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16. Abstract

The Transportation Planning Division (TPD) of the Virginia Department of Transportation is responsible for developing transportation plans for areas in the state having a population greater than 3,500. Although transportation forecasting procedures for areas of 50,000 or more are well defined and uniform throughout the state, the procedures used for areas of under 50,000 population vary. Based on a review of available literature and a survey of the forecasting procedures being used by state transportation agencies throughout the country, it was concluded that the procedures currently being used are valid. A generalized process for formulating a forecasting procedure for specific areas is recommended, along with several suggestions to be considered when the procedures are being developed. Additionally, the report provides a summary of forecasting techniques currently in use.

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FINAL REPORT

UPDATING THE TRANSPORTATION PLANS IN VIRGINIA'S SMALL URBAN AREAS

by

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Graduate Research Assistant

and

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Research Scientist

Virginia Transportation Research Council
(A Cooperative Organization Sponsored Jointly by the Virginia
Department of Transportation and
the University of Virginia)

In Cooperation with the U.S. Department of Transportation
Federal Highway Administration

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ABSTRACT

The Transportation Planning Division (TPD) of the Virginia Department of Transportation is responsible for developing transportation plans for areas in the state having a population greater than 3,500. Although transportation forecasting procedures for areas of 50,000 or more are well defined and uniform throughout the state, the procedures used for areas of under 50,000 population vary. Based on a review of available literature and a survey of the forecasting procedures being used by state transportation agencies throughout the country, it was concluded that the procedures currently being used are valid. A generalized process for formulating a forecasting procedure for specific areas is recommended, along with several suggestions to be considered when the procedures are being developed. Additionally, the report provides a summary of forecasting techniques currently in use.

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Planning Procedures

For the convenience of the reader, the following list of specific planning procedures and page numbers is provided.

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INTRODUCTION

The Transportation Planning Division (TPD) of the Virginia Department of Transportation has the responsibility of developing transportation plans for areas in the state having a population greater than 3,500. Areas having a population of 50,000 or more require a "3C" planning process. The planning procedures for areas having a population between 3,500 and 50,000, however, are less formalized. Further, many of these areas have plans that were developed in the mid-1960s using demand forecasting procedures that are data-intensive and time consuming. Since many of these plans have target years in the mid-1980s, there is a need to update them using state-of-the-art procedures that incorporate simplified and less costly techniques.

PURPOSE AND SCOPE

The major purpose of this study was to recommend procedures for developing new transportation plans for the small urban areas in Virginia. These procedures should produce the most accurate plan within the framework of the TPD's existing manpower and resources. Specifically, procedures for travel demand forecasting that satisfy the following objectives and needs are required:

1. The procedures must lead to the development of long-range plans for these areas that could be used reliably for 20-year forecasts.

2. The procedures must be capable of areawide systems analysis. Corridor or subarea capabilities are not sufficient.

3. The procedures should minimize data needs and collection. For example, origin-destination (O-D) and external survey information should be synthesized.

4. The procedures should minimize the resources required for the completion of the forecasts. Procedures that require minimal manpower and eliminate the need to use a mainframe computer should be emphasized.

5. The procedures should be adaptable to any small urban area's planning needs. The objective should be to seek an approach that could be used consistently throughout the state.

The scope of this study was limited to an inventory and review of the existing transportation plans for areas in Virginia falling within the aforementioned range of population and to a review and evaluation of current planning procedures in small urban areas. It was hoped that an existing procedure could be adapted for use in Virginia. It was beyond the scope of this study for the investigators to select a procedure and use it in an actual case study.

STUDY METHODOLOGY

The study consisted of the tasks described below. It is important to note that coordination with the TPD was maintained throughout the course of the study. A task group consisting of several TPD personnel was formed to provide advice during the study. This task group was apprised of the study's progress, and members provided valuable input through review of the findings. It was this input that determined the direction of this investigation.

Inventory and Review of Existing Plans

The transportation plans for many of the small urban areas in Virginia were obtained from the TPD. These included plans that were developed in the mid-1960s and plans that have been recently updated. The supplemental technical reports for the updated plans were obtained for the cities of Harrisonburg, Winchester, and Martinsville.

Review of Literature

A comprehensive review of pertinent literature on transportation planning and forecasting techniques for small urban areas was conducted to determine state-of-the-art procedures. This effort was aided by a computer search using the Transportation Research Information Services as a data base.

Survey of Other States

A survey of other state transportation agencies was undertaken in order to determine the planning procedures used in their small urban areas. Follow-up contacts were made as appropriate.

Application of Findings in Virginia

The findings from the aforementioned two tasks were evaluated in view of the TPD's objectives and needs. The task group mentioned previously provided key input into this task. The completion of this task represents the fulfillment of the purpose of this report.

CURRENT TPD PLANNING PROCEDURES FOR AREAS WITH POPULATIONS BETWEEN 20,000 AND 50,000

The TPD has the responsibility of developing transportation plans for areas in the state having a population greater than 3,500. This study focused on those areas having a population between 3,500 and 50,000. Many of these areas have plans that were developed in the mid-1960s, and travel demand was forecast through the use of O-D survey results and the PLANPAC computer modeling process. This modeling process was used for three recently completed plan updates in Harrisonburg, Winchester, and Martinsville, all of which have a population greater than 20,000. The technical supplements to these thoroughfare plans(1,2,3) detail the procedures, socioeconomic variables, and data sources used in the development of the plan update. They also contain tabular listings of the data by traffic analysis zones and the O-D trip tables that were produced.

Figure 1, taken from the Winchester study, is a flow chart that depicts the general process used in all three areas. The synthetic modeling in the interim and forecast years was done using the PLANPAC battery of programs, with current and forecasted socioeconomic data as input. The purpose of the interim year thoroughfare system evaluation was to determine how well the previous modeling process (base year) could predict future traffic patterns using updated socioeconomic data. If the synthesized interim year data compared favorably with actual traffic counts, no revision to the trip generation, trip distribution, or traffic assignment models was necessary. If significant revision was necessary, the cost and time involved increased dramatically. Following is a description of the elements in the process for the interim or current year and the forecast year.

Cordon Line and Traffic Zone Revision

Due to annexations or general urban growth, it was necessary to change or expand the zonal configuration of the study area. Socioeconomic data for the interim year were collected for the expanded area.

Socioeconomic Data

In order to validate the models developed for the base year, it was necessary to collect and allocate current socioeconomic data. The elements and sources of these data include the following:

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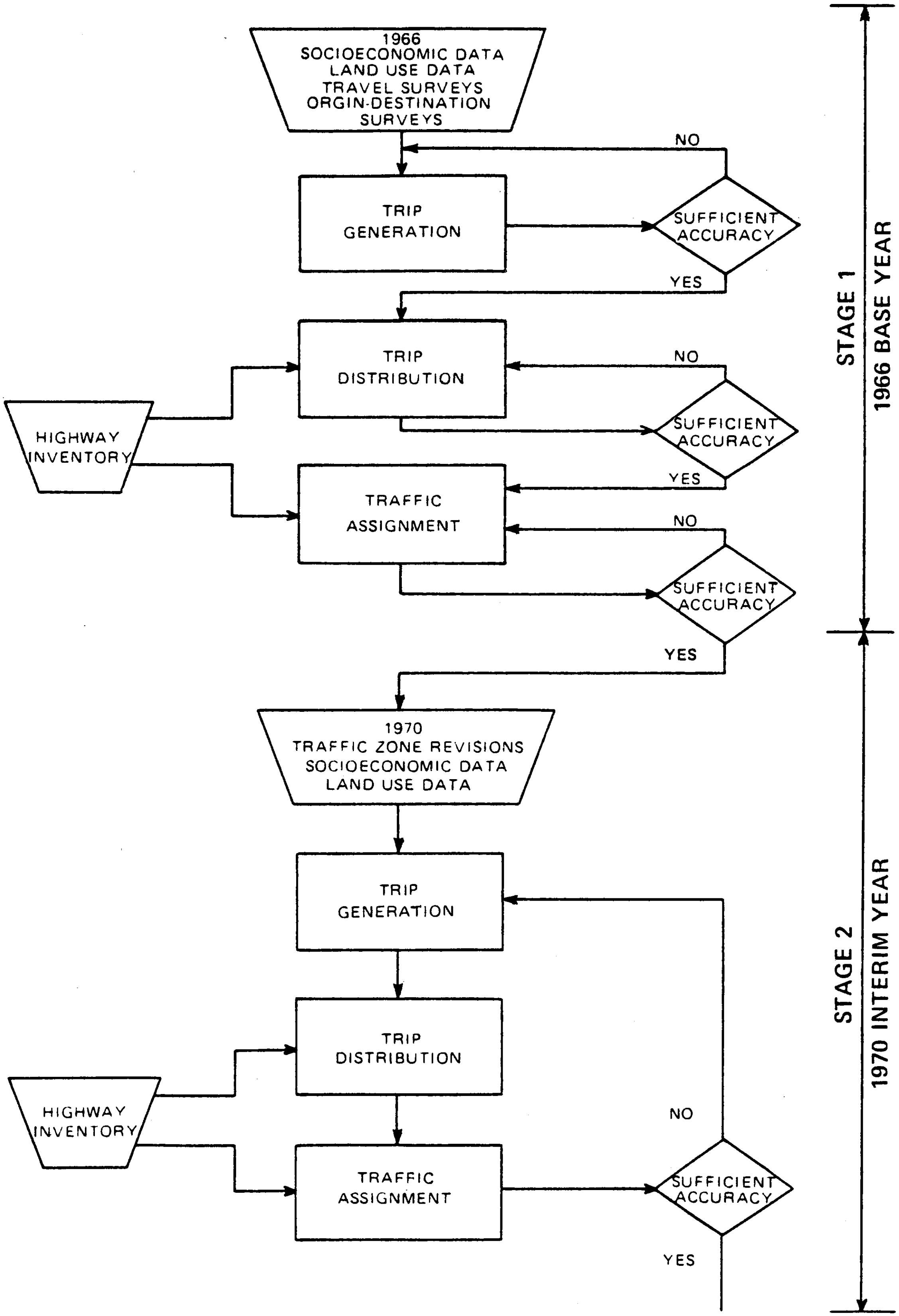

Figure 1. Winchester 1995 Transportation Plan Update-general flow chart.

Source: Winchester 1995 Transportation Plan Update: Technical Report

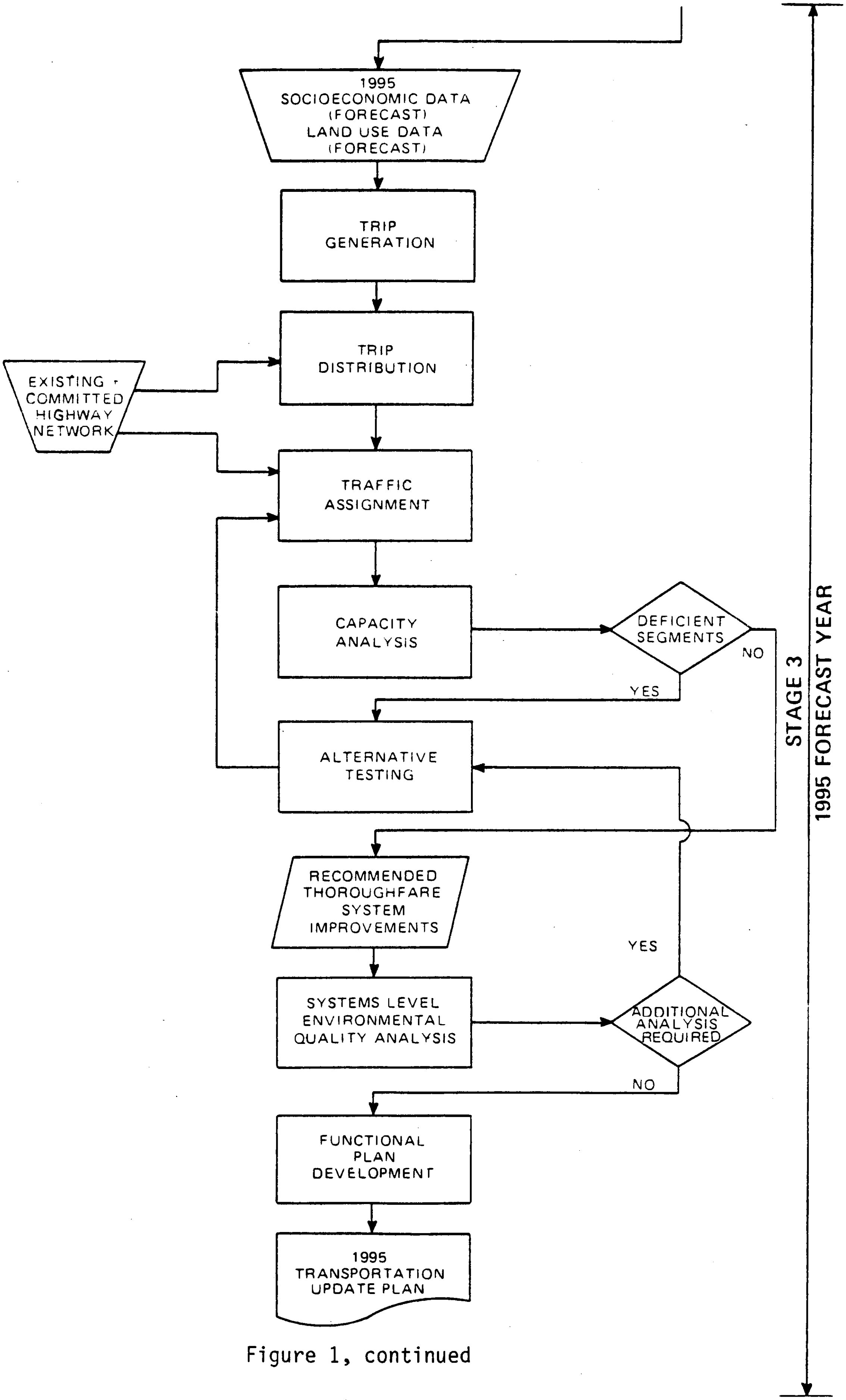

Figure 1, continued

1. Address Coding Guide

This document is an alphabetical listing of all streets within the study area denoting what block ranges are within the given traffic zones. This listing is used to assign addresses to their respective location by traffic zone. To compile this document, it was necessary to make a complete inventory of all streets and to make a field survey to determine breaks in block ranges by traffic zone.

2. Business Index

This document is an alphabetical listing of businesses and their employment or retail sales. The index also includes the address and nature of the business. By using the Address Coding Guide and this index, the number of employees and the volume of retail sales of each business was assigned to the appropriate traffic zone.

Employment figures were obtained through interviews with employers and data from the Virginia Employment Commission. The figures for volume of retail sales were obtained through the state's sales tax program from the Virginia Department of Taxation.

3. Land Use Survey

Land use was gathered through visual inspection and recorded on a topographic map of the study area.

4. Dwelling Units

The number of dwelling units was counted during the land use survey and stratified according to single family, multiple family, and group quarters. Occupancy was also noted.

5. Population

The 1970 U. S. Census data were used by applying the appropriate persons-per-dwelling-unit rates to the dwelling-unit counts previously compiled for each zone. In cases in which the interim year was not a census year, the current persons-per-dwelling-unit rate was estimated based on a review of past census data.

6. Automobiles

Automobile ownership per zone was derived and assigned to traffic zones using a combination of two procedures. The first matched addresses from automobile registrations obtained from the Department of Motor Vehicles with addresses in the Address Coding Guide to assign autos to each zone. The second was accomplished by dividing the population of the zone by the persons-per-auto rate for the zone. The results of each procedure were reviewed and checked for reasonableness, and a final number of vehicles per zone was chosen.

7. Student Enrollment

In those plans using student enrollment as a variable in the regression equations, data were obtained from the local school board. Enrollment data for other educational facilities, such as private and parochial schools, were obtained by contacting them on an individual basis.

Trip Generation

The trip generation linear regression equations that were developed from the survey data used in an area's previous travel-demand model were used as the basis for the current trip-generation process. Interim year socioeconomic data were input into the equations with the resultant unbalanced zonal productions and attractions by trip purpose as output. Regression equations were developed for the following trip purposes:

1. Home - work productions
2. Home - work attractions
3. Home - other productions
4. Home - other attractions
5. Non-home-based productions and attractions
6. Internal/external attractions

Productions were held constant and attractions were factored to match the productions. Since the non-home-based productions and attractions were developed using the same equation, it was not necessary to factor either. For internal/external (I-X) trips, only attractions were developed for the internal zones. Productions were determined from traffic counts at external stations. The percentage of the total area's I-X trips at each external station was applied to the total I-X attractions as developed by the trip generation equations to provide I-X trip productions at each external station. The I-X trips were subtracted from the external station counts, and the remaining trips were considered through- or external-to-external (X-X) trips. These were then factored and distributed with the Fratar Model(4).

Trip Distribution

The Gravity Model was used to distribute all I-I and I-X trips. Input to the model was the previously developed zonal productions and attractions, friction factors and travel times from the base year, and the existing highway network description data. If necessary, the friction factors were adjusted using the Gravity Model calibration program. All internal-related trips were split 50/50 to create in combination with the output of the Fratar Model a balanced O-D trip table.

Traffic Assignment

The final step for the interim year check was to assign trips to the existing highway network. This was done using the all-or-nothing algorithm, which assigns trips based on the shortest travel time.

Accuracy Checks

In the absence of survey data, the only check for accuracy for the interim year was a comparison of the synthesized daily traffic volumes with known ground counts at screenline stations and on several individual roadway links.

If it was found that the general areawide trip-generation regression equations and the Gravity Model distribution procedure simulated the interim year travel patterns effectively, it was concluded that the developed models were sufficient to forecast travel data in the future.

Forecast Year Socioeconomic Data

In order to adequately assess the future transportation needs of an area and to utilize the various models developed for the base and interim years, accurate projections of the same socioeconomic variables are needed. An important factor in this process is the input from localities. The following describes the procedures used for forecasting and distributing each of the socioeconomic variables.

Population

In Virginia, all population projections used by state agencies are obtained from the Department of Planning and Budget. A projection for an area is provided on a jurisdictional basis, and it must then be disaggregated to the traffic-zone level on the basis of each zone's ability to attract and support additional population. This was determined by factors such as availability of suitable vacant land, relative location of the traffic zone, and knowledge of planned development. Specifically, the distribution was based on information obtained from local officials regarding commercial activity, plans for industrial development, and expansion of government services, such as new schools.

Dwelling Units

Having distributed the forecast year population to traffic zones, the number of expected dwelling units was derived through the use of persons-per-dwelling-unit rates. Rates in the forecast year were developed by examining historical trends found in census information and then applied to the zonal population forecasts to determine the future number of dwelling units. Information provided by local officials was used to determine the reasonableness of the dwelling-unit forecasts.

Automobiles

The procedure for determining auto ownership for the forecast year was based on statewide persons-per-auto rates for the interim or current year and the forecast year. The percent change in the statewide rate for this period was applied at the zonal level to develop a forecast for persons-per-auto rate by zone. The forecast rate for each zone was then applied to the forecast population to derive auto ownership per zone.

Employment

Employment data from the Virginia Employment Commission's records were used to make forecast-year employment projections based on historic trends. Rates of change derived from these projections were applied to the interim year survey data to produce a forecast year total employment control figure for the area. This control figure was then disaggregated by sector of employment utilizing city-to-state and county-to-state ratios for each sector. Distribution to traffic zones was made by employment sector. The distribution was based on information obtained from local officials regarding commercial activity, plans for industrial development, and expansion of government services, such as schools. The zonal employment by sector was then totalled to yield forecast-year employment by traffic zone.

Retail Sales

Retail sales forecasts, when needed, were obtained by using historical sales data from Census of Business publications to make projections from which an interim-year to forecast-year percent increase could be determined. The zonal distribution of the study area's increase in retail sales was a two-step procedure. The first step involved the distribution of that portion of the sales increase to be spent in the central business district (CBD) and shopping centers. Buying power allocation was based on each zone's percent of the total population increase. The portion of each zone's buying power to be spent in the CBD or at shopping centers was determined by the use of a Gravity Model. Travel time from the zones to the CBD and to the shopping centers was the variable factor used in the model. The second step was to distribute the balance of the projected increase in sales activity to zones other than CBD and shopping-center zones. This was based on the zone's existing retail activity and its population and employment growth. The distribution of these sales was also accomplished with the Gravity Model.

Forecast-Year Trip Generation

As with the interim year, the trip generation regression equations developed for the base year were utilized with forecast-year socioeconomic data. The resultant output was forecast-year zonal vehicle trip productions and attractions by purpose. These were then balanced through factoring of productions for use in the Gravity Model distribution process. The Fratar Model was again used for distribution of X-X trips.

Forecast-Year Trip Distribution

Trip distribution was accomplished through the use of the Gravity Model for I-I and I-X trips. When these trips were distributed and combined with the output from the Fratar Model, a forecast year zone-to-zone trip table was produced and used for all subsequent alternative testing for the forecast year.

Forecast-Year Traffic Assignment

The forecast-year vehicle trip table was loaded on the existing-plus-committed (E+C) thoroughfare system utilizing the all-or-nothing traffic assignment process. A capacity analysis was performed utilizing procedures from the 1965 Highway Capacity Manual. Subsequent recommendations for improvements of deficient sections were then tested in an effort to develop a transportation plan that would alleviate these deficiencies.

CURRENT TPD PLANNING PROCEDURES FOR AREAS WITH POPULATIONS LESS THAN 20,000

As stated previously, the use of the preceding procedure has generally been limited to those urban study areas with a population greater than 20,000. Areas of this size currently comprise less than 20% of the total areas in Virginia with a population between 3,500 and 50,000. Transportation planning for the rest of these areas has typically focused on short-range transportation systems management (TSM) improvements and use historical trends for forecasting future travel demand along with external cordon O-D surveys. This procedure is outlined below.

In predicting future travel desires, trends in traffic flow, population, and vehicle registration are examined. In addition, due to the typically high percentage of through trips found in small areas, external cordon O-D surveys are conducted in order to assess potential bypass needs.

As a part of the regular work of the VDOT, traffic counts are obtained seasonally on all primary routes within the state. From these counts, annual average daily traffic volumes are developed and published. Traffic volumes on secondary routes are developed biennially. Using these data, historical trends for each route are developed and used in estimating travel increases.

Trends in population provide an indication of the rate of growth and denote relative levels of activity within an area. Often, data are not available or are insufficient to develop population statistics for the specific survey area included in the study. Instead, an approximate trend for the area is obtained through a comparison of population trends for the state, county, and the town. Those trends are then extrapolated graphically in order to determine what the situation should be in the future.

Historical trends in motor vehicle registrations are also a reliable index of traffic growth in an area. As is the case with population data, motor vehicle registrations cannot be refined to match the specific study area. Again, available state and local historical trends are extrapolated graphically in order to obtain projections of future registrations.

Through analysis of the trend projections for traffic flow, population, and vehicle registration, a growth factor is developed and applied to existing traffic counts to assess future deficiencies and needs.

The major purpose of the external cordon O-D survey is to develop the I-X and X-X trip data in the study area. The information obtained is used in conjunction with the previously forecasted traffic volumes in the evaluation of the existing thoroughfare system and in determining the need for additional facilities, such as bypasses.

LITERATURE REVIEW - GENERAL

In the last decade increased attention has been focused on the transportation planning needs, requirements, and processes for small urban areas. This reflects a recognition on the part of federal and state planners that, due to the unique character and diversified needs of many small urban areas, the conventional urban transportation planning process used extensively throughout the 1960s and 1970s may not be necessary or appropriate in many cases. The planning process used in larger urban areas is often exceedingly comprehensive and time consuming, while at the same time unresponsive to the special needs of smaller areas.

This new focus is evidenced, in part, by work done recently by the Transportation Research Board's (TRB) Committee on Transportation Planning for Small- and Medium-Sized Communities(5). This report was done in response to the findings and recommendations of a workshop conducted by the TRB and sponsored by the UMTA, FHWA, and U.S. DOT(6). These findings showed a need for the following:

1. Improved communication between the planner and the decision maker.
2. Local determination of goals, problems, and planning processes.
3. Sharing of technical assistance among various public and private entities.
4. Sharing of techniques.
5. Reduction in the administrative burden inherent in the transportation planning process.
6. Greater flexibility in the planning process.

These needs are a reflection of the growing awareness that local participation is often essential to the implementation of any proposal, particularly in smaller areas. The integration of the transportation planning process into the regional planning process is a necessity and is possible only through a flexible and cooperative approach. In order to be accepted, plans must address local problems and concerns as well as satisfy the state and regional objectives.

Concurrent with this new local emphasis is the existence of budgetary and time constraints, which can limit the level of effort and resources that can be spent on transportation plans. Accordingly, a need was recognized for small area planners to have an inventory of transportation planning procedures available to them. It was realized that different situations require different analysis procedures. In fact, the procedures from the Transportation Planning for Your Community series(7) were developed to aid smaller urban area transportation planners in their analyses.

Stover(8) identified four factors which can be used to determine an appropriate study design for an area.

1. Status of Planning

In many of the areas targeted by this research, a local comprehensive land-use plan may not exist. In such cases, any substantial effort on a transportation plan could prove wasteful. Such an effort cannot proceed without first developing an effective local planning process. Local goals and objectives must be determined. Also, many improvements and projects cannot legally proceed without the existence of a comprehensive plan.

2. Growth Potential

The potential for economic and population growth is a key factor in determining the extent of any transportation system analysis. An area with low growth potential would probably not require a comprehensive modeling procedure in order to determine any transportation needs. With the possible exception of evaluating a major bypass, the area's travel demand can be forecast using a factoring approach to analyze the existing situation. In these areas, TSM and other traffic engineering measures will no doubt alleviate many deficiencies.

3. Local Staff Skills

If local officials (represented by their staffs) are not involved in the development of a transportation plan, implementation will be difficult. Also, in situations in which socioeconomic data are required for the forecasting procedure, a lack of available local data can add significantly to the cost and time required for a study.

4. Community Size

In a very small urban area, the existing street system will work reasonably well. Extensive corrective measures will not be required. As a result, expensive, data-intensive modeling procedures are not needed to test elaborate alternatives.

The TRB Committee report (5) provides a synthesis of planning practices for small- and medium-sized urban areas. Various case studies are used to illustrate variations of several planning procedures that can be used according to an area's characteristics and needs. An underlying assumption of this synthesis is the realization that a formal and well-documented approach may not always be appropriate. Studies that emphasize short-range needs primarily and long-range needs in a secondary capacity are highlighted. A schematic representation of this idea is shown in Figure 2.

Fleet, et al.(9) provide the following summary comments and simplified guidelines for dealing with the appropriate level of effort for small area transportation studies:

1. The trend should be toward eliminating unwarranted complexity, excessive data collection, and over-sophisticated computer processes.

2. Some areas have developed very systematic, efficient methods of analysis based on computer models; however, the mere presence of a computer modeling package should not necessarily dictate the approach used.

3. For many areas, an incremental planning process may be the best approach; that is, develop a responsive, ongoing capability through a traffic engineering and transit development program approach. If situations warrant, expand the techniques to be more responsive to other issues.

4. The long-range time frame is not fixed. Every area is not constrained by 20 years as the appropriate planning horizon.

5. Reserve travel-demand modeling for major system testing. The use of land use/road spacing techniques and functional classification are more appropriate for lower facility types.

6. Make greater use of sketch planning and gross-level analysis to test alternative systems and to reject noncompetitive options.

7. Procedures should be kept operational, and excessive startup times should be avoided.

8. Greater use should be made of traffic engineering studies. In many areas, the best approach may be the combination of several traffic engineering studies--e.g., special generators, parking, intersection analysis, safety, external travel analysis, etc.

9. Eliminate large-scale O-D surveys and think in terms of small sample surveys; if surveys are needed at all.

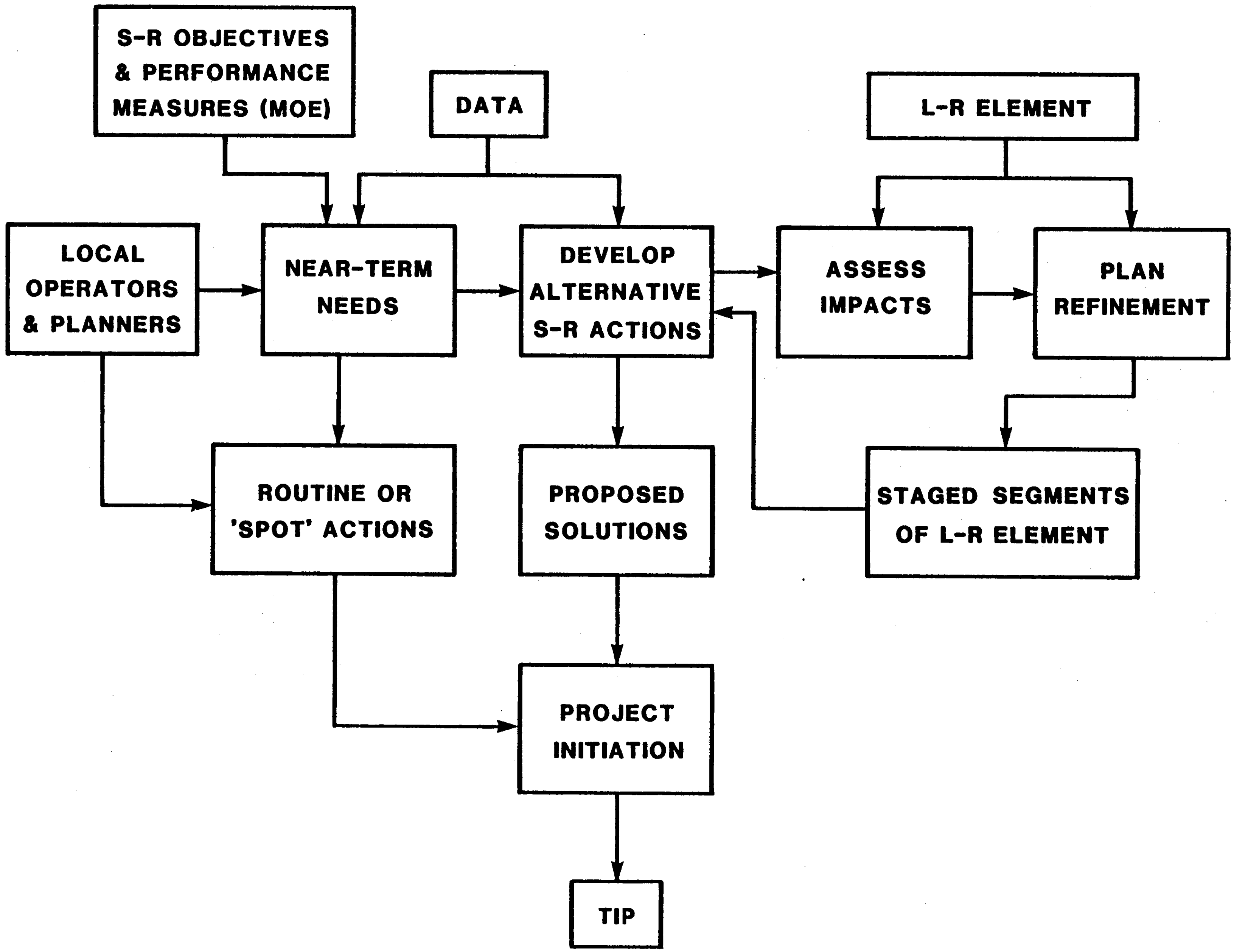

Figure 2. Urban transportation planning process short-range emphasis.

Source: Achieving a Long-Range/Short-Range Planning Balance with an Appropriate Level of Effort

10. Emphasize the surveillance of existing conditions by means of a comprehensive traffic-counting program. This is important in evaluating the effectiveness of improvement programs and checking synthetic traffic estimating procedures.

11. Maximize the use of secondary sources for socioeconomic data, previously developed travel relationships for travel data, and generalized system supply data.

12. Emphasize the short-range for transit, where easily changed bus and paratransit options are the norm.

13. For many small areas, informed judgment and common sense may contribute as much as detailed technical analysis.

14. Evaluate the long-term consequences of all short-term alternatives. The future options should be examined and varied in light of changing community attitudes.

15. Emphasize procedures for quickly assessing alternative programs and their cost effectiveness.

In addition, Figure 3 and Table 1 demonstrate the relative distribution of planning resources by key criteria and their ranges. They are intended only as a guide and do not represent an attempt to specify any formal distribution of resources.

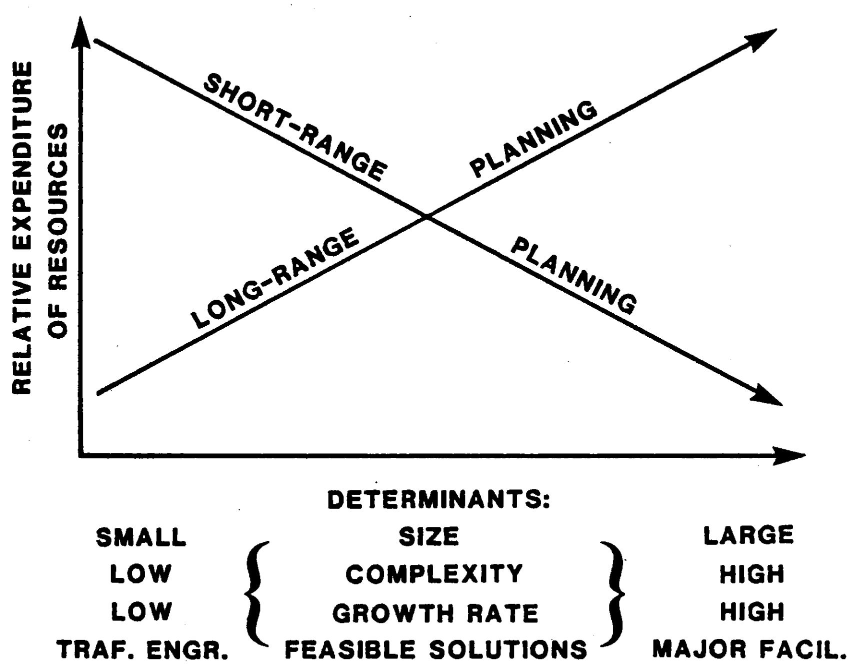

Figure 3. Relative distribution of planning resources.

Source: <u>Achieving a Long-Range/Short-Range Planning Balance with an Appropriate Level of Effort</u>

TABLE 1
LEVEL OF EFFORT SCALE

Criteria	Range	
1. Local Issues and Policies		
Growth policies	No growth	Growth
Air Quality	No problem	Transportation Control Plan (TCP) required
Land use development patterns	Limited (filling in)	New concentrations (redistribution)
CBD	Allow decline	Revitalize and promote growth
Attitude of State and local officials	Good and open to new approaches	Closed--do it the old way
2. Area Characteristics		
Growth potential and past trends	Low (- to +1%)	High (+5%)
Physical constraints	Limits growth potential	Allows spread growth
Size	Near 75,000	Near 300,000
Type of area	Self contained and limited attractor of new industry	Bedroom community to rapidly growing metro area
Employment location/distribution	Low density and scattered	Significant major generators
Land use development patterns	Limited (filling in)	New concentrations (redistribution)
CBD	Declining	Growing and dynamic
3. System Characteristics		
Complexity and nature of problems:		
a. Extent and limits of congestion	Limited and localized	Severe and areawide
b. Traffic flow and capacity	Level of service B-C, few links with high V/C ratios	Level of service E extensive, high # of links with high V/C ratios
c. Status of existing system	Mature	Developing and expanding
d. Extent of public transportation	Good regional service	None or limited service
e. Source of traffic problems	External (through travel predominate with existing Interstate highway bypass)	External (no existing by pass) or internal (area is attractor)
f. Parking supply	Adequate	Limited
Effect of other services	Transportation facilities developed as part of comprehensive development --orderly	Transportation service plays "catch up" only

Criteria	Range	
4. Range of Feasible Solutions		
Amount of capital resources available	Limited	Not as limited
Possible transportation solutions	Traffic engineering, transit operation	New highway systems, major facilities
5. Constraints on Planning		
Local regulating constraints	Supportive of planned development and effective	Hinderance to effective TSM actions--more coordination
Staff capability	Little or no staff	Full skills mix
Amount of planning resources available	Limited	Not as limited
Attitude of local and State officials	Good and open to new approaches	Closed--do it the old way
Program level support by planning	Supportive	Significant justification required
6. Existing Planning Process		
Status of existing plans and planning	Established process	None or long-range plan evaluation needed
Existing data base	Adequate data base	None

Table 1, continued . . .

Source: Achieving a Long-Range/Short-Range Planning Balance with an Appropriate Level of Effort

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LITERATURE REVIEW - PLANNING PROCEDURES

A comprehensive review of transportation system planning literature revealed two general methodological categories currently in use. The first category includes those procedures that synthesize travel demand following the traditional four-stage urban transportation modeling system. These stages are trip generation, trip distribution, modal split, and traffic assignment. It was found that modal split analysis was unnecessary in most small urban areas. As a result, detailed discussion of this stage is avoided in this report; however, most of the microcomputer software planning packages incorporate this capability.

These synthetic modeling procedures vary in scope and effort, from manual quick-response techniques to the use of a simplified adaption of the PLANPAC/UTPS computer program sequence. The simplified procedures make extensive use of transferred or previously developed trip-generation rates or equations.

The second methodological category includes those procedures that utilize trend and growth-factor analysis to forecast travel demand. These procedures are less data-intensive than most of the synthetic procedures; however, there seems to be a corresponding loss of accuracy and reliability in their application. The literature search and the survey responses revealed that their use is limited in areawide system planning. There are, however, situations in small urban area analysis in which their use might be appropriate, such as subarea or corridor analysis.

Various procedures used in these methodologies are summarized in the remainder of this section.

It is noted that the first four techniques are described in Transportation Planning for Your Community(7). This document was published in 1980 by the U.S. Department of Transportation (DOT) as a series of manuals that covered the following subjects: traffic planning, programming projects, system planning, transit planning, monitoring, and forecasting. The system planning manual reviews a non-computer and a computer technique, a ground-count projection technique, and a partial-matrix technique.

Non-Computer Techniques

Non-computer techniques are described mostly by referencing the NCHRP Report Number 187, Quick-Response Urban Travel Estimation Manual Techniques and Transferrable Parameters - A Users Guide(10). Non-computer techniques are suitable for analyses related to problem identification and location. Although they are most appropriate for subareas or specific sites and corridors, they may be used for an entire urban area if the number of zones is no more than 40 and the network has no more than 200 links.

These manual techniques have been incorporated into the Quick Response System (QRS) microcomputer planning package, which includes a detailed documentation and tutorial manual. The latest version of this software is limited to the following:

Maximum number of zones (including external stations)	50
Maximum number of links	800
Trip purposes	3
Gravity Model "F" factors	45

A flowchart illustrating the steps in the QRS procedure is shown in Figure 4.

Two studies reviewed concerned the application and evaluation of the QRS(11,12). A summary of their conclusions follows.

1. Some data files must be laboriously reentered every time the model is run, e.g., for testing of alternatives.

2. Screen prompts and written documentation sometimes fail to give sufficient guidance.

3. The Gravity Model output is never transposed into an O-D matrix, although it is labeled as such.

4. The mode-choice model has several undesirable features, such as the lack of an explicit transit penalty. This makes calibration difficult.

5. Use of the graphs showing airline distance vs. travel time vs. distribution factors can be tedious and time consuming.

6. The best application of QRS might be for local traffic analysis and not for corridor or regional studies.

In response to these conclusions and other limitations related to the package's capabilities, the QRS package is currently being upgraded. This work is being performed at the University of Wisconsin by A. J. Horowitz. The new highway side component is now being tested in case study situations. This new package should be available early in 1987. The transit side component is due to be tested in January 1987.

Although the previous 1984 revision was intended basically as an aid in performing the computations required for the manual procedure in NCHRP 187(10), this updated version will integrate networking capabilities similar to a PLANPAC modeling analysis. The theoretical background and use of transferrable parameters embodied in the original QRS is still used; however, the capabilities and options have been greatly expanded. A summary of some of the main new features follows(13).

1. A powerful graphic network editor with a color graphic capability will be added. As an input device, it will be able to save network and zonal data. In addition to providing a new graphic capability, the reentering of data files to test alternatives will no longer be necessary.

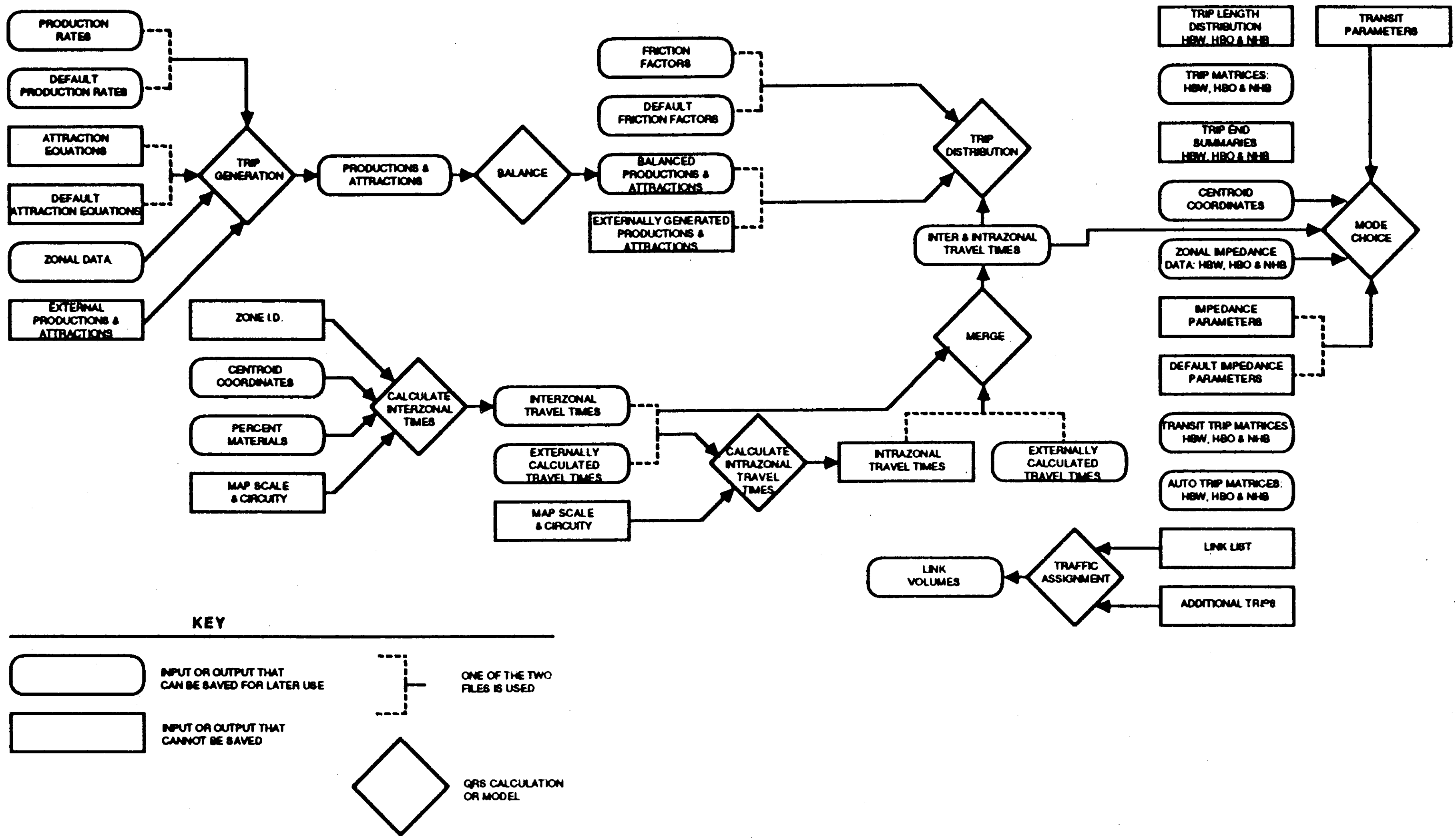

Figure 4. QRS flowchart.

Source: "Travel Demand Forecasting with the Quick-Response Microcomputer System: Application and Evaluation of Use"

2. The coded highway system will be network-based, much like a PLANPAC or UTPS network.

3. The size of the networks that can be modeled has been increased significantly. The QRS will now handle 250 zones, 1,750 nodes, and 2,500 links. These numbers can be varied.

4. The original all-or-nothing assignment capability has now been upgraded to include various assignment algorithms. All-or-nothing, capacity restraint, and equilibrium assignment methods are now possible. These options can be expanded through incremental and iterative procedures. The equilibrium assignment is accomplished using the iterative technique rather than the non-linear technique. Initial work indicates that equilibrium is approached after four or five iterations.

5. The new version will be capable of incorporating automatic turn penalties and turning movements.

6. The new transit side will contain a dual-mode split model. This model will incorporate a logit-mode split equation. Network analysis will be accomplished using a stochastic multipath algorithm.

Computer Techniques

The four-step planning procedure can be accomplished in a simplified manner by combining appropriate UTPS software and appropriate default rates developed by urban area size. The use of these programs is illustrated in Figure 5. These programs have the following functions.

1. <u>HR</u>: Produces a computerized street and highway network description (historical record) from coded highway link data.
2. <u>UROAD</u>: Produces a matrix of travel times between zones.
3. <u>SCAGM</u>: Applies trip generation rates and a Gravity Model to produce a trip table.
4. <u>UMATRIX</u>: Converts person trips to vehicle trips, and incorporates through trips and truck trips.
5. <u>UROAD</u>: Converts the P & A table to O-D format (split 50/50), and assigns trips to the network.

Each of these programs requires certain data as input, as shown in Table 2. The programs contain multiple options to allow their use in a wide variety of situations. The UTPS documentation should be obtained and reviewed before any application of this procedure is attempted.

The following four traffic-assignment options can be selected by the user: all-or-nothing, all shortest paths, probabilistic multipath (stochastic), and capacity restraint.

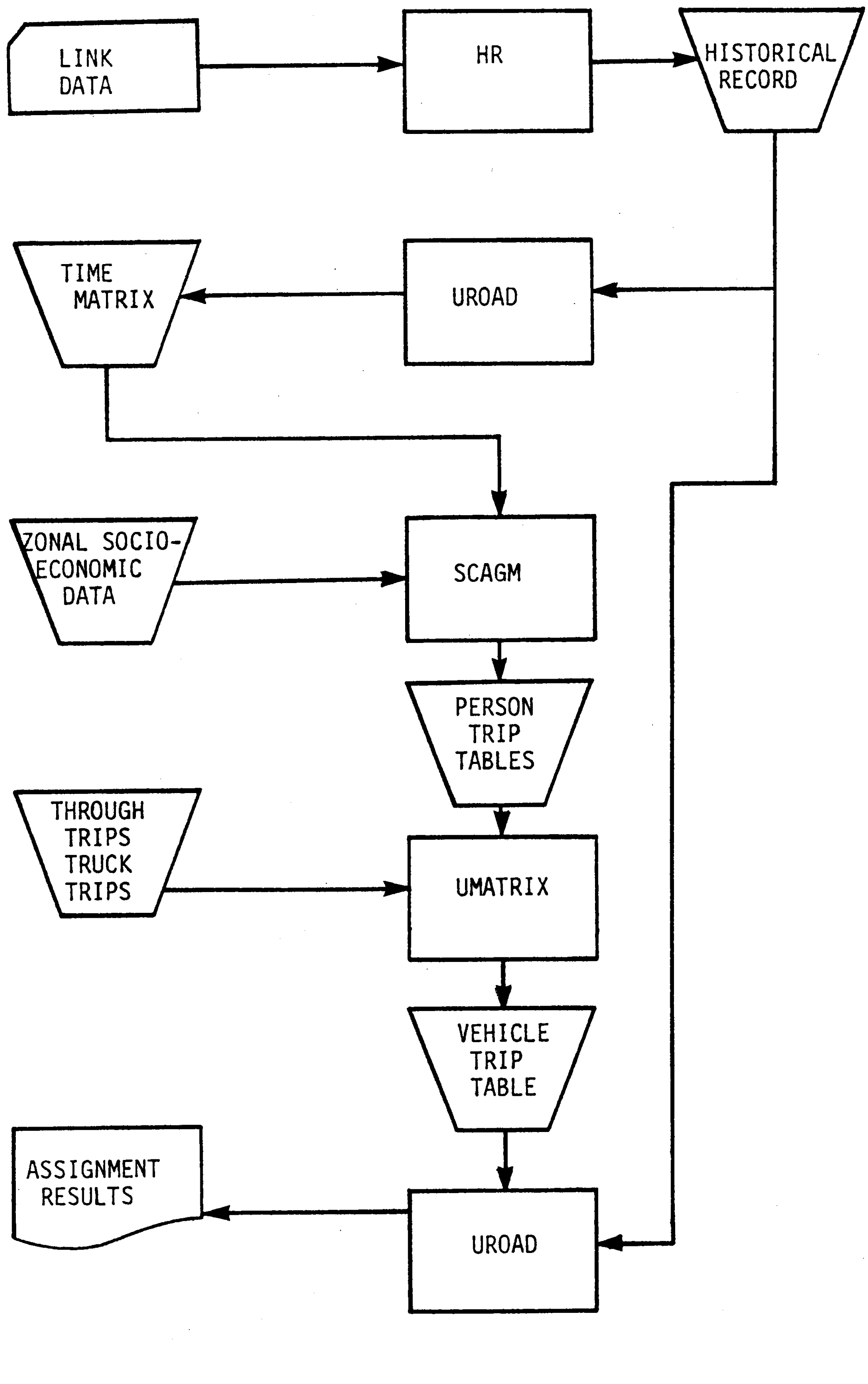

Figure 5. Simplified chain of UTPS programs for four-step transportation planning.
Source: Transportation Planning for Your Community

Table 2

Data Input for UTPS Programs

Program	Input
HR	A - node B - node Distance Time or speed Options No. of lanes Parking code Land use Area and facility type
UROAD	Historical record (from HR)
SCAGM	Time matrix (from UROAD) Optional special generators Friction factors (default available) "K" factors (optional) Zonal type 1 data - income and/or autos - dwelling units Zonal type 2 data - retail employment - non-retail employment - intrazonal travel time - terminal time production - terminal time attraction Trip generation rates (default files)
UMATRIX	External-external trips
UROAD	Historical record (from HR) Vehicle trip matrix (from UMATRIX)

Various report output tables from UROAD include the following:

1. Link and turn volumes
2. Summary of VMT and balance speed by V/C ratio, facility type, and geographic location
3. Same as number 2, except V/C ratio is volume/count
4. Summary V/C ratio and total volume by link group
5. Same as number 4, except V/C ratio is volume/count
6. Impact estimates (pollutants, cost, fuel, accidents)
7. Vehicle cost of travel summary

Ground Count Projection Technique

This traffic estimation approach is basically a link-count factoring approach requiring no model calibration or validation. External travel is forecast separately from internal travel and is assigned to the network. The ground count factors are based on trip characteristics normally used for estimates of trip generation.

This traffic estimation technique is tied directly to an external O-D trip table and link counts. It is most suitable for small urban areas with slow growth (less than 3%) where external O-D and land use data are available, where future alternatives do not include major new facilities, and where external travel through the area is a significant part of total local travel.

In many instances the factoring procedure may be considered a first step in estimating system loads. If the results indicate no particular system overloading problems, further analysis might not be necessary. This technique requires the same data and analysis required by more detailed procedures; however, fewer steps are necessary. The technique can be applied manually or by computer, depending upon the number of zones and system size. Flow charts for the two applications are shown in Figures 6 and 7.

The input required to utilize this approach includes the following:

1. A functionally classified road system including facility travel times.

2. For the computer approach, link data for input into the HR program.

3. An external cordon roadside O-D survey with resultant trip matrix.

4. Traffic counts on all facilities for which future estimates are required.

5. Socioeconomic data by internal analysis area for base year and future year.

6. Growth factors for external travel.

Partial Matrix Technique

The partial matrix technique (PMT) is based on an extension and application of the theoretical work by Kirby(14). Conclusions from Kirby's work used in the PMT include the fact that the unknowns in the Gravity Model formulation can be derived from a partial set of observed trips, and that the solution from the partial set is unique, provided that the trip matrix cannot be partitioned such that diametrically opposite quadrants are zero. The implication is that once a Gravity Model is calibrated to a partially observed matrix, the parameters that have been derived can be used to estimate the values of the unobserved trips of the matrix.

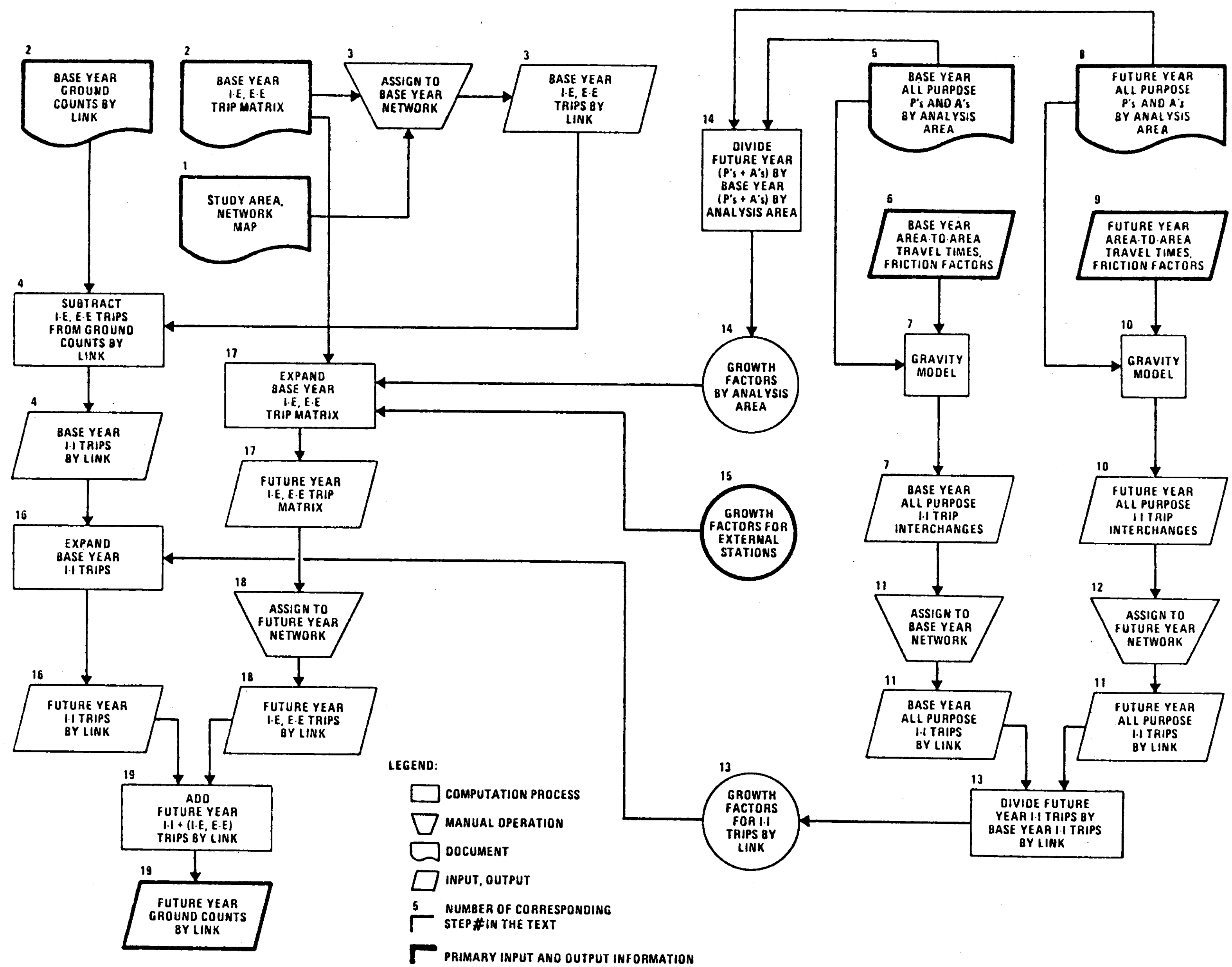

Figure 6. Flowchart representation of the traffic estimation method based on ground counts.
Source: Transportation Planning for Your Community

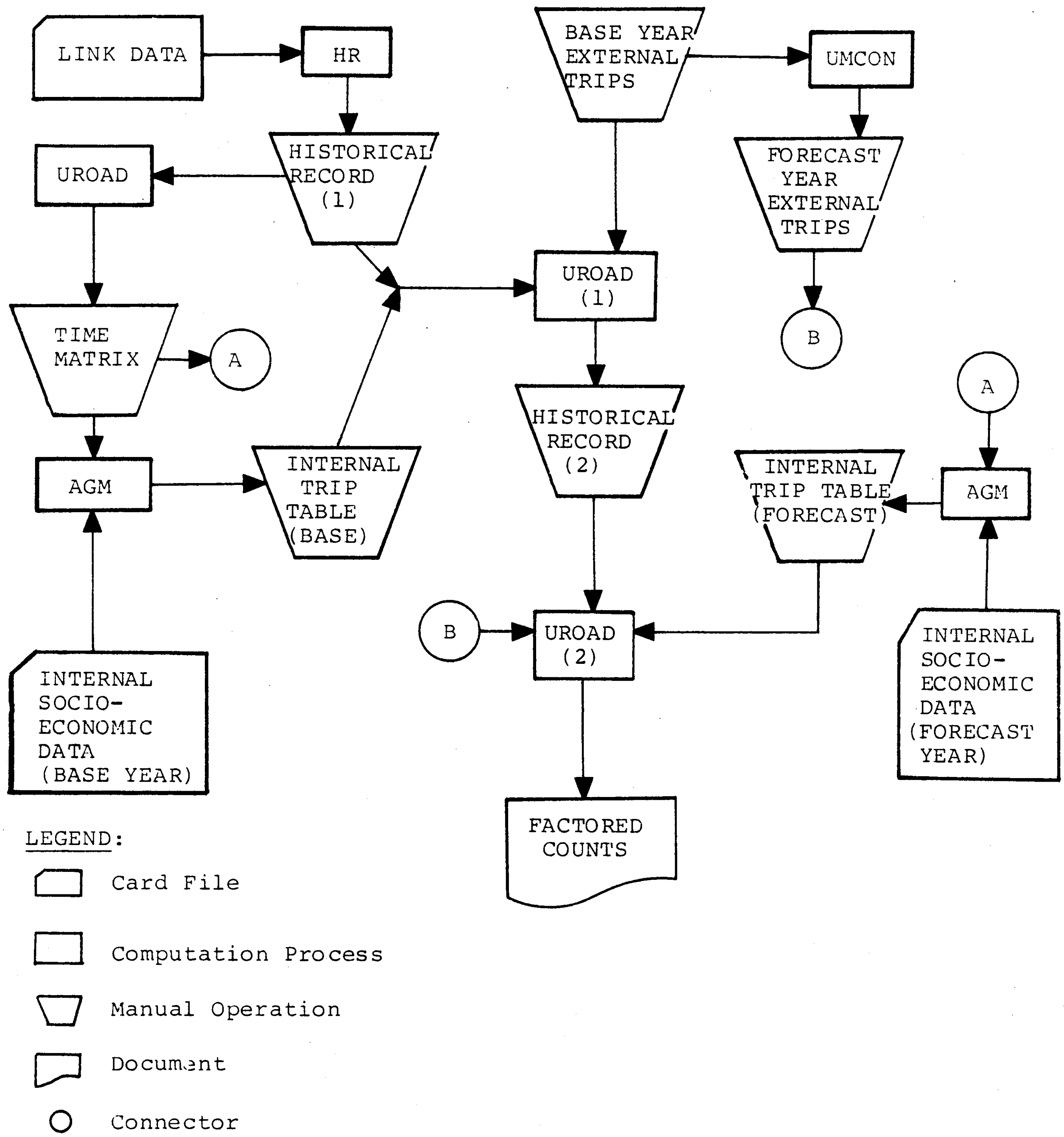

Figure 7. Program chain for computerized traffic estimation based on ground counts.

Source: Transportation Planning for Your Community

The input to this model consist of information obtained from roadside interviews at appropriately located screenlines and cordon stations in the study area. These surveys yield a partially complete trip matrix of observations. Subsequently, using the unique properties of this partial matrix, one can synthesize the complete matrix.

Corridor Growth Factor Technique

This technique is a result of the combined work of A. D. Jones(15,16,17) and D. K. French(18). The goal of French's research was the development of a simple model requiring easily obtainable data that could be used to derive and forecast I-I traffic volumes on arterial streets. This was done by using three independent variables: dwelling units, retail employees, and total employees. The procedure necessitated, however, an external cordon survey.

Jones' research, on the other hand, was directed specifically to the development of models to duplicate information normally obtained from external cordon surveys. His research utilized data from completed external cordon surveys to develop models that could be used to obtain future traffic volumes.

The combination of Jones' and French's work yielded a procedure capable of giving ". . . results sufficiently accurate to determine major improvements needed, the location and the number of lanes for which a facility should be designed, and necessary information for establishing construction priorities"(15). This conclusion was based on the results of applying the technique in the cities of Lafayette and Columbus in Indiana. The basic assumption is that the existing travel patterns in the study area will remain stable over time. The procedure has three basic parts: corridor and external cordon identification, traffic volumes, and travel patterns and forecasts.

Corridor and External Cordon Identification

Small urban areas are characterized by a CBD that is served by radial thoroughfares forming corridors. The procedure for corridor identification begins by evenly dividing the distance between radial thoroughfares. These boundaries are then adjusted to reflect any physical characteristics of the area that might affect the attractiveness of a particular thoroughfare. The objective is to locate the boundaries such that vehicles move in opposite directions to reach a thoroughfare destined to the CBD. The external cordon line should be located so that it includes all existing and planned urban development within the study area.

Traffic Volumes

Existing traffic volumes should be obtained at all arterial street or highway cordon crossings and at the central area screenline crossings. Volumes on the arterials approximately midway between the CBD and the outer cordon should also be obtained. Existing volumes are used to determine the available excess capacity.

Travel Patterns and Forecasts

The traffic volumes existing on each major thoroughfare are divided into two components--internal and external. Forecasts are made for each component and then summed for the design-year volumes. The development of the growth factors for internal trips is accomplished in the following manner(17).

1. The total dwelling units existing and forecasted for each corridor and for the entire study area are to be determined. Aerial photography supplemented by field checks may be used.

2. The total number of employees and the number of retail employees are to be determined for each corridor and for the entire area for the base year and target year.

3. The percentage of the total trips to be represented by each parameter can be varied based upon available information. If local information is not available, the following percentages may be used: 50% for dwelling units, 35% for total employees, and 15% for retail employees.

4. A trip generation rate is calculated as follows:

$$\frac{\text{Percent of trips represented by parameter}}{\text{Total units of parameter in study area}}$$

   Example: Assume there are 10,000 dwelling units, 5,000 total employees, and 1,000 retail employees in an area in the base year.

   For dwelling units: $$\frac{.50}{10{,}000} = 5.0 \times 10^{-5}$$

   For total employees: $$\frac{.35}{5{,}000} = 7.0 \times 10^{-5}$$

   For retail employees: $$\frac{.15}{1{,}000} = 15.0 \times 10^{-5}$$

   For further calculations the 10^{-5} may be discarded from the factors.

5. A total trip generation rate is calculated for each corridor for the base year and the target year as follows.

   Example: Assume for the above study area there are 1,000 dwelling units in the corridor for the base year and 1,200 dwelling units in the corridor for the target year, 500 total employees in the corridor for the base year and 700 total employees in the corridor for the target year, and 100 retail employees in the corridor for the base year and 125 retail employees in the corridor for the target year. Calculation of growth factor:

Base Year

1,000 dwelling units	x 5.0	=	5,000
500 total employees	x 7.0	=	3,500
100 retail employees	x 15.0	=	1,500
			10,000

Target Year

1,200 dwelling units	x 5.0	=	6,000
700 total employees	x 7.0	=	4,900
120 retail employees	x 15.0	=	1,800
			12,700

The growth factor for the corridor is the total for the target year divided by the total for the base year.

Example: $\text{Growth Factor} = \frac{12{,}700}{10{,}000} = 1.27$

6. The growth factor is applied to the existing internal traffic volume in the corridor near the screenline adjacent to the central area to determine the forecasted volume for that point for the target year. The same procedure should be followed for a point in the corridor near the midpoint between the central area and the external cordon, or outside boundary of the study area. The same growth is applied to the existing traffic volume because the existing traffic volume represents total vehicle movement and is not directional.

Corridor delineation should be checked by applying the above procedure to an earlier year and the base year. If the use of the calculated growth factors does not accurately replicate the existing counts, the boundaries of the corridor should be reevaluated and if necessary, redefined.

There are two possible procedures for determining the total external traffic and its components of X-X and I-X trips. The first is used if an external cordon survey is available for the study area from an earlier year, and the second is used if only traffic volumes for the cordon sections from an earlier year are available.

When an external cordon survey report is available, a growth factor based on the increase in vehicle registration in the region should be adequate for forecasting the future. The percentage of total cordon traffic at each station as well as the X-X and I-X split determined from the earlier survey is assumed constant for both the base and target years. Calibration is accomplished by calculating the growth in vehicle registrations between the year of the external survey and the base year and applying that rate to duplicate base year or current volumes.

When an earlier survey is not available, 24-hour volume counts at each cordon station must be known for an earlier year as well as for the base or current year. A growth factor between the two years is based on total vehicle registration and applied to the traffic volumes for the earlier year. If results reasonably duplicate current volumes, then the accuracy of the procedure is satisfactory, and a growth factor for the forecast year is developed based on vehicle registration. Application of this growth factor provides total external volumes.

In order to determine the split between X-X and I-X traffic, Jones developed a regression model by using external survey reports from 77 cities in 19 states. The resulting equation is

$$Y = 4.28 + 0.035(X1) + 0.066(X2) - 0.064\ (X3),\ \text{where}$$

Y = the total X-X cordon crossings for the city,
X1 = population of cities larger than the subject within a 25-mile radius of the center of the city, expressed in thousands,
X2 = area's population density, expressed as persons per square mile, and
X3 = population of cities smaller than the subject city within a 25-mile radius of the center of the city, expressed in thousands.

This volume is distributed among the cordon stations using the same percentage of the total that currently exists for each station. Subtracting this volume from the total external volume determined previously gives the I-X component.

The next step is to determine the percentage of the I-X traffic destined to the central area. It is assumed to be the same as the ratio of employment in the central area to the total employment in the study area. This ratio is then applied to the total I-X traffic to determine the I-X traffic destined to the central area. The X-X volume is added to the I-X volume destined to the central area to give the total traffic to be expanded using the external growth factor.

North Carolina Procedure for Synthesizing Movements

The planning staff of the North Carolina Department of Transportation (NCDOT) has developed procedures for synthesizing travel movements in small- and medium-sized urban areas(19). Four methods are used depending upon the extent of travel surveys that may be done as part of the transportation study. All four methods require comprehensive traffic volume counts and inventories of employment, commercial vehicles, and dwelling units. Flow charts for each of the four methods are shown in Figures 8 through 11. A data bank of information on trip generation rates, trip attractions, trip purpose distribution, and trip length frequency is needed to apply the synthesis procedure. Method 4, which involves no surveys, is used almost exclusively by the NCDOT. Method 3 is occasionally used in order to update the data bank.

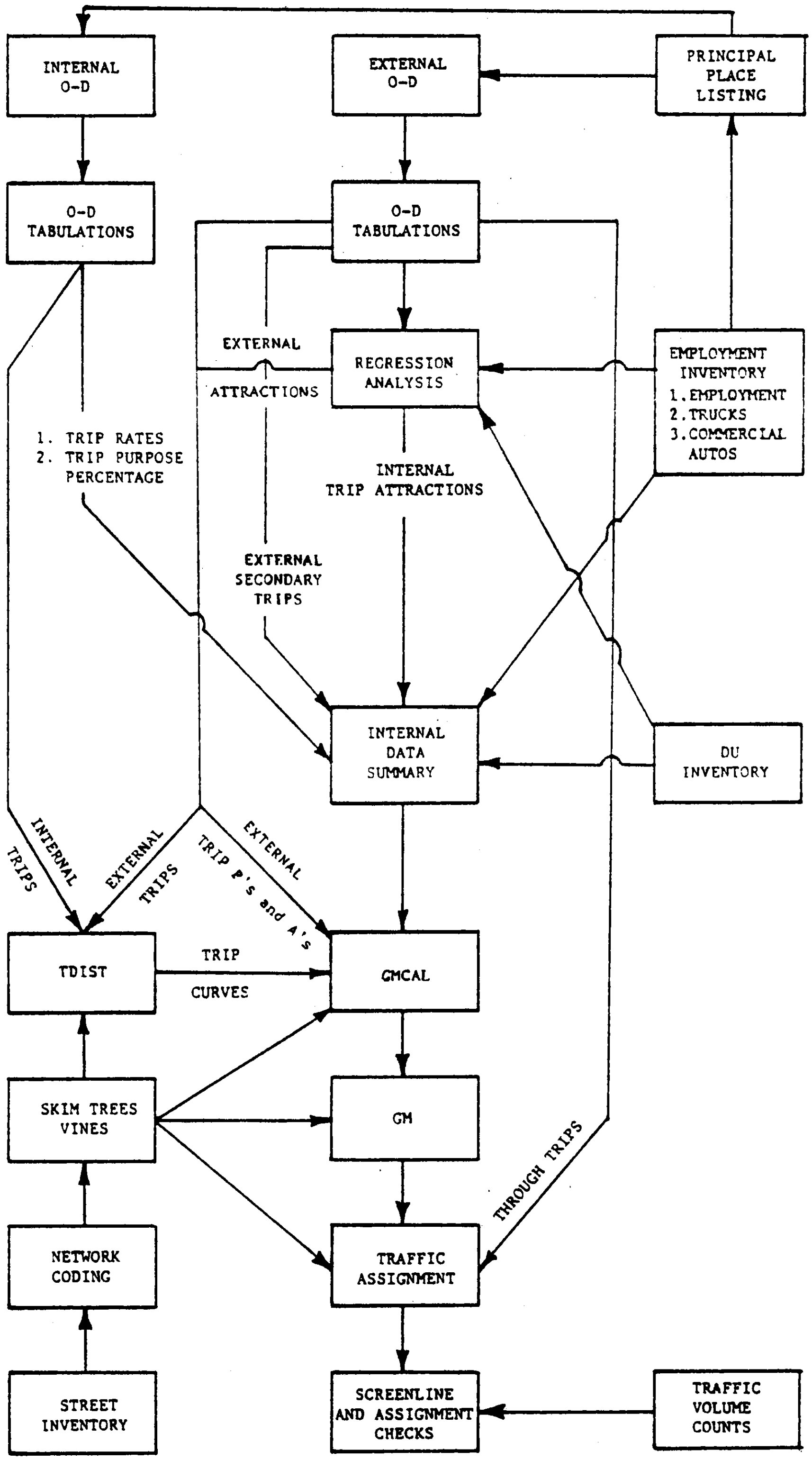

Figure 8. Synthesis of travel with small sample internal origin and destination travel survey and external cordon origin and destination traffic survey.

Source: North Carolina Procedure for Synthesizing Travel Movements

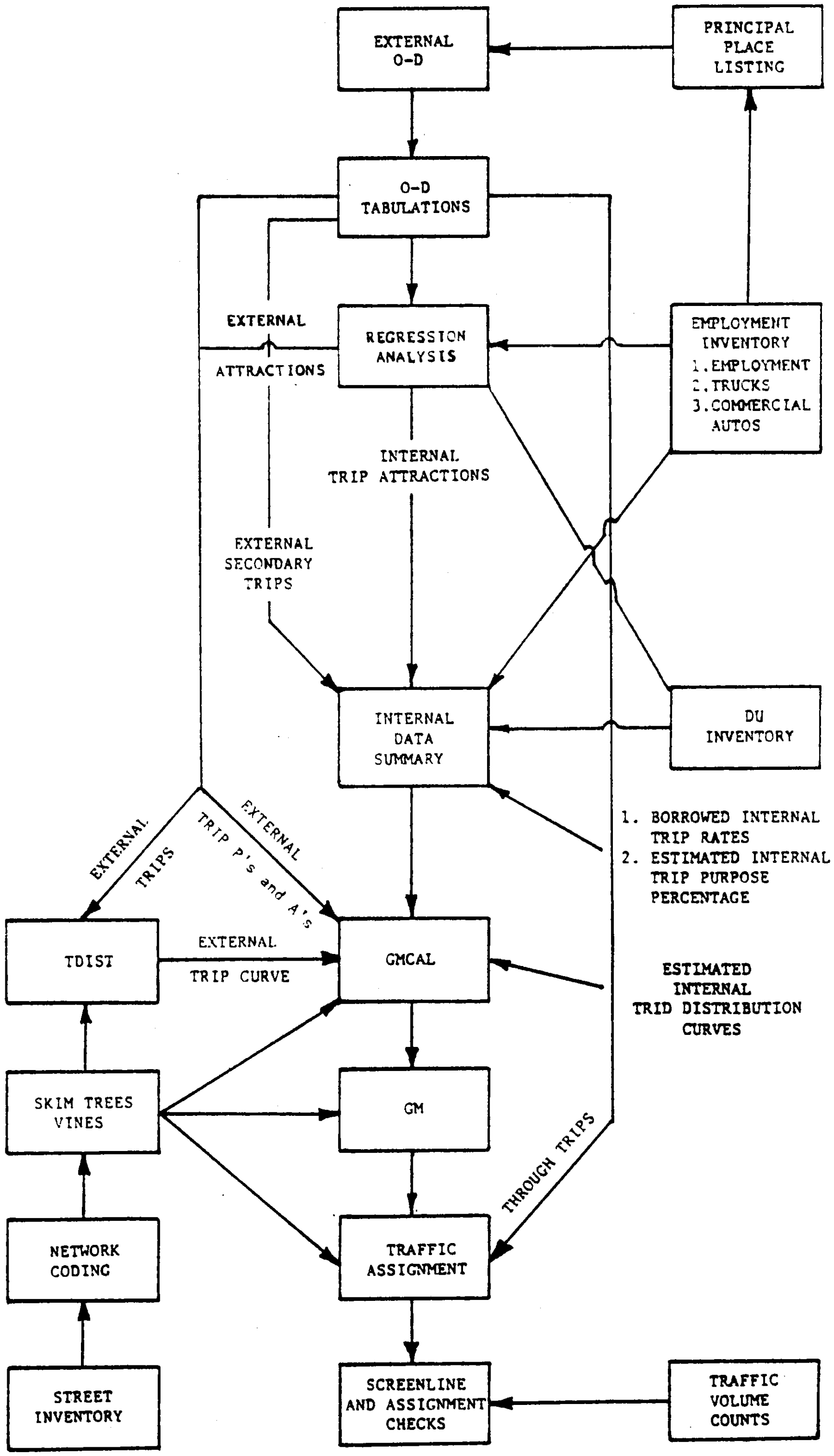

Figure 9. Synthesis of travel with an external cordon origin and destination traffic survey.

Source: North Carolina Procedure for Synthesizing Travel Movements

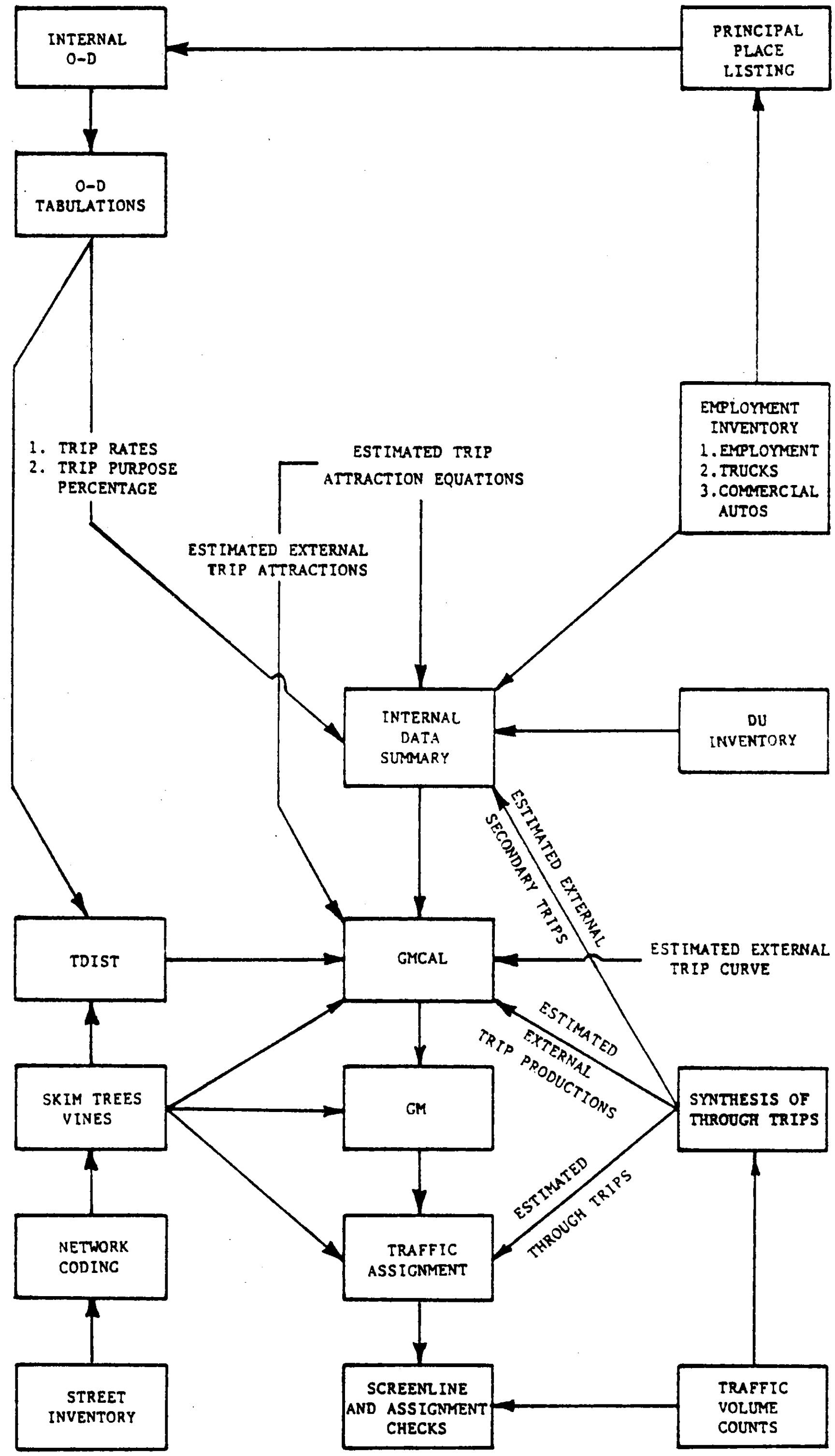

Figure 10. Synthesis of travel with a small sample internal origin and destination travel survey.

Source: North Carolina Procedure for Synthesizing Travel Movements

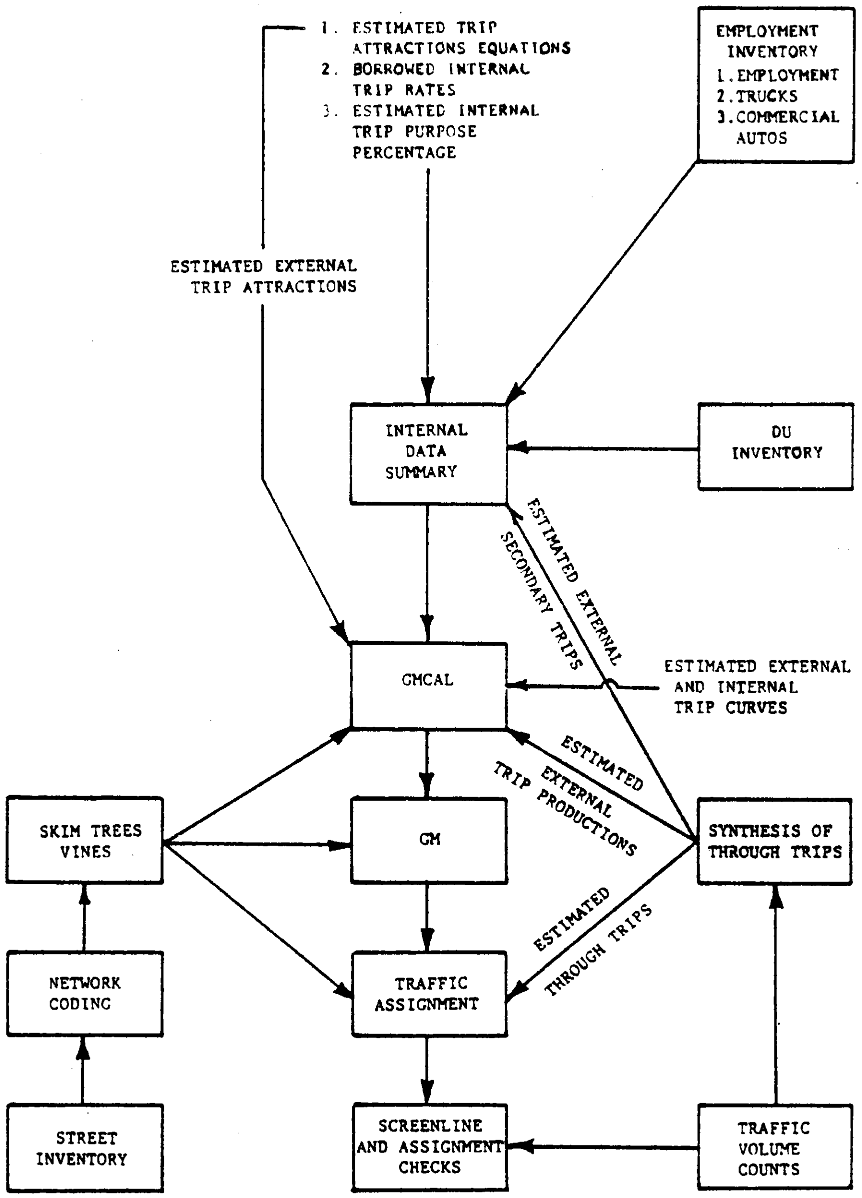

Figure 11. Synthesis of travel with no origin and destination travel surveys.

Source: North Carolina Procedure for Synthesizing Travel Movements

An internal data summary (IDS) computer program is a key element of the synthesis procedure common to all methods. Input to the program includes the following.

1. Occupancy rates for five dwelling-unit classes.

2. Trip generation rates for five dwelling-unit classes.

3. Trip generation rates for trucks, commercial autos, and taxis.

4. Percentage internal trips remaining inside the cordon.

5. Percentage of home-based work (HBW), home-based other (HBO), and non-home based (NHB) trips.

6. Number of occupied dwelling units in each class in each zone.

7. Number of trucks, commercial autos, and taxis in each zone.

8. Total number of internal trips generated by traffic garaged outside the study area.

9. Trip attractions by zone: trip attractions for HBW trips are total zonal employment; trip attractions for HBO and NHB are the factors from the regression equation

   $Y = a + bX_1 + cX_2 + dX_3 + eX_4 + fX_5 + gX_6$, where

   Y = external trip ends
   X_1 = industrial employment
   X_2 = retail and wholesale employment
   X_3 = highway retail employment
   X_4 = office employment
   X_5 = service employment
   X_6 = number of dwelling units

Output of the IDS program includes the following:

1. Zonal totals of trip productions and attractions by purpose.

2. Zonal and areawide trip totals.

3. Zonal and areawide totals of population and employment.

4. Zonal and areawide totals of dwelling units, trucks, and commercial autos.

In the absence of an external cordon survey, it is necessary to synthesize the number of through trips. The procedure used to estimate through and external travel productions was developed by Modlin(20). His research was performed to develop an improved and simple-to-use set of models that would facilitate the synthesis of a through-trip table for urban areas of less than 50,000 population. The effects of functional classification, average daily traffic, percentage of trucks, route continuity, and urban-area population were determined to be significantly correlated with through-trip patterns. A least-squares analysis led to the development of a set of multiple regression equations that estimate the percentage of through-trip ends at each station and the distribution of these trips among stations.

The X-X generation model represents all functional classes and utilizes three independent variables: urban population (UP), average daily traffic (ADT) at the external station, and the percentage of trucks (TRK). The equation is

$$Y = 9.29 - 0.00031\ UP + 0.0026\ ADT + 1.48\ TRK,$$ where

Y = percentage of the ADTs at the external station that are through trips

It is interesting to note that work done by Pigman(21) produced an X-X generation equation that is remarkably similar to Modlin's. Pigman's equation was developed using data from twenty small cities (6,000 to 50,000 in population) in Kentucky. Modlin recognized this and stated that this "finding should validate the applicability of the technique and lend credence to the hypothesis that the models might be transferrable"(20). Pigman's equation uses the same independent variables and is

$$Y = 17.43 - 0.0007\ UP + 0.003\ ADT + 1.49\ TRK$$

The X-X distribution model is a composite model in which equations for each of five functional classifications estimate the distribution of trip ends among stations. The resulting trip matrix is then balanced and adjusted using the Fratar Model.

Simplified Network Procedures

In an effort to eliminate the need for costly internal O-D surveys, recent work has been done that focuses on the use of synthetic models for forecasting travel demand. These models invariably utilize borrowed or transferred factors from travel models from a community or cross-section of communities that are thought to have socioeconomic characteristics similar to the area under study. The factors transferred generally include zonal trip production and attraction values, either as rates or equations, and the travel time or friction factors for use in a Gravity Model. A comparison of assigned link volumes developed from applying the model with actual ground counts is a valid check on the accuracy of the borrowed models.

There are two basic approaches for developing synthesized models for estimating internal trip productions and attractions. The first approach, aggregate trip analysis, develops relationships of trip production and attractions with independent variables at the traffic-zone level, usually through the use of multiple regression analysis. The principal advantage of this approach lies in its zonal orientation. One of its primary disadvantages is that the models are not behavioral in nature and may be valid only for the zonal system in which they were developed.

The second approach, disaggregate trip analysis, is based on the development of equations or rates describing the effect of independent variables on the trip-making characteristics of households. As in the aggregate approach, regression analysis can be used to develop equations in which the dependent variable is trips per household. A more common disaggregate analysis technique is the cross-classification method. Cross-classification models stratify households according to two or more independent socioeconomic variables. Automobile ownership, income, and family size are commonly used. Disaggregate models have been shown to be superior to aggregate models in various respects, such as yielding better estimates of zonal totals and the average trip rate(22). These models are also more data efficient: they require fewer data for their calibration(23). It is also thought that due to their behavioral nature, they are transferable between small urban areas. The adaptability of disaggregated models to any zonal scheme is an important advantage in small urban areas for synthetic models and updates.

An approach becoming increasingly popular in recent years utilizes both aggregate and disaggregate techniques. A disaggregate cross-classification model is used for trip productions, and aggregate zonal equations are used to estimate trip attractions. In this manner the basic trip producing units (households) will be directly related to trip productions, and the attractiveness of each zone will be related to such independent variables as zonal employment, commercial and residential land, and population. This approach was used in the development of the recently completed Charlottesville, Virginia, area transportation plan(24).

Several studies have investigated and compared the feasibility of transferring aggregate and disaggregate models between small urban areas(22,23,25,26). All of these concluded that disaggregate cross-classification models demonstrated the highest potential as well as the strongest theoretical justification for being transferred between small urban areas.

Data Available from the 1980 Census

Values for many of the variables that are input to the trip generation model can now be obtained from the 1980 Census. Improvements both in the level of detail of the 1980 questionnaire and in the geographic coding of the data can now provide planners with information that previously had necessitated large-scale and expensive local collection. Two of these improvements are the geographic base file/dual independent map encoding (GBF/DIME) system and the 1980 Census Urban Transportation Planning Package (UTPP).

The GBF/DIME file, in effect, is a computerized map. Each computer record in the file identifies a single segment between two node points and all of the geographic information related to that segment. Associated with each side of the segment are the appropriate codes for census block, census tract, place, zip code, and even traffic zone. The most common use of the GBF/DIME file is for the geocoding of addressed data(27).

The UTPP is a special data tape that must be ordered from the U.S. Bureau of the Census. Table 3 provides a summary of the information available from this package. Of particular interest to transportation planners is the fact that the Census Bureau will code the available information according to traffic zones supplied by the planning agency. This is also the only source from which place-of-work information by traffic zones can be obtained.

Unfortunately, in most cases the GBF/DIME file and the UTPP are only available for Standard Metropolitan Statistical Areas (SMSAs). As a result, this information is not available for urban areas in Virginia that are the subject of this report.

A study done in Alabama by Meyer, et al.(12), however, illustrates the use of census data in small urban areas. The purpose of their work was to examine the possibility of using the QRS software in conjunction with available census data in the analysis of downtown revitalization programs. The source of their census data was the Summary Tape Files (STF). Pertinent information that can be obtained by tract of residence includes population, household size, household income, auto ownership by household, mode of travel to work, average carpool size, average travel time, and dwelling units by type. These data are not available at the block or traffic zone level. Procedures for doing this are available from several sources(12,28,29).

Transportation Planning Packages for Microcomputers

Microcomputer transportation planning software packages that incorporate many of the capabilities of the UTPS and PLANPAC/BACKPAC batteries of programs have been developed in recent years. In addition, software packages that have more specialized capabilities are available. The majority of these packages are developed and distributed through the private sector, one notable exception being the QRS package discussed earlier. The "Microcomputers in Transportation - Software and Source Book" (February 1986 edition)(30) contains one-page summaries of each package's capabilities, availability, cost, and hardware needs.

Although the information available in this publication is useful, it is not sufficient for assessing a package's applicability and cost effectiveness in different situations. In addition, the number of new packages entering the market and the continuous upgrading of the existing packages make this guide's information current for only a short time. Any agency that is considering the acquisition of microcomputer packages should contact the developer in order to ascertain the package's current capabilities. Also, in many cases the developer can modify the package to meet the specialized needs of the prospective buyer. The remainder of this discussion will focus on the transportation network planning software packages and their general capabilities.

PART	BASIC SUMMARY LEVEL	SUBTOTALS PROVIDED	NUMBER OF WORKERS	NUMBER OF HOUSEHOLDS	VEHICLES/CARPOOL	OTHERS
I RESIDENCE END	Tract or Block Group (User supplies block zone equivalence)	CBD Central City Urbanized or Study Area County SMSA	Sex & Occupation Sex & Industry Sex & Class of Worker Not working at home by mean travel time, mode & carpooling Using car, truck, van by carpool type & vehicle occup. Mode & Earnings in household by mode & household income Mode, Race & Spanish origin Mode, Sex, Age Mode & Vehicle available Place of work not reported by mode With public trans. disability by mode and carpooling	Size of household Number of Workers in household Household Income Number Autos available Number Trucks or Vans available Total Vehicles available	Number vehicles used in travel to work Persons/Vehicle Persons/Carpool	In household by sex & age In group quarters by sex & age All persons by sex & age All persons by race and Spanish origin 3 years & older enrolled in school Number years around housing units by duration of vacancy Number years around housing units by duration of vacancy Non-institutional population 16 or older by type of disability & age
II RESIDENCE END	Large Areas CBD (optional) Central City Area (Urbanized or study) County SMSA		Race, Spanish origin, earnings by mode, carpooling Mode, carpooling, class of work Age, earnings, mode & carpooling Not working at home by travel time & mode By household income, household size, mode & carpooling Household income, number vehicles available mode & carpooling Sex, number workers/household, number vehicles, mode & carpooling Role & Spanish origin, household income & vehicles available Who use car, truck or van by vehicle occ., household income & vehicles available Who use car, truck or van by sex, carpool type & vehicle occ.	Type structure, household income, & household size Auots available, household income & household size Number trucks or vans available, household income, & household size Number vehicles available, household income & household size Type structure, number autos available Type structure, number vehicles available		
III WORKER END	Tract or Zone (With user supplied block-tract equiv.)	CBD Central City Area (Urbanized or study) County SMSA	Sex & Occupation Sex & Industry Sex & Class of worker Mode & Earnings Mode & Carpooling Not working at home mean travel time & standard service mode & carpooling Mode, Race, Spanish origin Mode & Sex Using car, truck or van by carpool type & vehicle occ. In household by workers per household, mode & household income In household by mode & vehicles available		Number vehicles used in travel to work Persons/Vehicle Persons/Carpool	
IV RESIDENCE TO WORKER END	Tract or Zone (With user supplied block-tract equiv.)	CBD Central City Area (Urbanized or study) County SMSA Within community Outside community	Total workers Workers by mode Workers (not working at home) By mean travel time & mode		Number vehicles used in travel to work Persons/Vehicle Persons/Carpool	
V WORKER END	Block Group	Track or Zone (With user supplied block-zone equiv.)	Sex & Occupation Sex & Industry Sex & Class of worker Mode		Number vehicles used in travel to work Persons/Vehicle Persons/Carpool	
VI COUNTY RESIDENCE TO COUNTY OF WORK	Counties		Sex & Occupation Sex & Industry Sex & Class of worker Mode & Earnings Mode, Race, Spanish origin Mode & Sex Using vehicle by carpool type Mode all vehicles availabe Mode & household income		Number vehicles used in travel to work Persons/Vehicle Persons/Carpool	

Table 3 Summary of Information in Urban Transportation Planning Package

Source: Transportation Planner's Guide to Using the 1980 Census

In response to numerous inquiries as to the capabilities and performance of the planning packages, UMTA sponsored a report(31) to provide prospective users with information for their prepurchase evaluations of the various packages available at that time. This report covered ASSIGN, EMME/2, IRAP, MicroTRIPS, MINUTP, MOTORS, TMODEL, and TRANPLAN.

The UMTA report did not evaluate the packages for the reader; rather, it summarized the features, capabilities, limitations, availability, and costs of the packages covered. These summaries enabled the reader to screen and compare the packages for use in their own situation. Summary tables from the UMTA report are included in Appendix A. In addition to these comparative descriptions, each package was individually analyzed with respect to its overall structure and operation, its data handling characteristics, and its constraints. A function sheet summarizing this information was prepared for each package.

Although the information in the UMTA report is somewhat dated, prospective users of these packages will benefit from a review of the methodology and information described.

Based on the above information and a review of the documentation of several of the packages(32,33,34), it is concluded that the comprehensive transportation planning packages--TRANPLAN, MINUTP, MicroTRIPS, MOTORS, AND EMME/2--all have generally the same features and capabilities. All attempt to emulate the UTPS or PLANPAC modeling approach. Although TMODEL and TRANSPRO are more appropriately applied in a site-specific or subarea highway analysis, they also utilize the same travel-estimation methodology as the above packages. Differences between the packages relate to cost, operating environment, data entry, and network size constraints rather than to modeling capabilities and output.

RESULTS OF STATES SURVEY

A survey of the other state transportation agencies was undertaken in order to determine the planning procedures used in their small urban areas. Of particular interest was their travel demand forecasting procedure and, in particular, any experience they might have had with any of the microcomputer transportation planning packages available. This survey consisted of the distribution of a questionnaire and follow-up contacts with respondents. A copy of the questionnaire used is included in Appendix B. After one follow-up mailing, a 100% return rate was achieved.

The responses to the survey indicated that the subject of this research reflected the needs of other state planning agencies as well as Virginia's. Although the extent of their involvement varied from that of total responsibility to that of a support role, the need for a reliable and less data-intensive forecasting method was a commonly expressed desire.

Planning Responsibility

Twenty-seven of the 49 other states indicated that they had direct responsibility for developing transportation plans for their small urban areas. Of the 22 states that did not have any direct responsibility, many often assisted in a technical support capacity, provided they had the time and resources.

Planning Procedures

Of the 27 states that had direct responsibility for small urban area planning, 25 used a formal, documented travel forecasting procedure. Many of these states made use of, or had access to, more than one specific procedure. Eight states are currently investigating the use of microcomputer packages. A breakdown of the procedures and the number of responses is given in Table 4. The various microcomputer packages were described previously, whereas the other procedures are described in the remainder of this section.

Table 4

Planning Procedures Used by Other States

Procedure	No. Respondents
UTPS	5
PLANPAC/BACKPAC	5
NCDOT PROCEDURE	1
NY PROCEDURE	1
SPF	2
MINUTP	8
QRS	8
MICROTRIPS	3
TRANPLAN	2
TMODEL	2
TRANSPRO	1

PLANPAC/BACKPAC/UTPS

Ten states use the traditional PLANPAC/UTPS forecasting methodology. Some of these states have utilized synthetic, or borrowed, parameters in an effort to reduce the time and cost involved in this type of study. These procedures are no doubt familiar to most planners, and are well documented elsewhere(35). One of the objectives of this research was to investigate possible replacements for these data-intensive procedures.

NCDOT Procedure

The NCDOT travel forecasting procedure has been described earlier in this report. Method 4 is now used almost exclusively in North Carolina urban areas with a population between 5,000 and 50,000. Transportation plans for urban areas of less than 5,000 normally consist of (1) a capacity-deficiency analysis of the existing system, (2) trend-line projections of traffic, and (3) the development of a preliminary thoroughfare plan.

NY Procedure

The New York (NY) procedure(36) is used to obtain estimates of future traffic at urban project sites. Growth in travel demand is related to growth in selected demographic variables through the use of elasticity-based equations that apply growth rates to AADTs. The general form of these equations is

$$AADT_f = AADT_p\ [1.0 + e_1\ (\%\Delta X_1) + \ .\ .\ .\ + e_n(\Delta X_n)],\ \text{where,}$$

$AADT_f$ = future AADT,
$AADT_p$ = present AADT,
$\%\Delta X_n$ = percent change of variable X_n from future year to present year, and
e_n = elasticity of AADT with respect to X_n.

The point elasticities (e_n) are determined through the use of a shrinkage ratio, which is the ratio of percent change in AADT to percent change in a variable. Based on shrinkage ratios obtained during the period 1970-1980, New York has developed a series of equations to forecast future traffic. These are shown in Table 5. Care must be taken in the transfer of these equations to other areas, as evidenced by the variance of the point elasticities of the different SMSAs. The NYDOT uses this procedure to provide quick estimates of future traffic to assist in design activities for non-capacity-improving projects. It is not intended to replace the network assignment process.

Simplified Project Forecasting

The Simplified Project Forecasting (SPF) procedure is the result of research sponsored by the FHWA. The work was accomplished by the COMSIS Corporation and the New York State Department of Transportation. The User's Guide(37) and distribution diskette are available from the Center for Microcomputers in Transportation for a nominal charge.

The product of the SPF procedure is a growth factor that is used to expand existing ground counts to determine project level design traffic. The derivation of the growth factor and its application is accomplished through the following steps.

Step 1 - Establish project zonal system

The SPF considers a standard district system of 24 districts. The size of the districts is determined by the functional classification of the project under consideration and its location in the community. The orientation of the district system must follow the orientation of the traffic flow on the project. An example of this system is shown in Figure 12. In those areas where a traditional traffic-zone system has been established, the microcomputer version of the SPF procedure will allocate the traffic zones and their data to the 24-district system. This process can also be done manually.

Table 5

Urban Traffic Forecasting Models

Interstates

$AADT_f = AADT_p$ [1 + 1.39 (%Δ SMSA Autos)]

Principal Arterials

A: $AADT_f = AADT_p$ [1 + 1.77 (%Δ County Households)]
B: $AADT_f = AADT_p$ [1 + 0.94 (%Δ County Households)]
C: $AADT_f = AADT_p$ [1 + 0.34 (%Δ County Households)]

Minor Arterials and Collectors

A: $AADT_f = AADT_p$ [1 + 1.37 (%Δ SMSA Autos)]
B: $AADT_f = AADT_p$ [1 + 0.34 (%Δ SMSA Autos)]
C: $AADT_f = AADT_p$ [1 + 0.77 (%Δ SMSA Autos)]

For Principal Arterials

Group A includes Albany-Schenectady-Troy, Buffalo, Rochester, Utica-Rome, New York (Westchester County) SMSAs.

Group B includes Binghamton, Elmira, Poughkeepsie, Syracuse SMSAs.

Group C includes Nassau-Suffolk SMSA.

For Minor Arterials and Collectors

Group A includes Rochester, Utica-Rome, New York (Westchester County) SMSAs.

Group B includes Albany-Schenectady-Troy, Buffalo, Syracuse, Binghamton, Poughkeepsie SMSAs.

Group C includes Nassau-Suffolk SMSAs.

Source: "An Incredibly Quick-Response Procedure to Forecast Urban Traffic"

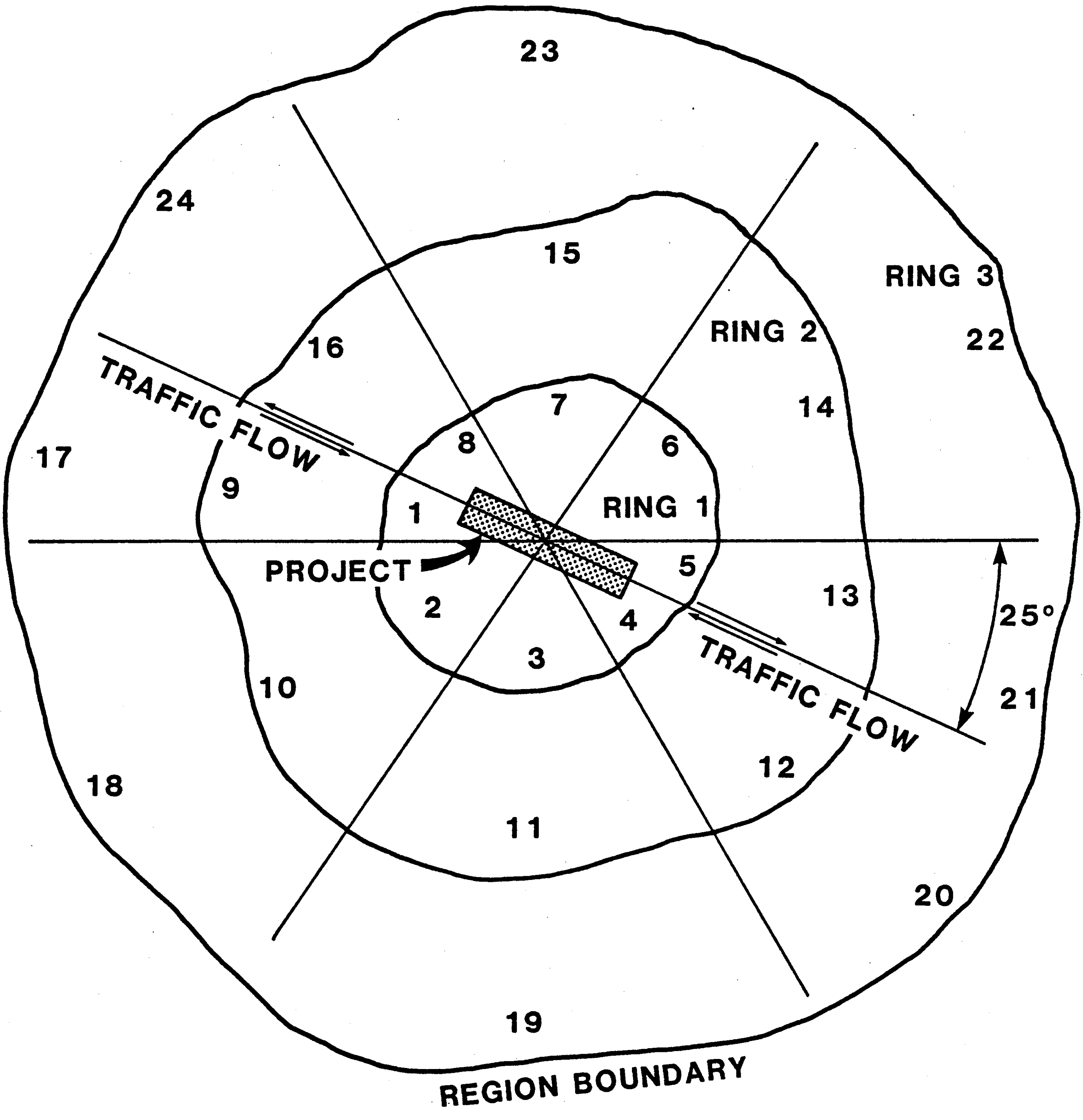

Figure 12. Districts related to orientation of facility.
Source: Simplified Project Forecasting (SPF) User's Guide.

Step 2 - Compute productions and attractions for each district

The SPF requires some representation of travel by zone or district for the base and forecast years. It is recommended that trip productions and attractions be developed as is normally done using the traditional four-step process. Where trip production and attraction estimates are not normally produced in the planning effort, surrogate values of growth such as population and employment may be utilized. For example, the South Dakota DOT uses the SPF model to develop growth rates based on current and future land use, population, and employment. An alternate method might utilize ITE trip rates or information from NCHRP 187(10). If many applications of the SPF model are expected, users should construct a comprehensive zone system since those zones can be allocated to the SPF district system automatically.

Step 3 - Develop usage factors

In order to reflect each district-to-district movement's probability of traveling on the project under consideration, a usage factor must be applied. The usage factor is an estimate of the percent of total trips between an origin district and destination district that will be traveling on the facility being evaluated. A facility's default usage table was developed for the SPF model and is included in the microcomputer version and user's guide.

Step 4 - Determine travel time and friction factors for each district movement.

Utilizing the travel-time procedure in NCHRP 187(10) and data provided by the Ohio DOT, a formula was derived to estimate speed as a function of distance. Speed functions were developed for each of four population size groups and are included in the microcomputer version as default speeds.

The friction factors used by the SPF model were derived from material in NCHRP 187(10). These are one-purpose friction factors that are provided as defaults for the four population size groupings. The SPF microcomputer program calculates the friction factor for each movement based on the distance between zone centers and default speed function.

Step 5 - Apply growth factor equation

The derivation of the growth factor equation is shown in the SPF user's guide. Basically, it involves the application of the usage factors to a Gravity Model in order to generate a growth factor. These calculations are automatically accomplished in the microcomputer version.

Step 6 - Apply traffic smoothing procedure for new facility applications

This procedure is necessary for proposed facilities for which no current ground counts exist. The SPF process should be applied to each facility that parallels the project under analysis in the corridor. This smoothing procedure is the same as that used in NCHRP 187(10), but is not part of the SPF software. It must be accomplished manually or by using the QRS software(38).

Before applying the SPF growth factor, the developers recommend that it be checked for reasonableness. These checks can be based on the examination of trends in traffic counts, land use, and socioeconomic activities. The particular checking method used will depend on the availability of historical data. A description of the extrapolation procedure can be found in the SPF user's guide(37).

Recently, participants from six state and local planning agencies chosen to conduct SPF case studies presented their results. Preliminary results showed that the SPF model produced good project-level design-year traffic forecasts. They compared quite well with existing model forecasts. All of the participants reported that the SPF procedure was easy to implement and inexpensive to operate(39).

Strengths and Weaknesses of the Planning Procedures

The respondents generally highlighted the advantages of the use of microcomputer packages rather than mainframe computers. The advantages included the following: (1) rapid turnaround, (2) scientific capability, (3) ability to examine a wide range of alternatives in a timely fashion, (4) maximum flexibility with respect to desired level of effort, (5) less data-intensive, and (6) reduced costs.

The reported weaknesses were generally related to the collection and allocation of the necessary socioeconomic data and manpower resource limitations that prevented the initiation of new studies as needed. Several respondents felt that the microcomputer planning packages were too data-intensive and represented an "overkill" in their application to small urban areas. Problems related to the necessary socioeconomic data included the following:

1. Questionable accuracy.
2. Delays in acquisition.
3. Subjectivity in the projection of such data.
4. Unavailability of the 1980 Census Urban Transportation Planning Package for cities under 50,000.
5. Difficulty of allocating available census data to traffic analysis zones.

Follow-Up Survey of States Using Microcomputer Transportation Planning Packages

Follow-up contacts with those states that indicated they had used one or more planning packages or had investigated their use were made to determine the answers to the following questions:

1. Is the package being used for small urban area planning?
2. Is the package performing satisfactorily?
3. What were the criteria for selecting the package being used?

Use in Small Urban Areas

It was found that the microcomputer packages were not always used in small urban areas. Like Virginia, many states that have the responsibility for planning in these areas use trend projections of certain variables to forecast traffic with growth factors. Still others limit their studies to identification of existing problems in a short-term approach. These procedures are used in small areas, usually with a population of less than 20,000.

There does not, however, seem to be any formal criteria that are used to determine when system modeling is needed. Often, several factors seem to be taken into account in the development of the scope and design of a study. These include study area size and growth potential, existence of an earlier modeled plan, manpower and monetary resource availability, range of possible improvements, and availability of reliable socioeconomic data. Trade-offs must often be made with respect to cost, level of effort, perceived needs, and desired output.

Computer modeling of some of these areas' transportation systems is necessary. In relatively complex and dynamic small urban areas, the ability to forecast travel demand and examine a wide range of alternatives is required. In most cases, this type of analysis must be done with the aid of a system modeling procedure. When modeling is done, there is a definite trend toward the use of a microcomputer planning package.

Performance

With the exception of users of the early version of QRS, most software package users are quite satisfied with their performance. No one package received "higher marks" than the others. Any dissatisfaction on the part of the users was related to factors other than the modeling capabilities--e.g., cost, lack of support, or incompatibility with existing data files.

In addition to the positive responses concerning the comprehensive packages, users of TMODEL and TRANSPRO were also satisfied with their performances. Neither of these packages has transit networking capabilities, and each lacks many of the features found in the comprehensive packages. For many small urban areas these latter two highway packages may be quite adequate and, in fact, preferred since they are cheaper and less involved. These packages, however, are probably not adequate for medium and large area studies.

Selection of a Package

Most respondents selected a package on the basis of several specific factors rather than on a comprehensive, in-depth analysis. Specific factors cited include the following:

1. Features, capabilities, and size constraints.
2. Cost.
3. Data file flexibility and maintenance.

4. Level of support and service from distributors.
5. Compatibility of data files with mainframe files.
6. Source code availability.
7. Hardware compatibility and needs.
8. Graphic capabilities.
9. Ability to incorporate subarea analysis.
10. Company (distributor) stability.

Notable exceptions to the above procedure have occurred in Alabama and Minnesota. The Alabama DOT performed a case study in Huntsville using the MicroTRIPS software package. This process has been documented in a three-phased technical analysis(40,41,42). A key element of the study is model validation.

A two-step process was used to validate the Huntsville MicroTRIPS modeling system. The first step replicated all-or-nothing assignment results as produced by Alabama's PLANPAC modeling system. This check resulted in the identification of refinements that were required to produce reasonable replication of the PLANPAC assignments. These refinements, when made, produced results comparable to PLANPAC.

The second part of the validation effort consisted of showing that MicroTRIPS could be used to produce capacity restraint results that replicated 1980 ground counts. This process entailed selection of the capacity restraint technique and a determination of how it was to be used. The result was a tuned model producing assignments that acceptably replicated 1980 ground counts.

As a result of this evaluation, the Alabama DOT has acquired the MicroTRIPS package and is distributing it to the metropolitan planning organizations (MPOs) in the state.

In the early 1980s, Minnesota DOT officials were faced with a situation similar to that of Virginia's. They needed a quick and easy-to-use methodology for forecasting travel demand in their small- and medium-sized urban areas. In 1984 a study was done utilizing a QRS (old version) and IRAP combination. This was seen as the best possible combination available at that time. Three major drawbacks of this method were the constraints with respect to size of the study area, its labor-intensiveness, and the lack of graphic capabilities.

As a result, a project was undertaken with the objective of identifying a process that could be used by MPOs throughout the state for their transportation forecasting. The method should also incorporate an interface capability of site-specific and regionwide planning needs. The available software packages underwent an initial screening, which narrowed the possibilities to four packages--MicroTRIPS, MINUTP, TRANPLAN and TRANSPRO. The City of Fargo was chosen as the site for the case study because the necessary data for the models were already available.

Criteria used in the evaluation included the following.

1. Size constraints (e.g., number of zones, links and nodes).
2. Data file flexibility.

3. Clear and complete accompanying documentation.
4. Level of support from software distributor.
5. Cost of package and training.
6. Feasibility for interim use.
7. Ability to incorporate site specific needs.
8. Ability to control routing.
9. Graphic capability.

A recommendation concerning the use of a specific package is not made in the final report for the project(43). Rather, information regarding the performance of all four models with respect to the evaluation criteria will be presented. The MPOs can then decide which package to use in light of their specific needs.

APPLICATION OF FINDINGS IN VIRGINIA

Having conducted the literature review and survey, the next task was to determine how these findings could be applied to the needs of the Transportation Planning Division. Before reaching the final conclusions, however, two further factors were addressed: the characteristics of Virginia's small urban areas and concerns expressed by the Task Group for the study.

Characteristics of Virginia's Small Urban Areas

The characteristics that were examined included population trends, frequency distributions of urban areas by population grouping, and the existence of earlier transportation studies. These characteristics are important because the transportation situation varies greatly in small urban areas, and varying levels of planning analysis are appropriate. For instance, travel-demand forecasting procedures needed for long-range planning and alternative testing in a fast-growing area of 40,000 people would likely be very inappropriate if utilized for analysis of a smaller area with little growth potential.

A listing of all the urban jurisdictions in Virginia was obtained from the TPD along with their 1980 census population. In addition, a July 1986 publication that examines the 1980-1984 population trends in Virginia was obtained from the Tayloe Murphy Institute(44). These two sources were used to develop Table 6. The population figures are for the urban jurisdiction rather than for the urban study area used in planning; however, they should serve as a good indicator of the area's characteristics. Further, jurisdictions having a population less than 50,000 that are part of a large urbanized area's regional plan are not included.

Statewide population characteristics and trends that concern the small urban area include the following.

1. Population growth is highly concentrated in the state: 73% of the 1980-1984 growth took place in only 18 of its localities. Average annual statewide growth has been 1.2%.

-2034

Table 6

Population Characteristics of Virginia's
Small Urban Areas

Jurisdiction	1984 Population	1980-1984 Average Annual Growth Rate (%)
Abington	4,476	0.9
Altavista	3,879	0.2
Ashland	4,417	-1.2
Bedford	6,200	0.9
Big Stone Gap	4,903	0.8
Blackstone	3,435	-1.3
Bluefield	5,845	-0.4
Buena Vista	6,600	-1.1
Clifton Forge	4,900	-0.7
Covington	7,900	-3.2
Culpeper	6,825	0.8
Emporia	4,800	-0.2
Farmville	5,824	0.6
Franklin	7,100	-0.7
Galax	6,700	0.7
Lexington	6,900	-1.3
Luray	3,427	-1.1
Marion	7,321	0.1
Norton	4,500	-1.4
Pulaski	9,570	-1.3
Richlands	5,979	0.8
Rocky Mount	4,231	0.2
Smithfield	4,115	2.7
South Boston	7,200	0.4
South Hill	4,447	0.6
Tazewell	4,685	1.2
Warrenton	4,595	4.4
Wise	4,281	2.6
Wytheville	7,061	-0.3
Christiansburg	11,657	3.2
Fredericksburg	18,800	1.5
Front Royal	11,535	0.9
Martinsville	18,400	0.3
Radford	13,400	-0.1
Waynesboro	15,100	-0.4
Harrisonburg	26,000	1.4
Staunton	21,700	-0.2
Winchester	20,600	0.5
Blacksburg	30,434	-0.2

Source: Estimates of the Population of Virginia Counties and Cities: 1984 and 1985

2. These 18 localities contain only 12% of the state's total land area.

3. Since 1980, metropolitan areas (groups of socioeconomically integrated counties and cities) have grown at four times the rate of nonmetropolitan areas (1.6% vs. 0.4%). This is a reversal of the trend in the 1970s.

4. An important reason for this shift is net migration. In the 1970s cities experienced a net outmigration of population. Since 1980 cities have had net immigration of population.

The above statistics are reflected in Table 6 for the small urban areas. All the areas except Smithfield, Tazewell, Warrenton, Wise, Christiansburg, and Harrisonburg experienced either an average annual decrease or less than 1% increase in population growth between 1980 and 1984. This compares with the 1.2% statewide growth and the 1.6% metropolitan area growth.

Table 6 illustrates the distribution of population among the small urban areas considered in this report. About three-fourths (29) of these areas have a population of less than 10,000. An additional 6 areas fall in the 10,000 to 20,000 grouping, which means that about 90% have populations under 20,000.

Previous transportation plans were obtained for eight of the areas with populations less than 10,000. All travel-demand forecasting was done using trend analysis and an external O-D survey. One of these, Smithfield, has a plan that was completed in 1981. Of the ten areas with populations over 10,000, five have had their transportation plans updated recently. Four of these--Fredericksburg, Martinsville, Harrisonburg, and Winchester--were modeled using the process described earlier in this report, whereas Staunton's recent plan utilized trend analysis and an external O-D survey. Plans for Front Royal and Waynesboro are underway; they also utilize the trend-analysis forecast procedure.

Concerns of the Task Group

The concerns of the task group for the study provided the final input to the determination of how the findings could be applied in Virginia. A major concern was that the collection of socioeconomic data might not be justified for small urban areas. Specifically, the cost and time involved in collecting these data and allocating them to traffic zones would not result in a proportional increase in the reliability of the forecasts. The applicability and utilization of the traditional modeling methodology in a small urban area situation was questioned.

Another fact causing concern is that through-traffic constitutes a large percentage of the traffic flow in small urban areas. Hence, information on external trips must be known in order to examine potential by-pass alternatives. Currently, external O-D surveys are conducted to obtain the data. The cost of these surveys is high; however, the elimination of procedures needed for internal traffic modeling offsets this.

Conclusions

The TPD's current procedures are quite similar to those in use elsewhere. Also, an examination of Table 6 shows that the plans that need to be updated in Virginia are for those areas in the 3,500-10,000 population range. As was pointed out in the literature review, areas of this size may not require traffic modeling to satisfy their transportation planning needs. Often, an identification of existing deficiencies and use of a short-range planning methodology are adequate(5,6,8,9). Since these areas are characterized by low ADTs (i.e, less than 10,000), forecasting errors of even 35-45% (45) may not have an appreciable impact on the alternatives that are considered.

On the other hand, if long-range, twenty-year forecasts are desired for these very small areas, a trend-analysis forecasting procedure would produce a plan of dubious reliability. In areas this small, the addition of a major land development could significantly alter the local travel characteristics. Plans developed through trend analysis need to be monitored and updated more frequently than every twenty years.

The primary question with respect to these small areas is: Should the area be modeled at all? This has been addressed earlier in this report with the result that no formal guidelines were found. The character of the areas in Virginia that are due for updating would be better suited for short-range forecasting and problem identification than for long-range modeling. If it is determined that network modeling is required, the use of one of the microcomputer planning packages would be most appropriate. Since the TPD has already acquired the MINUTP software package, it would be logical to use it. This investigation has not found any compelling reasons that justify the purchase of a different package.

On the other hand, both TMODEL and TRANSPRO may be more appropriate for small urban areas. Socioeconomic data are required as input; however, the program's operations are less complex than those of MINUTP. The updated QRS package may also be appropriate.

MAJOR CONCLUSIONS AND RECOMMENDATIONS

The recommendations in this section are based on certain underlying conclusions reached in this study concerning the transportation planning process in small urban areas. These can be stated as follows.

1. The literature review showed that there are two basic categories of transportation forecasting methodologies being utilized for small urban areas. The first is based on analyzing trends in readily obtainable data--such as population, vehicle registration, and traffic flow--in order to develop a growth factor. This factor is then applied to existing volumes to derive a forecast of future demand volumes. The second method is based on the development of a model that incorporates socioeconomic data to synthesize existing travel patterns. Forecasted socioeconomic data are then used in the model to derive the future travel demand.

2. Other states use forecasting procedures that fall within these two broad categories of methodology; however, they may use different techniques. For example, there are several techniques for developing growth factors. Likewise, there is a variation in modeling techniques, ranging from those requiring a mainframe computer to those available on a microcomputer.

3. Forecasting procedures falling within both of these categories are also used by the TPD for areas having a population less than 50,000. The specific techniques are well documented and widely used.

4. The major issue in transportation forecasting in small urban areas facing the TPD is the selection of a technique (or combination of techniques) that provides for the transportation needs of the area and the desired degree of accuracy.

The following process should be used by the TPD in formulating a transportation forecasting procedure to be used in a specific small urban area.

1. Select the broad category of transportation planning methodology to be used; that is, either develop a model or use growth factors. Each urban area has its own unique set of characteristics that govern its transportation needs, and these must be examined in order to make an appropriate selection. Factors to be considered include the following:

   1. Study area size and growth potential.
   2. Existence of and type of an earlier plan.
   3. Manpower and monetary resources available.
   4. Range of potential transportation alternatives.
   5. Availability and reliability of socioeconomic data.

   Based on a review of the characteristics of small urban areas (populations are very small, growth is non-existent or minimal, and socioeconomic data are lacking), a growth-factor methodology appears appropriate for most of the small urban areas in Virginia that need updates.

2. If a growth-factor methodology is selected, the current techniques used by the TPD are satisfactory. Historical trend analysis of population, vehicle registration, and traffic volumes should be performed to derive a growth factor. This factor should then be used to forecast travel in the target year. It should be noted that long-range forecasts based on historical trends are often unreliable in small areas due to the significant impacts on travel of unanticipated development. Accordingly, short-range planning that focuses on identifying and solving current problems, possibly utilizing TSM improvements, may be appropriate. However, more frequent updates or monitoring would be required. Finally, if external traffic flows suggest the need for a bypass, an external cordon O-D survey of some form should be conducted. The current technique used by the TPD is satisfactory; however, it is recommended that the technique used by the North Carolina Department of Transportation(19,20) described on

page 35 of this study be evaluated for applicability in Virginia. This technique provides an estimate of the percentage of through-trips at each external cordon station. This eliminates the expense of conducting an O-D survey.

3. If a modeling methodology is selected, the current technique used by the TPD is not satisfactory. The state-of-the-art in transportation modeling eliminates the need for using a mainframe computer and the PLANPAC battery of programs. Rather, the TPD should consider the use of one of several microcomputer-based planning packages. Specifically, if a comprehensive analysis is desired, the MINUTP package should be used. The TPD already has this package, and it has performed elsewhere as well as any of the other available packages. If a less detailed model is desired, then the TMODEL package should be used. This package is often cited as being appropriate for small urban area analysis and, although requiring basically the same input as MINUTP, its operation is less complex. Again, the TPD already has this package, and its performance elsewhere is satisfactory. Finally, consideration should be given to obtaining the updated QRS package when it becomes available. This package is in the public domain and can be purchased at a minimal cost.

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APPENDIX A

Excerpts from Transportation Network Analysis Packages for Microcomputers, UMTA, 1985

Table 1:

PACKAGE CAPABILITIES

Package	Highway Networks			Transit Networks			Travel Estimation			Matrix Handling			
	Network Building	Impedance Tables	Traffic Assignment	Network Building	Impedance Tables	Trip Assignment	Trip Generation	Trip Distribution	Mode Split	Entry/Updating	Scaling/Combining	Transposition	Squeezing/Expanding
ASSIGN	X		X				X	X					
EMME/2	X	X	X	X	X	X	X	X	X	X	X	X	X
IRAP	X		X							X			
MicroTRIPS	X	X	X	X	X	X	X	X	X	X	X	X	X
MINUTP	X	X	X				X	X	X	X	X	X	X
MOTORS	X	X	X	X	X	X	X	X	X	X	X	X	X
TMODEL	X		X				X	X		X			
TRANPLAN	X	X	X	X	X	X	X	X	X	X	X	X	X

Table 2:

BASIC STRUCTURE AND OPERATION

Package	Function Selection			Option Selection			Parameter Specification				Data File Selection		
	Menu Choices	User Specification	Control File	Menu Choices	Screen Prompts	Control File	Screen Prompts	Default Values	Internal Tables	Control File	No Choice	Scenario Name	Individual File Name
ASSIGN	X			X	X		X					X	
EMME/2	X	X		X	X		X		X			X	
IRAP	X				X		X				X		
MicroTRIPS		X			X	X	X			X			X
MINUTP		X	X		X	X	X			X		X	X
MOTORS		X			X		X	X					X
TMODEL	X			X	X		X	X					X
TRANPLAN			X			X		X		X			X

Table 3:

HIGHWAY NETWORK PREPARATION

Package	Network Development				Intersection Features				Link Changes				General Changes		
	Screen Templates	Screen Plots and Tables	Card-Image File	"Main-Frame" File Conversion	Turn Prohibitors	Specific Turn Penalties	General Turn Penalties	Calculated Impedances	Interactive Modification	Changes to Data File	Card-Image Modifications	Duplication Required	Speed or Capacity Tables	Time Period Conversion	Other Macro Procedures
ASSIGN	X				X	X			X			X			
EMME/2		X	X		X	X		X	X	X		X			
IRAP	X				X	X			X			X			
MicroTRIPS			X		X	X				X		X	X		
MINUTP			X				X			X		X	X		X
MOTORS	X		X	X		X		X	X	X		X		X	
TMODEL	X							X	X						
TRANPLAN			X		X		X			X	X			X	X

Table 4:

TRAFFIC ASSIGNMENT OPTIONS

Package	Unrestrained Options					Volume/ Delay			Incremental Options			Other Capacity Restraint				
	All-or-Nothing	User-Defined Paths	Dial's Multi-Path	Impedance Variance	Loaded Network Impedances	Adjustment Formula	User-Supplied Curves	Damping	User-Specified Fractions	Automatic Fractions	Origin Zones	Iterative	Iterative Multi-Path	Incremental Multi-Path	Volume Averaging	Automatic Equilibrium
ASSIGN	X		X			X					X					
EMME/2	X						X					X				
IRAP	X	X														
MicroTRIPS	X			X	X		X		X			X			X	
MINUTP	X		X		X	X		X	X			X	X	X	X	
MOTORS	X				X	X				X						X
TMODEL	X					X		X	X			X				
TRANPLAN	X		X		X	X	X	X	X			X				

Table 5:

HIGHWAY ANALYSIS PRODUCTS

Package	Basic Reports				Report Control			Special Reports			Select Link Analysis				
	Unloaded Network	Selected Paths	Link Loads	Turning Movements	Deferred Printing	Partial Networks	Format Choice	Assignment Convergence	Ground Count Comparisons	VHT/VMT Summaries	Volume Traces	Origins of Node Users	O-D's of Link Users	Link-to-Link Tables	Subarea Trip Tables
ASSIGN		X	X	X	X							X			
EMME/2	X		X	X	X	X				X					
IRAP	X	X	X	X											
MicroTRIPS	X	X	X		X			X		X			X		X
MINUTP	X	X	X	X	X	X	X	X	X	X	X		X		
MOTORS	X	X	X	X	X	X		X		X					
TMODEL	X	X	X	X	X		X								
TRANPLAN	X	X	X	X	X	X		X	X	X			X	X	X

Table 6:

TRANSIT ANALYSIS FEATURES

Package	Running Times				Path Building					Assignment Reports			
	Specified Link Times	Free-Flow Auto Times	Congested Auto Times	Factored Auto Times	Wait and Walk Weights	Wait/Transfer Limits	Fare Surrogates	Mode Use Prohibitions	Multiple Paths	Transit Link Loads	Access Link Loads	Route Load Profiles	Station-to-Station Tables
ASSIGN													
EMME/2	X	X		X	X		X			X	X	X	
IRAP													
MicroTRIPS	X	X	X		X	X	X	X	X	X	X	X	
MINUTP													
MOTORS	X	X			X					X		X	
TMODEL													
TRANPLAN	X				X	X	X	X		X	X	X	X

Table 7:

TRAVEL ESTIMATION

Package	Trip Generation					Trip Distribution							Mode Split	
	Equations	Category Rates	Rate Estimation	Automatic Balancing	Trip End Entry/Updating	Table Building/Conversion	Fratar	Exponential Gravity	Friction Factor Gravity	K-Factors	Gravity Calibration	O/D Conversion	Diversion Curves	Binary Logit
ASSIGN		X			X			X						
EMME/2	X				X	X	X					X		X
IRAP														
MicroTRIPS		X		X	X	X	X	X	X	X	X	X	X	X
MINUTP	X	X		X	X	X	X		X			X		X
MOTORS	X	X	X		X	X	X	X				X	X	
TMODEL		X		X	X	X		X				X		
TRANPLAN	X	X			X	X	X		X	X	X	X	X	

Table 8:

PLOTTING CAPABILITIES

Package	Scope				Media			Attribute Display			Special Features			
	Highway Networks & Loads	Highway Paths	Transit	Zonal Data & Matrices	Screen Displays	Dot Matrix Printers	Plotters	Posting	Bandwidths	Color-Coded Ranges	Windows	Selective Displays	Calculated Attributes	Node Volumes and Delays
ASSIGN														
EMME/2	X	X	X	X	X		X	X	X	X	X	X		X
IRAP														
MicroTRIPS	X						X	X	X		X			
MINUTP	X						X	X		X	X	X	X	
MOTORS														
TMODEL	X				X	X		X	X		X			X
TRANPLAN	X	X					X	X	X	X	X			

Table 9:

HARDWARE REQUIREMENTS

Package	Micro Computers				Minimum Memory				Disk Drives		
	CP/M-80 Machines	Apple II	Apple II+ or IIe	IBM-PC or Compatible	IBM-PC: 128K	256K	384K	Other: 48-64K	1 Floppy	2 Floppies	Hard Disk
ASSIGN			X					X		X	
EMME/2											
IRAP		X	X	X	X			X		X	X
MicroTRIPS	X			X		X		X		X	X
MINUTP				X	X				X	X	X
MOTORS	X			X		X		X		X	X
TMODEL	X	X	X	X	X			X	X	X	X
TRANPLAN				X			X			X	X

Table 10:

NETWORK SIZE GUIDELINES

Package	Fixed Limits	Highway Zones	Highway Nodes	Highway Links	Highway Turns	Transit Zones	Transit Nodes	Transit Links	Transit Routes
ASSIGN	yes	75	500[a]	2500[b]	20[c]	-	-	-	-
EMME/2	yes	400	2500	8000	?	400	2500	8000	200
IRAP	yes	50	99	400[b]	all	-	-	-	-
MicroTRIPS									
CP/M(64K)	no	100	700[a]	2000[b]	?	100	700[a]	2000[b]	1020
IBM(256K)	no	300	2000[a]	4600[b]	?	300	2000[a]	8000[b]	1020
MINUTP									
IBM(320K)	no	1000	8000[a]	16000[b]	?		-	-	-
-									
MOTORS									
CP/M(64K)	yes	200	800[a]	2500[b]	200[c]	100	600[a]	1000[b]	64
IBM(256K)	yes	400	2000[a]	6000[b]	200[c]	400	1500[a]	2000[b]	64
TMODEL									
CP/M(64K)	yes	65	150[a]	550[b]	21	-	-	-	-
Apple(64K)	yes	72	150[a]	550[b]	21	-	-	-	-
IBM(128K)	yes	80	350[a]	1200[b]	28	-	-	-	-
IBM(512K)	yes	300	800[a]	2000[b]	42	-	-	-	-
TRANPLAN									
IBM(384K)	no	500	4000[a]	6000[b]	?	500	4000[a]	6000[b]	200

[a] number includes zones
[b] one-way links
[c] number of nodes at which turns are reported

Table 11:

PACKAGE PRICES

Package	Price
ASSIGN	?
EMME/2	?
IRAP	$ 750
MicroTRIPS	$ 7,500 (can be separated into the following components: highway, travel and matrix $5,000 plotting $1,000 transit $1,500)
MINUTP	$ 5,000 (prices have not been set for the plotting program or the transit program under development)
MOTORS	$ 3,500 (a version without transit and mode split can be purchased for $2,500)
TMODEL	$ 1,200 (an extended IBM-PC 512K version is available for $1,500, and a separate plotting program can be obtained for $250)
TRANPLAN	$12,000 (includes source code, and can be separated into the following components: highway, travel and matrix $7,500 plotting $2,000 transit $2,500)

-21-3

Table 12:

APPLICABILITY OF MICROCOMPUTER PACKAGES

Package	Stand-Alone Subarea Analysis	Integrated Subarea Analysis	Small Regional Analysis	Large Urban Corridor Analysis
ASSIGN	highway only, still in development	highway only, still in development	no	no
EMME/2	multi-modal	multi-modal	multi-modal	multi-modal
IRAP	highway only, requires a trip table	highway only	no	no
Micro-TRIPS	multi-modal	multi-modal	multi-modal	multi-modal
MINUTP	highway only	highway only	highway only	highway only
MOTORS	multi-modal	multi-modal	multi-modal	multi-modal
TMODEL	highway only	highway only	extended version may be applicable; highways only	no
TRANPLAN	multi-modal	multi-modal	multi-modal	multi-modal

APPENDIX B

Questionnaire Used in States Survey

Questionnaire on Transportation Planning For
Small Urban Areas

1. Agency ____

2. Name, address, and telephone number of person completing questionnaire.

____
____
____
____
____

3. Is your agency responsible for developing transportation plans for small urban areas (less than 50,000 population) in your state?
Yes ____ No ____

If no, could you please provide the name of the person who does have this responsibility and return the questionnaire?

____
____
____
____
____

4. Does your agency have a formal methodology for developing transportation plans for urban areas of less than 50,000 population?
Yes ____ No ____

If yes, please attach, or describe, any available documentation of your methodology.

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5. Does your agency use a microcomputer software package in your planning for small urban areas?
Yes____ No____

5a. If yes, please describe the package.

____
____
____
____
____

5b. If no, please describe any packages that may have been considered, and the reasons for their rejection.

____
____
____
____
____

6. What are the strengths and weaknesses of your present planning methodology?

____
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____
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____
____
____
____

Thank you

Please return to: Chris Gay
Va. Highway & Trans. Research Council
Box 3817 University Station
Charlottesville, Virginia 22903

____ Check here if you would like a copy of the final report.