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SUMMARY

SYSTEM PLANNING AND ANALYSIS STUDY OF THE TWIN CITIES AREA

FOR THE
MINNESOTA HIGHWAY DEPARTMENT

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PLANNING/TRANSPORTATION/ENGINEERING/ARCHITECTURE

June 30, 1975

Mr. Fred P. Tanzer
Coordinator
Metropolitan Planning Section
Minnesota Highway Department
St. Paul, Minnesota 55155

Dear Mr. Tanzer:

Transmitted herein is BRW's Summary Report completed for Agreement No. 57645 for the Twin Cities System Planning and Analysis Study.

This report summarizes the information contained in the eight Technical Memoranda submitted for the Greater Minneapolis System Planning and Analysis Study and the three Technical Memoranda submitted for the Greater St. Paul System Planning and Analysis Study. These memoranda and the separately submitted detailed traffic assignments provide the Minnesota Highway Department with new traffic forecast information for use in various projects within the study area.

The assistance of your staff with the computer processing greatly aided in the completion of this work.

Sincerely yours,

BATHER-RINGROSE-WOLSFELD, INC.

Richard P. Wolsfeld, P.E.

RPW:jw

Enc.

SUMMARY REPORT

THE TWIN CITIES
SYSTEM PLANNING AND ANALYSIS STUDY

PREPARED FOR

STATE OF MINNESOTA
DEPARTMENT OF HIGHWAYS
ST. PAUL, MINNESOTA 55755

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JUNE 30, 1975

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BACKGROUND

Two major transportation planning programs have been conducted in the Twin Cities area. The first of these, the Joint Land-Use-Transportation Planning Program, began in 1958 and continued into the 60's. The second program, the Transportation Planning Program (TPP) began in 1970 and is presently in process.

The data base for the Joint Program included origin-destination and land use studies made in 1958. Two primary street and highway plans were produced by the Joint Program. One of these, System 14, represented the street and highway system as it was then planned for 1985. In addition to the Interstate System, several other freeways were included in System 14. The other plan, System 16, represented a 1975 street and highway network. Most of the diagonal and cross-town freeways of System 14 were not included in System 16.

System 16 was originally intended to be an intermediate stage in the development of the ultimate street and highway network. However, through time, as certain facilities were eliminated from the future network, System 16 became more representative of a 20 year system than System 14.

PURPOSE OF THE TWIN CITIES SYSTEM PLANNING AND ANALYSIS STUDY

Due to a number of reasons the Transportation Planning Program is behind schedule. Models are being calibrated and future networks based on a zcnal system have not been developed. During this time the Minnesota Highway Department has been involved in a number of controversial freeway projects. Some of the legitimate questions raised about these projects center on the validity of the travel demand that forms an important part of the need and justification for the facility. Questions include:

- Is gasoline going to be available such that travel characteristics of the past will continue in the future?
- Is gasoline going to be available to allow an increase in the number of trips taken each day by the average resident, as forecasted?

- What is the impact of different transit service concepts on the vehicular travel demand?
- Are low capital alternatives a solution to the problem?
- Why is 1958 data being used as a base for projecting 1995 or 2000 needs?

Given this background a study, the Twin Cities System Planning and Analysis Study (TCSPAS), was commissioned by the Minnesota Highway Department to develop year 2000 forecasts that were sensitive to:

- the use of the most recent measurement of travel characteristics
- the most recent forecasts of urban activities, i.e. population, employment, dwelling units, etc.
- the impact of a transit system
- the impact of low capital alternatives, such as car pooling, van pooling, staggered work hours, etc.
- the impact of a change in amount of travel made by each person in the area

The intent of this work is to provide interim forecasts until the work of the Transportation Planning Program is available.

Two separate studies were conducted for the Twin Cities System Planning and Analysis Study (TCSPAS). The first to be undertaken was the Greater Minneapolis System Planning and Analysis Study (GMSPAS). Later the Minnesota Highway Department expanded the scope of the work to include a Greater St. Paul System Planning and Analysis Study (SPSPAS).

The work completed for the GMSPAS is documented in a series of eight technical memoranda submitted to the Minnesota Highway Department on April 15, 1975. For the GMSPAS the transportation planning process included a network analysis, analysis and allocation of demographic data, analysis and development of planning models as needed, and development of travel forecasts. For the SPSPAS the process was much the same except that the models as developed from the GMSPAS were used. Both studies produced traffic assignments for the entire network; however, because revised demographic forecasts were available and some further network refinements were made, the assignments from the SPSPAS replaced those from the GMSPAS.

STUDY AREAS

Four study areas are referenced throughout the planning process, they include (Figure 1):

- Twin Cities Metropolitan Area

  This area, the "Seven-County Area", includes all of Anoka, Carver, Dakota, Hennepin, Ramsey, Scott, and Washington Counties.

- Joint Program Area

  This area, used by the Joint Program study, was subdivided into 756 traffic analysis zones. The System 16 network is based on this zonal system.

- Greater Minneapolis System Planning and Analysis Study (GMSPAS) Area.

  This study area is bounded on the south and west by I-494, on the east by Snelling Avenue in St. Paul, and on the north by I-694 and I-94.

- Greater St. Paul System Planning and Analysis Study (SPSPAS) Area.

  This study area is defined as all of the Joint Program Study area east of Snelling Avenue.

OVERVIEW OF WORK TASKS

The work tasks for the study are shown on Figure 2. Following are brief statements summarizing each of the tasks:

- System 16 Network Analysis. The historical record of System 16 was audited for errors in link coding. Turn penalties and link distances were checked for compatibility with existing or planned facilities. Travel speeds were examined for inconsistencies on facilities with similar characteristics and traffic volumes.

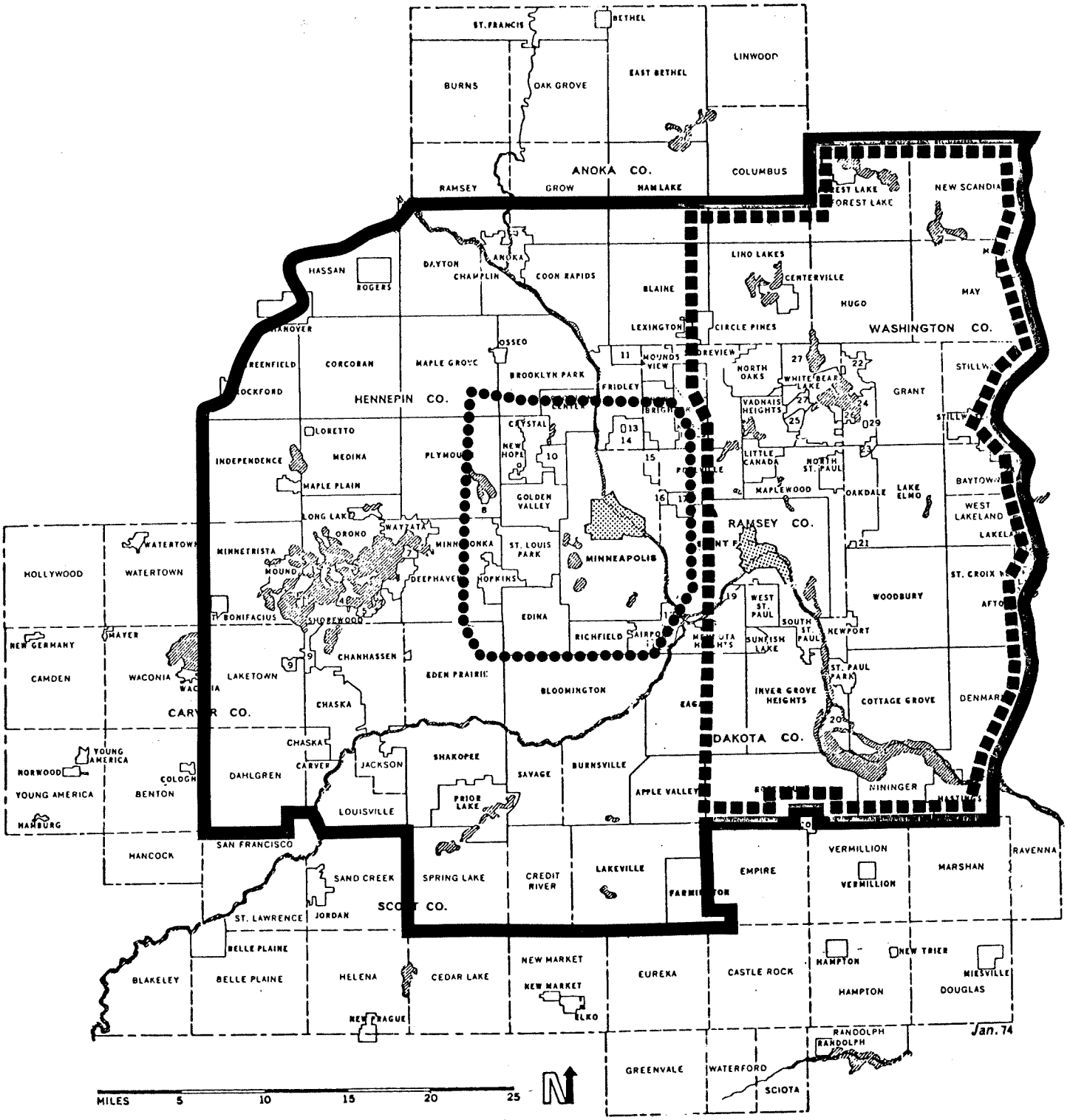

FIGURE 1
TWIN CITIES METROPOLITAN AREA

OVERVIEW OF WORK TASKS FOR THE TWIN CITIES SYSTEM PLANNING AND ANALYSIS STUDY

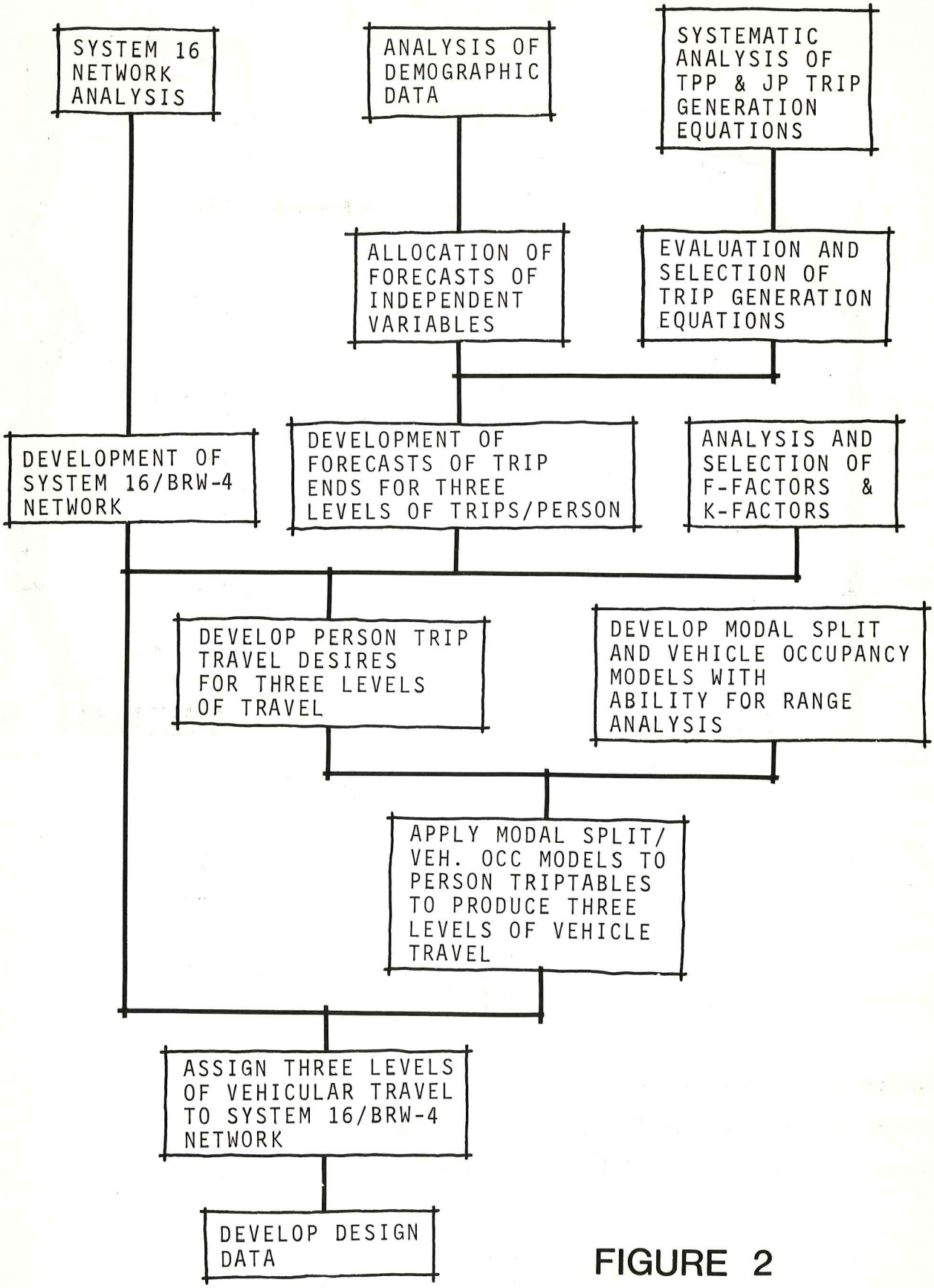

FIGURE 2

- Development of System 16/BRW-4 Network. The System 16 network was revised through several stages into a final network, System 16/BRW-4. Included in the revisions of the System 16 network are the following: errors found in the network coding were corrected; links were added in the suburban areas; the latest planning for access to freeways was coded into the network; and travel speeds were adjusted as necessary following an analysis of minimum travel time paths.

- Analysis of Demographic Data. Joint Program forecasts for population, dwelling units and employment were compared to observed data for 1970 and to Metropolitan Council forecasts interpolated to 1985. Areas used for comparisons were the development rings and sectors. Following this analysis, the Metropolitan Council forecasts based on the Development Framework for the year 2000 were selected for the Twin Cities System Planning and Analysis Study (TCSPAS).

- Systematic Analysis of TPP and Joint Program Trip Generation Equations. A study was made of the sensitivity of the trip generation equations to changes in the independent variables in those equations. Two sets of trip generation equations were analyzed, the Transportation Planning Program (TPP) equations and the Joint Program (JP) equations. Selected revisions were made to the TPP equations using the home interview data from the 1970 Travel Behavior Inventory; the new equations were called TPP/BRW. Independent variables in the new equations are similar to those in the TPP equations except that the logarithm of income instead of absolute income is used.

- Evaluation and Selection of Trip Generation Equations. The three sets of equations, TPP, TPP/BRW, and JP, were tested by using 1970 data to calculate 1970 trips. The calculated trips were compared to the trips observed in the 1970 Travel Behavior Inventory. The TPP/BRW equations were selected to be used for this study.

- Allocation of Forecasts of Independent Variables. Metropolitan Council district forecasts for the independent variables used in the trip generation equations were allocated to the zone system. The Metropolitan Council forecasts, dated January 9, 1975, were used. The variables include population, dwelling units, total employment, retail employment, FIRE employment, income, school age population, and distribution of household size.

- Analysis and Selection of F-Factors and K-Factors. The first step in this analysis was a visual comparison of the two sets of F-factors plotted on a logarithmic scale. Next two gravity model runs were made, each run using all data in common except for the F-factors. The trip tables, trip length frequencies, and average trip lengths from the two runs were compared. The Joint Program F-factors were selected for use in the GMSPAS.

  For the analysis of the K-factors, the effects of using no K-factors, a partial set of K-factors, and all K-factors were studied. Also the feasibility of using a complete set of the TPP district K-factors applied at the zonal level was examined. It was decided to use the entire set of Joint Program K-factors.

- Develop Modal Split and Vehicle Occupancy Models. These models predict the proportion of trips for each trip interchange to be made as an auto driver, auto passenger, or transit passenger. These models are "goal oriented"; that is, goals for transit usage and vehicle occupancy are established and the model achieves those goals. Variables used in these models are average household income and average household size for the origin zone, trip purpose and transit availability.

- Development of Forecasts of Person Trip Ends. Trip productions and attractions for year 2000 were calculated for each zone using the selected trip generation equations (TPP/BRW) and the allocated independent variables. These trip ends were calculated for three levels of travel forecasts based on low, medium and high estimates of trips per person.

- Development of Person Trip Travel Desires. The person trip ends calculated in the preceding step were used as input to the gravity model. Person trip tables for each of the three levels of travel forecasts were produced by the gravity model. A "trip splitter" program was used to convert the production and attraction tables to origin-destination tables.

- Application of the Modal Split and Vehicle Occupancy Models. The three person trip tables were transformed into vehicle trip tables using the modal split and vehicle occupancy models previously described. Different values of percent transit and vehicle occupancy were combined with the three levels of trip making to establish ranges of vehicular travel demand.

- Assignment of Vehicular Travel to System 16/BRW-4. The three levels of vehicular travel demand were assigned to System 16/BRW-4 and resulted in ranges of forecasted daily traffic for each facility in the network.

- Development of Design Data. A general discussion of the design hour factors and directional distribution factors to be applied to the 24-hour forecasted volumes to develop design data is presented.

APPROACH TO FORECASTING TRAFFIC DEMAND

Traditionally transportation planners have analyzed existing travel demands, developed models to explain the travel relationships, and then forecasted traffic volumes. The forecasted traffic volumes are the result of the application of point values for the following items:

- Trips/person/day
- Percent transit
- Vehicle occupancy
- F-factors (impact of travel times on amount of trip interchanges)
- Travel speeds on the future network

1975 represents a very difficult point in time to forecast the future, due to questions on:

- Gasoline availability
- Future direction of transit
- Impact of low-capital alternatives on vehicle occupancies
- Impact of the Metropolitan Council's Development Framework on land development and resultant travel

Thus, the general approach to forecasting traffic for the TCSPAS is not to end the planning process with a single value for forecasted demand, but to develop a range of values based on a reasonable high, medium, and low value for trip/person, percent transit, and vehicle occupancy. For this analysis F-factors and travel speeds on the future network were not varied.

To set the brackets for the range of forecasts, the highest trips/person are combined with the lowest vehicle occupancies and percent transit and the lowest trips/person are combined with the highest vehicle occupancies and percent transit.

The selected values for transit, vehicle occupancy, and trips/person are discussed in the following sections.

The intent of this range of forecasts is to present alternatives to policy makers. Questions such as the following can be answered:

- Is the facility justified even with the most optimistic forecasts of transit usage?

- Are low-capital alternatives an option versus new construction?

- What is the impact on peak-hour travel of lower trips/person rates caused by gasoline shortages?

However, with the additional data goes the requirement of additional analysis and interpretation. Questions on which values to use for design purposes, noise analysis, and air quality work will arise and have to be answered on a project by project basis.

Thus, in summary the approach to forecasting traffic volumes for the TCSPAS is to provide a range of forecasts that brackets high and low expected travel demands. The influencing factors on the range of values includes transit usage, vehicle occupancy, and trips/person/day.

NETWORK ANALYSIS

Two major factors influence the forecasted traffic volume on any street network link: the travel speeds assigned to the links and the magnitude of the travel desires that can be satisfied by the links. Technical Memorandum No. 1 (GMSPAS) and Technical Memorandum No. 1 (SPSPAS) report on the network analyses. The purpose of this analysis was to determine whether the System 16 network accurately represented accessibility within the study area, and to revise network parameters where necessary in order to have a network for use in developing traffic projections for the year 2000.

Several network characteristics were analyzed in arriving at an adequate year 2000 network:

- Additional suburban arterial streets were added to increase the network density and better represent actual conditions.
- Planned regional freeway facilities were corrected for the currently proposed designs.
- Link travel times were reviewed in terms of facility functional classification.
- Minimum travel time paths were analyzed in terms of logical routing, zone to zone travel time, return routing path and travel time, and the relationship between trip length and facility functional classification.

A forecasted trip table was assigned to three different versions of the System 16 network to determine the effect of link parameter changes on link volumes, trip length, screen line crossing, and average network speed.

Link travel times for the final network were coded after consideration of the impact of the travel times on the volumes and volume to capacity ratios.

As an example, the results of these analyses for I-335 are discussed. In the immediate area of I-335 several problems were identified and resolved, including network coding errors, an important freeway access revision and travel path rerouting discrepancies. In addition to these problems, those minimum time travel paths which used links of I-335 were found to be extremely sensitive to small changes in network parameters, such as travel speed and turn penalties. This is because there are alternate routes available, some with a much shorter

travel distance than on I-335. For instance, eastbound traffic on I-335 destined for the East Bank Campus of the University of Minnesota would travel a shorter route using University Avenue from I-335 instead of continuing on the freeway. Travel time for the two choices are so nearly the same that a small change in travel speed results in shifting the traffic assignment from one route to the other.

A major lesson learned during the System 16 review was that a thorough network analysis is essential to development of logical traffic assignments. Although the I-335 assignments are unusually sensitive to network parameter changes and point out the importance of the network analysis in a particularly emphatic way, the lesson is reinforced with experience at many other locations. For instance, in some cases minimum time paths were found to follow arterial streets parallel to a freeway. Time saved by using the freeway route was not as much as the time required for traffic to travel the additional distance from the arterial to the freeway. For short trips on the freeway this is to be expected. However, cases were found where the minimum time path followed an arterial for as much as six miles instead of diverting one mile to a freeway.

Careful attention must be given to maintaining a realistic relationship in travel speeds between the separate classifications of facilities and a consistent travel speed pattern on facilities of similar type with similar traffic loads.

The network resulting from this analysis had the three levels travel demand assigned to it.

TRIP GENERATION

TRIP GENERATION PROCESS FOR TCSPAS

Trip generation is the process by which a transportation planner forecasts the number of trips produced or attracted by each traffic analysis zone. The trip generation phase of the TCSPAS consisted of the following steps:

- Analysis of demographic data. Technical Memoranda Number 2 (GMSPAS and SPSPAS) report on this step. The work included reviewing three major forecasts of values used as independent variables in the trip generation equations. These forecasts, one by the Joint Program and two (EMPIRIC and Development Framework) by the Metropolitan Council, were compared for similar areas and for similar points time. The Metropolitan Council forecasts based on the Development Framework were selected to be used as a basis for predicting future travel demand.

- Two sets of trip generation equations, one developed by the Joint Program, the other developed by the Transportation Planning Program were analyzed and tested. This process included a review of the equations for general reasonableness and for sensitivity of the equations to changes in the independent variables. This analysis is discussed in Technical Memorandum Number 3 (GMSPAS). The equations were tested by predicting 1970 trips from the equations using known 1970 values for the independent variables. The predicted trips were compared with actual trips as determined by the 1970 Travel Behavior Inventory. See Technical Memorandum Number 4 (GMSPAS).

- Analysis of the TPP equations indicated that the influence of income was too dominant. Hence, a new set of equations was developed using a new variable, the logarithm of average household income. The new equations were developed using regression analysis on the data from the 1970 TBI. These equations were also tested by using them to predict 1970 trips.

- The new equations were selected to be used for the TCSPAS.

- Trip productions and attractions for the year 2000 for each of the 756 zones were calculated by using the selected trip generation equations and the forecasts of the independent variables. The forecasts used for the GMSPAS are from the Metropolitan Council's Development Framework district forecasts dated October 31, 1974, and from the District Forecast File Report dated November 26, 1974. The allocation of the district totals to the traffic analysis zones is discussed in Technical Memorandum No. 6 (GMSPAS). For the SPSPAS the revised Development Framework forecasts dated January 9, 1975, were used; this resulted in only minor changes in trip end forecasts.

FORECASTS OF PERSON TRIP ENDS

As discussed in the previous section, travel forecasts are difficult to make because there are at present many questions regarding gasoline availability, future transit developments and other factors affecting travel in the Twin Cities Area. For this reason the TCSPAS developed a range of forecasts for travel. This range encompasses the lowest to the highest amount of travel that at this time appears possible to occur.

The first value selected to establish the range of travel forecasts is the expected trips per person. The three levels of trip making rates used for the TCSPAS were:

- High Travel Forecasts - 3.50 Trips/Person/Day
- Medium Travel Forecasts - 2.72 Trips/Person/Day
- Low Travel Forecasts - 2.35 Trips/Person/Day

The middle value is the measured 1970 value, the high value is the number the Metropolitan Council is currently using for forecasting, and the low represents a value experienced in the past.

Control totals for the total number of trips were computed using the above trip making rates. Control totals for the number of trips by trip purpose were based on the following:

- Total home based work trips equals 1.39 times the employed residents and is assumed constant for all levels.
- Total non-home based trips equals 21.5 percent of the total trips for all purposes.
- Total home based trips for purposes other than work equals total trips minus total home based work trips and total non-home based trips.

Trip productions and attractions calculated for each traffic analysis zone using the trip generation equations were adjusted so that the total number of trips by purpose would equal the established control totals for each traffic forecast level. The forecasts used are shown below.

Characteristic	1970 TBI	2000 Trip Production Forecasts* Low	Medium	High
Population	1,874,400	2,811,550	2,811,550	2,811,550
Employment	854,400	1,576,040	1,576,040	1,576,040
Trips/Person	2.72	2.35	2.72	3.50
HBW Trips	1,105,640	2,044,600	2,044,600	2,044,600
HBO Trips	2,931,090	3,142,000	3,958,600	5,680,100
NHB Trips	1,058,310	1,420,500	1,644,200	2,115,700
Truck Trips **	455,080	736,800	736,800	736,800
Total Trips	5,550,120	7,343,900	8,384,200	10,577,200

* for Joint Program area (756 zones)

Notes: Population and employment forecasts for 756 zones are based on Metropolitan forecasts as follows:

- Population - 2,888,000
- Employment - 1,586,000

** for truck trips, vehicle trips are assumed to equal person trips.

ANALYSIS AND SELECTION OF F-FACTORS AND K-FACTORS

The gravity model used for distributing trips from zone to zone is calibrated, that is made to reproduce known travel, by utilizing certain factors within the model. These factors are the following:

- F-Factors. These factors relate the separation, expressed as travel time, between two zones to the magnitude of the travel between the two zones.

- K-Factors. These factors relate the effect of distinctive social-economic factors that are not accounted for otherwise, to zone to zone movements.

Both the Joint Program and the TPP had developed F-Factors and K-Factors. The analysis of these factors conducted for the TCSPAS is discussed in Technical Memorandum Number 5 (GMSPAS). It was concluded in Memorandum Number 5 that the two sets of F-Factors produce different trip distributions. It was decided that the Joint Program F-Factors would be more applicable to use with the gravity model for the TCSPAS because these factors are based on the same network system as used by the TCSPAS.

Because of the inter-relationship of the F-Factors and K-Factors and the network upon which they are based, the Joint Program K-Factors were selected to be used in conjunction with the Joint Program F-Factors.

Development of new factors using 1970 data and the System 16 network was not within the scope of this study.

TRIP DISTRIBUTION AND ASSIGNMENT

Technical Memorandum Number 8 (GMSPAS) and Technical Memorandum Number 3 (SPSPAS) report on the distribution of person trips to zone to zone movements, the application of the modal split and vehicle occupancy models and the assignment of the vehicular traffic to the network system. Development of the modal split and vehicle occupancy models is discussed in Technical Memorandum Number 7 (GMSPAS).

DEVELOPMENT OF PERSON TRIP TRAVEL DESIRES

This task included the application of the gravity model to determine zone to zone person trip movements. The model was applied once for each of the three levels of forecasts. The F-Factors, K-Factors and network parameters were the same for each level.

MODAL SPLIT AND VEHICLE OCCUPANCY MODEL

For the TCSPAS it was necessary to determine the number of vehicle trips, defined as auto driver trips plus truck trips, that would travel from zone to zone. To estimate the proportion of zone to zone person trips that would be made as an auto driver a modal split model was developed.

This model determines the proportion of travelers by each of the following three modes:

- Auto driver
- Auto passenger
- Transit passenger

The model is "goal" oriented, that is, goals or estimates of transit use and vehicle occupancy were established and the model is made to produce these goals. The goals and model results for each level of forecast are shown below:

MODAL SPLIT AND VEHICLE OCCUPANCY - 2000

	Trip Purpose	Vehicle Occupancy From Model	Vehicle Occupancy "Goal"	Transit Use* From Model	Transit Use* "Goal"
High Travel Forecasts	HBW	1.23	1.23	7.86%	7.60%
	HBO	1.75	1.75	8.59%	8.30%
	NHB	1.51	1.51	2.30%	2.20%
	Total	1.56	1.56	7.09%	6.90%
Medium Travel Forecasts	HBW	1.35	1.35	11.97%	12.00%
	HBO	1.79	1.80	10.04%	10.00%
	NHB	1.55	1.55	3.01%	3.00%
	Total	1.60	1.61	9.04%	9.00%
Low Travel Forecasts	HBW	1.48	1.50	20.08%	20.00%
	HBO	1.79	1.80	11.86%	12.00%
	NHB	1.60	1.60	5.06%	5.00%
	Total	1.65	1.66	12.94%	12.90%

*Includes School Bus Trips

ASSIGNMENT OF VEHICULAR TRAFFIC

The final phase of the TCSPAS is the assignment of vehicle trips to the System 16/BRW network. These assignments are recorded on magnetic tape and computer printout and are available for developing trip assignments for individual highway projects. These assignments will be included in the individual project documents developed by the Minnesota Highway Department.