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THE APPROACH and techniques for long-range transportation planning in urban areas have evolved through several phases. In the early stages of development, during the 1940's and early 1950's, urban planning was accomplished primarily with conceptual procedures and transportation planning in small urban areas emphasized the development of "thoroughfare plans," which were based primarily on broad principles recognizing (1) the needs of future growth, (2) the integration of a hierarchy of roadways, (3) separation of through traffic from local movements, etc. During the late 1950's and 1960's, transportation planners became extensively involved with the location of controlled access highway facilities in and around urban areas, and the transportation planning process became more complicated and analytically oriented. The transportation studies in large metropolitan areas, such as Detroit and Chicago, used elaborate mathematical techniques for both land use and transportation planning, and the use of similar procedures continued to increase.

The long-range urban transportation planning procedures eventually were standardized through the provisions of the 1962 Federal-Aid Highway Act and subsequent interpretations, which established a comprehensive, cooperative and continuing (3-C) planning process for urbanized areas with more than 50,000 population (1,2). The prevailing procedure for plan development is rather complex and utilizes mathematical models for travel forecasts, which require substantial data inputs and the use of large scale computers. To permit the calibration of trip generation, trip distribution, and modal split models, a home interview origin-destination (O-D) survey and an external cordon O-D survey were specifically required. Based on the relationship of existing travel with socio-economic and land use characteristics, future trip generation by traffic zones in the study area are determined. With the use of computer-oriented mathematical models, these future trips are distributed between the various traffic zones. The mode of travel also is predicted before the trips between zones are assigned to the existing and future alternative transportation networks. Planners then are able to determine the segments of the present transportation system requiring improvement and/or new facilities to handle forecast traffic for the target year.

As the large urban area transportation studies reached completion and entered the continuing phase, interest in small urban areas increased. Small urban areas generally possess unique transportation problems, although not of the same magnitude and scope as encountered in the large urban areas; these problems nevertheless affect many individuals and the overall quality of their lives. As smaller areas develop and prosper, their transportation problems usually magnify and thus through timely transportation planning, these areas have an opportunity to confront transportation problems while still in their infancy, and to avoid the mobility problems currently strangling the larger urban areas. Thus, the opportunity may be wasted unless there is a vigilant long-range transportation planning process. However, the focus of the planning process and the techniques/procedures for planning must be compatible with the needs and resources of these areas. The objective of this paper is to evaluate the applicability of the existing transportation planning procedures to small urban areas and explore alternative means of alleviating any incompatibility.

It must be pointed out that there is no standard definition of small urban areas and sometimes areas as large as 250,000 are considered to be small. The 1962 Federal Aid Highway Act made transportation planning funds available to all urban areas with a population of 50,000 or more. Many states conducted transportation studies in urban areas below 50,000 population on their own initiative, but such efforts were limited in scope. This paper focuses primarily on urban areas with less than 100,000 population. However, many of the observations and conclusions are applicable to larger areas also.

NEED FOR SIMPLIFICATION AND ALTERNATIVE APPROACHES

Because of the familiarity and preoccupation with the experience in large urban areas, the planning procedure used in the early small area transportation planning studies tended to follow the same format and depth of detail as required in the larger areas. The standard three-step procedure of trip generation, trip distribution and traffic assignment was used to forecast 20-25 year traffic loading on alternative transportation systems leading to the development of long range facility-oriented plans. However, the extension of long-range transportation planning to smaller urban areas necessitates a sizable commitment of resources.

The traditional transportation planning work program is not necessarily proportionate to the size of urban areas. Usually the number of work items is the same for both cases and the primary

Simplified Procedures for Long-Range Transportation Planning in Small Urban Areas

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difference is that larger areas require more repetition of work (3). Thus, because of the magnitude of work, even at the minimum level of repetition, and the need to collect relatively expensive inventory data, the cost and time required for carrying out the traditional transportation planning process in small urban areas are significantly high.

The cost and time constraints have adversely affected the ability to prepare transportation plans for small urban area en masse. Some highway departments reported a time commitment of three years to complete a typical small area study (4). At the present level of financial and manpower resources available to the state highway department/department of transportation, it is possible to undertake only a few new studies in each year. In this situation it is not considered practical to extend the modelling-oriented systems analysis techniques to smaller urban areas except through simplification. Simplified or short cut procedures can be justified also based on the hypothesis that they would provide results consistent with the accuracies demanded by the planning decisions to be made in small urban areas.

Approach Towards Simplification

Simplification in transportation planning procedures as a concept can be interpreted in more than one way. To some, simplification implies a reduction in data requirements and the use of less sophisticated models, but still maintaining the sequential traffic estimation procedure associated with the traditional urban transportation planning process. To others it means a change in the basic approach through a reduction in the complexity, specialization and reliance on large scale computer-oriented network anaysis (5). For example, the complexity of the planning procedure can be reduced significantly by resorting to conceptual systems planning, which does not rely on travel forecasts on every segment of a highway network.

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The above two different approaches are examples of a variety of alternatives towards simplification. These alternatives are not mutually exclusive and actually there is a need for each approach individually as well as collectively. This paper focuses primarily on the simplification in data requirements and modelling procedures, and briefly discusses the scope of conceptual systems planning.

SIMPLIFICATION IN DATA REQUIREMENTS AND MODELLING PROCEDURES

The exploration of simplified transportation planning procedures, which would retain the basic structure of the conventional long-range and systems analysis techniques, has focused on developing traffic estimation models with a minimum need for current travel data. The cost of conducting the home interview surveys has been estimated to be in the range of $7.25 to $40.00 per dwelling unit interviewed, with the proportionate cost of conducting such a survey in a small area representing as much as 50 to 60 percent of total study costs (5,6). Since statistical reliability requires the sample rate be higher in smaller areas, the cost per capita required to perform a home interview survey is relatively higher for these areas.

Alternative strategies have been forwarded in recent years to reduce the data collection costs and yet maintain the reliability of the models at an acceptable level. These are discussed below.

1. Eliminate the need for home interview O-D survey by borrowing trip generation and trip distribution models from transportation studies for other similar areas where such data were available. Internal-internal trips then can be synthesized based on these models. In some cases a single set of trip generation and trip distribution relationships was considered adequate to predict trips for a range of cities portraying similar characteristics, the hypothesis being that there is a high degree of similarity in the traffic characteristics of urban areas of similar size and economic character (7,8,9,10).

2. Reduce the size of the home interview O-D survey from the recommended

12.5 or 20 percent to a one or two percent sample. The small sample would be utilized to calibrate trip production and trip attraction models as well as calibrating a synthetic gravity model. The hypothesis advanced is that a reduced sample size either through a reduced systematic sampling rate or by cluster sampling will provide adequate basis for model calibrations. Any limitation of the small sample data may be overcome with available information from other urban areas (11,12,13).

3. Use disaggregate trip generation models with households as the basic trip generating units, the hypothesis being that the fundamental relationships based on household characteristics would have greater temporal and spatial stability than models based on data aggregated to the zonal level. Disaggregated models would thus possess greater transferability between cities (6,14,15).

An extensive literature has developed reporting on the use of synthetic procedures and tests performed to verify their accuracy. Some consensus is being reached. It has been found that synthesized models are capable of reproducing the internal-internal trip pattern with an accuracy acceptable for transportation planning in small urban areas. Yet it must be noted that in the case of borrowed relationships various adjustments have to be made to calibrate the models by reconciling the synthesized trips with observed volume counts and screenline checks (8). The testing of synthetic models has not progressed to the point where it is possible to identify and relate any pattern or consistency in errors to the population size of urban areas or some other socio-economic or travel characteristics.

The savings from synthesizing the internal trip pattern is quite substantial, although this advantage must be weighed against the fact that synthetically derived models cannot match the reliability of studies based on traditional internal home interview surveys. It is not clear exactly when the benefits of simplification must be sacrificed in favor of the added capability of responding to system complexities and the unique characteristics of an urban area's traffic problems. It should be pointed out that the synthetic development of travel pattern without an O-D survey is usually limited to internal-internal trips and most small area studies still require an external cordon survey, although a few attempts have been made to synthesize even the external travel pattern (16).

The concept of using borrowed models and/or small sample survey has been enhanced further with the increasing popularity of disaggregate household models for trip generation. There are several reasons for the increasing popularity of household category models for estimating trip productions in traffic zones (17). Some of the advantages, such as the adaptability of varying zonal schemes, are inherent characteristics of disaggregated household models and are beyond any question. Some of the other acclaimed advantages of such modes are not so obvious and have not been established conclusively. For instance, the household trip rates generally are expected to remain stable over a long period of time: however, a recent study has cast doubts on such temporal stability (18). Two other characteristics—the transferability of trip rates between different urban areas and the adequacy of a small sample in developing a household category model—need further investigations and are discussed in the following sections.

Transferability of Disaggregate Household Models

Many recent studies for small urban areas have reported the use of trip production models borrowed from another "similar" area. The criteria that have been used to evaluate "similarity" between two areas, in most cases, have been limited to population size and very gross indicators of the economic base. In order to evaluate whether such assumptions and gross criteria for similarity are valid, comparisons of trip rates from different areas were made as reported below.

Comparison of Trip Rates. In a recent investigation the trip rates of Milwaukee, which has a population of approximately one million, were compared with two small cities in the same region—Racine with a population of approximately 110,000 and Kenosha with a population of less than 100,000 (19). Milwaukee's trip rates were compared also with those for the rural area in the same region. The household categories and typical data used in the analysis are shown in Table 1, which actually represents the home based work (HBW) trip rates for Racine. The comparisons were based on trip rates treated in groups and utilized a statistic similar to Chi Square, which was developed specifically for this purpose. The statistic took into account the number of observations and the variance in each cell in evaluating the differences of the average trip rates.

The results of the above investigation indicated that there was a significant difference between urban and rural trip rates for the four trip purposes con-

CROSS-CLASSIFICATION ANALYSIS OF HBW TRIPS FOR RACINE, WISCONSIN (1972 DATA)

Auto Ownership (No. of Cars)	Household Size (Number of Persons 5 Yrs. or Older) 1	2	3	4	5 Yrs. or More
	0.26	0.48	1.00	0.29	1.20
0	(57)	(31)	(6)	(7)	(15)
	(0.64)	(0.98)	(1.15)	(0.70)	(2.17)
	1.13	1.53	2.15	2.11	2.08
1	(60)	(210)	(61)	(45)	(49)
	(1.09)	(1.40)	(1.35)	(1.64)	(1.72)
	0.00	2.14	2.63	2.31	3.42
2 or	(2)	(72)	(65)	(49)	(91)
More	(0.00)	(1.59)	(1.74)	(1.47)	(2.25)

Explanation of Cell Values: X.XX = Average Trip Rate
(XX) = Number of Observations
(X.XX) = Standard Deviation of Trip Rates

Source: Reference (20).

TABLE 1

sidered. However, the difference in trip rates between large and small urban area was not significant except for the nonhome based trip rates of Milwaukee and Kenosha, and home based shop trip rates of Milwaukee and Racine, which were found to be significantly different. Because the cities involved in the analysis are in the same region, it was considered necessary to extend the analysis to cities from different areas and a new investigation was carried out, for which person trip rates from three small cities—Elizabethton, Tennessee, with a population of approximately 20,000, Murray, Kentucky, with a population of approximately 27,000, and Paducah, Kentucky, with a population of approximately 45,000—were developed for three trip purposes (home based work, home based other and nonhome based) using the same household categories as previously shown in Table 1. The results of a comparison based on the data for the four cities of Racine, Elizabethton, Murray and Paducah, as shown in Table 2, indicated that in most cases the trip rates from different cities were significantly different (20). It must be pointed out that no universal conclusion can be drawn based on the limited number of comparisons and that the results merely imply that the transferability of trip rates between urban areas should not be taken for granted.

Sample Size for Household Category Models

The sample size for regular home interview O-D surveys is based on criteria that are primarily concerned with the reliability of aggregated values such

STATISTICAL COMPARISON OF TRIP RATES OF SMALL URBAN AREAS

Cities Compared	Trip Purpose	No. of Cell Pairs Included In Comparison[1]	'Q' Statistic[2]	$X^2_{.05}$ (df = No. of Cell Pairs)	Are Rates Significantly Different
Elizabethton (1968)	HBW	12	24.30	21.03	Yes
Vs.	NHB	12	18.67	21.03	No
Racine (1972)					
Elizabethton (1968)	HBW	9	33.39	16.92	Yes
Vs.	HBO	9	79.50	16.92	Yes
Murray (1967)	NHB	9	24.78	16.92	Yes
Elizabethton (1968)	HBW	11	46.61	19.68	Yes
Vs.	HBO	11	30.70	19.68	Yes
Paducah (1971)	NHB	11	142.46	19.68	Yes

[1]The cells with less than 15 observations were not included in the test.

[2]$Q = \sum \sum \{(X_{ij} - Y_{ij})^2 \div (SX_{ij}^2/N_{ij} + SY_{ij}^2/M_{ij})\}$

Source: Reference (20).

TABLE 2

as the zonal trip ends or the interzonal trips. Thus, in the case of regular surveys, samples must be taken from every zone and when the number of zones is substantial, even small numbers from each zone add up to a large overall sample. However, one of the advantages of disaggregate household models is the ability to "pool" data from various zones to common categories based on household characteristics, and thus the sample size requirements are much less.

Effect of Reducing Sample Size. A hypothesis related to the sample size for household category models which was examined, was that 30 samples for each cell would be adequate for estimating the average trip rate for each type of household. To test this hypothesis, the original 17 percent sample of 1020 households from Elizabethton, Tennessee, was used as the data base. The number of observations varied from cell to cell, and it was decided to reduce the sample size of cells that had observations larger than 30 by random sampling from the households of the respective cells. The samples in cells that originally had observations either close to 30 or less were not reduced at all. The overall sample size was reduced from the original 1020 to 445 households.

A comparison of the original trip rates and the new rates was performed by computing the statistic which was developed from comparing trip rates in groups and was mentioned earlier. The results of the Chi Square test for the three trip purposes, home based work, home based other and nonhome based, revealed no significant difference in the trip rates derived from the original and the reduced samples. It can be concluded from the results that from the standpoint of the household trip rates alone, the sample size can be much smaller than what usually is used in urban transportation studies.

CONCEPTUAL SYSTEMS PLANNING

Whereas a simplification in data requirements and modelling techniques is at one end of a range of alternatives towards simplifying long-range transportation planning procedures, conceptual systems planning lies at the other extreme. The basic approach underlying conceptual systems planning is to develop an idealized system of transportation facilities based on broad principles of functional design. Unlike the modelling oriented systems analysis techniques, this procedure does not attempt to develop detailed justification in terms of travel demand for every segment of a proposed system. Yet this idealized approach is especially applicable for long-range planning in small urban areas since a detailed justification is not necessary to establish the need for developing a sound basic framework of transportation facilities in all urban areas.

The applicability of conceptual systems planning in the case of small urban areas is further strengthened by the characteristics of the transportation system in these areas. The primary modes for passenger and goods movements within small urban areas are automobiles and trucks for which an efficient road system is essential. Public transit systems for small urban areas also utilize the urban streets, as practical service alternatives are limited to fixed-route and fixed-schedule bus systems possibly integrated with a demand responsive system for local distribution. Thus, the physical transportation system in a small urban area is relatively simple consisting primarily of a network of roadways or thoroughfares and the issues related to such a system in most cases also tend to be somewhat straight forward. Transportation problems in small urban areas usually are limited to a few congested arterial highways and/or lack of cross-town facilities. The identification of such problems and their solutions generally do not require sophisticated analytical tools. Thus, it may be argued that long-range transportation plans for small urban areas can be developed based on conceptual systems planning. The advantages of this alternative approach in terms of cost and time requirement are obvious.

Conceptual system planning is not a new technique. This approach was practiced as "thoroughfare planning" during the earlier stages of urban transportation planning. Actually several highway departments still use this simplified approach in the case of small urban areas usually below 25,000 population. The same agencies, however, rely on more sophisticated techniques for larger urban areas. The question that arises with respect to conceptual systems planning as an alternative approach to modelling-oriented procedure is how to decide in which cases the approach would be appropriate. It should be pointed out in this context that the conceptual system planning has a definite role to play in the transportation planning for both small and large urban areas. In addition to its potential to be used as a complete procedure by itself in the case of small urban areas, conceptual systems planning is needed for developing alternative test plans as part of the modelling-oriented planning procedure.

Simplified/or conceptual procedures naturally have their limitations and cannot be effective under all circumstances. Again, the procedure for conceptual systems planning itself may vary in terms of data inputs and citizen participation. There is a definite need to explore the full potential of a range of conceptual systems planning techniques and develop guidelines for their application in transportation planning for small urban areas.

SUMMARY AND CONCLUSIONS

It is recognized that transportation problems and opportunities in small urban areas are not comparable to those in larger metropolitan areas. The resources available to small areas in terms of funds and manpower also are frequently limited. Thus, simplified procedures for transportation planning must be sought.

Simplification can be interpreted as a reduction in data requirements and the use of less sophisticated models, but still continuing the use of sequential travel estimation procedure. Opportunities for simplifying the trip generation analysis with "borrowed" disaggregate household models were explored. It was demonstrated that the transferability of household trip rates between different urban areas could not be taken for granted. However, household category models based on small samples proved to have significant promise.

Simplification can also be achieved by completely bypassing the traditional modelling procedure and relying on conceptual systems planning. Actually there is a range of alternative approaches towards simplification and the applicability of a given approach would depend on the transportation issues and resource availability in a specific area. It is recommended that transportation planning procedures for small urban areas be made flexible recognizing that planning is performed in a variety of environment under different institutional and resource restraints. To further transportation planning in small urban areas, efforts should be devoted towards developing a variety of simplified procedures appropriate for different situations.

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