed to all zones in the same proportion as known trips. The 30,000 trips will be distributed to the zones in UACs as known trips are proportional between the zones in the UAC.

Zonal Coding Differences

There is a question as to the method of development of the trip generation model for method 3 because of a change in zoning that took place in the study area between 1960 and 1971. Some question has been raised as to whether trip generation equations that were based on 546 zones could validly be applied to the same area divided into 685 zones. We do not believe this will be a problem. Another alternative is to use the cross-classification process and thus eliminate any problem caused by a differing number of traffic zones.

PMM FACTORS

In method 1, the second phase of processing calls for PMM factors to be used to expand peak-hour trips to ADT trips. These factors are based on the premise that the percentage of ADT traffic occurring on a link during a peak hour is dependent, among other factors, on the orientation of the link. The orientations are defined as CBD-radial-freeway, central city-circumferential-arterial, and so on. Also, the PMM work incorporates the influence of modal-split directional factors on peak hour-ADT traffic relation. The PMM approach, although reasonable, poses some problems. First, Rhode Island has not coded orientation into link data records. Second, the modal-split aspects of this methodology raise serious questions involving the direct use of these factors. For these reasons, it is expected that similar methodology will be used but that the link factors will be based on functional and design type classifications. These codes are available in the state and, in addition, are compatible with 1974 National Transportation Study methodology. Use of these stratifications should make the final results more directly usable in other areas.

CONCLUSION

Previous work by Parsonson and Armbrister has shown that primary work trips can be used as a basis for developing peak-hour and ADT volumes on a network. Their work was based on using origin-destination survey data to develop the relations. In this project, census data will be used as the source for developing relations, which may result in less predictive accuracy. The results should provide a clear indication of the usefulness of the census journey-to-work data for updating and forecasting purposes.

It would be well to consider, however, the relative costs of this approach to travel development versus the collection of new origin-destination data. There are 252 urban areas, each having more than 50,000 population. If sample rates of the size previously recommended by FHWA were used, approximately 1.6 million interviews would be required (an average of about 4.2 percent sample of households).

At $25 per interview, a total cost of $40 million would be realized. Most practitioners do not believe so high a sample rate as previously recommended is required. It the rate given below were used (these are generally half the FHWA previously recommended rates), urban areas could have surveys for all modes of travel producing more directly usable base data for approximately $20 million.

Population	Sample Rate	Population	Sample Rate
50 to 150	1 in 16	1,000 to 2,000	1 in 60
150 to 300	1 in 20	2,000 to 5,000	1 in 100
300 to 500	1 in 30	5,000 and more	1 in 200
500 to 1,000	1 in 40		

The costs for collecting the 1970 journey-to-work data are roughly estimated as follows:

Item	Millions of Dollars
Additional questions	5.0
Coding of census journey-to-work data	5.0
Processing to produce package	1.0
Coding guides for 80 nonmail areas	3.0
Produce information from journey-to-work data in usable format (252 areas at $5,000)	1.25

Obviously the dollars spent on the census journey-to-work data result in information useful in nonurban areas as well as in urban areas where home interview surveys are taken. However, it would appear that a critical evaluation should be made of the usefulness of the census data relative to that obtained from home interview surveys or perhaps some new collection process. We expect our work in Rhode Island to indicate the relative benefits and cost effectiveness of using census journey-to-work data versus collecting data in home interview surveys.

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The Albuquerque Project

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In the fall of 1972, the Federal Highway Administration initiated an evaluation of the 1970 standard package of census data for urban transportation planning studies. This evaluation study was conducted by the staff of the Middle Rio Grande Council of Governments with assistance from the Special Studies Group of the New Mexico State Highway Department. The objectives of this study were to verify the reliability of the data from the Urban Transportation Planning Package (UTPP) and to test and evaluate their practical usefulness in an actual transportation planning program. The study was conducted prior to the official release of the UTPP to other metropolitan areas in the anticipation that results of the Albuquerque study would be of general benefit to all transportation planning staffs attempting to use the census data.