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16. Abstract <p>This report documents a method for developing detailed traffic forecasts and turning movements for use by the Texas Department of Transportation (TxDOT) in roadway project planning and design. The methodology uses a combination of current TxDOT corridor analysis procedures, TRANPLAN travel forecasting applications, and traffic refinement and turning movement estimation procedures from the NCHRP Report 255.</p>			
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**TRANPLAN CORRIDOR ANALYSIS
PROCEDURES GUIDE**

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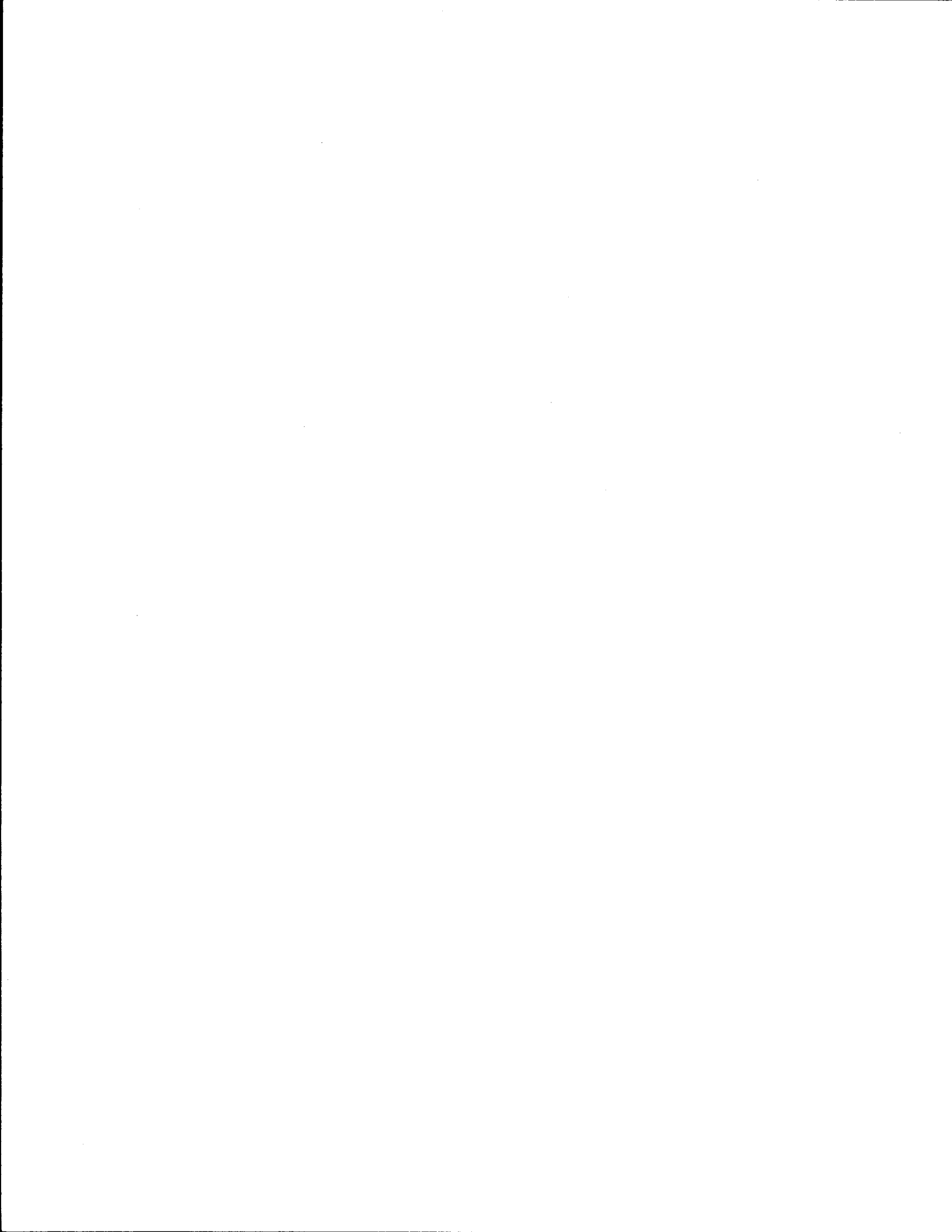
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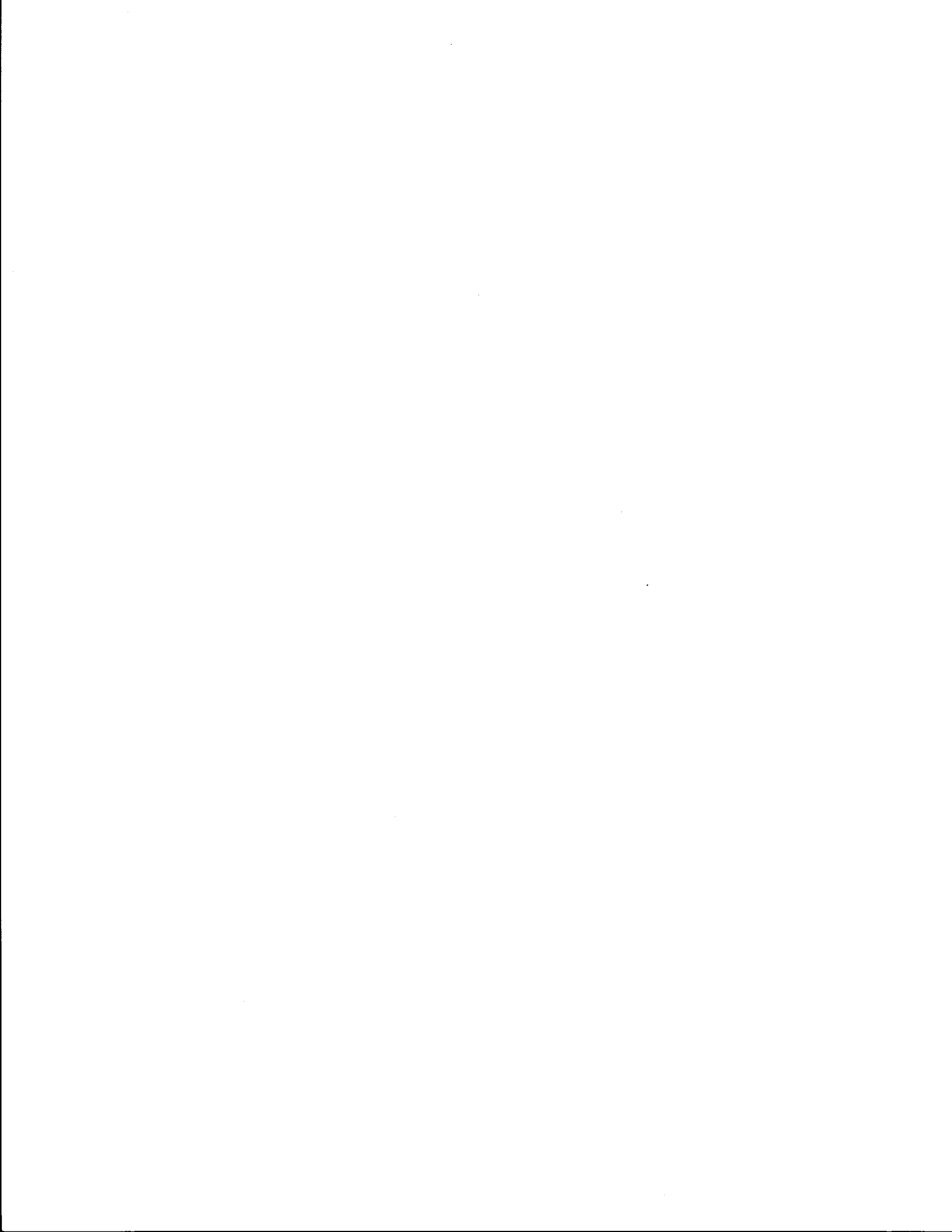
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IMPLEMENTATION STATEMENT

This corridor analysis procedures guide will assist the Texas Department of Transportation (TxDOT) in developing traffic and turning movement volumes for use in project planning and roadway design.



DISCLAIMER

The contents of this report reflect the views of the authors who are responsible for the opinions, findings, and conclusions presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration or the Texas Department of Transportation. This report does not constitute a standard, specification, or regulation. Additionally, this report is not intended for construction, bidding, or permit purposes. George B. Dresser, Ph.D., was the Principal Investigator for the project.

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SUMMARY

Corridor analysis is the term used by the Texas Department of Transportation to describe the development of traffic and turning movement volumes for use in roadway design. The existing corridor analysis process was reviewed and evaluated to identify methods and procedures that would reduce the time required and improve the process used to develop these volumes.

This report describes a procedure for corridor analysis using TRANPLAN, three DOS- executable programs, and a LOTUS-based screenline refinement process. Alternative procedures for developing turning movements are also detailed in the report. The screenline refinement process and turning movement procedures are based on methods detailed in NCHRP Report 255 *Highway Traffic Data for Urbanized Planning and Design*.

Within the process described, TRANPLAN is used to edit networks (using HNIS) and to develop traffic forecasts. The DOS NEWYR program is used to interpolate or extrapolate a set of production and attraction files to develop a production and attraction file for an intermediate or future year for which there is no current traffic assignment. The DOS BALANCE program is used to balance the production and attraction files. The DOS ALLOCATE program is used to revise production and attractions and reallocate productions and attractions to equal the designated urban area control totals. This report also provides information on network editing procedures and plotting procedures.

INTRODUCTION

Corridor analysis is the term used by the Texas Department of Transportation (TxDOT) to describe the development of traffic and turning movement volumes for use in roadway design. This procedure uses TRANPLAN, three DOS-executable programs, and a LOTUS-based screenline refinement process to develop and refine detailed traffic from Texas transportation system travel models. Procedures for developing turning movements are also presented in this guide.

This guide is organized into four major sections: a description of the steps used in the corridor analysis procedure, instructions on using TRANPLAN and the DOS-executable programs in the procedure, instructions on using the LOTUS screenline refinement procedure, and instructions on developing turning movements. The guide was written for use by individuals with knowledge of and experience in travel demand forecasting; experience in the use of TRANPLAN, including use of HNIS for updating networks; and with knowledge of running DOS programs and using LOTUS.

HOW TO USE THE GUIDE

The first section of this guide, Description of the Procedure, explains each of the steps used in preparing traffic and turning movements. Within this explanation, the use of TRANPLAN, three DOS-executable programs, a screenline refinement procedure, and the development of turning movements are referenced. Detailed instructions on the use of TRANPLAN can be found in the *Texas TRANPLAN Application Guide* (1). Information on using TRANPLAN in corridor analysis and the DOS programs, NEWYR, BALANCE, and ALLOCATE, are given in the section following the description of the procedure. Included in this second section are some helpful pointers on the use of HNIS to edit and update a network, how to access turning movements from TRANPLAN and when to use them, and on plotting assignments and network data. The third section provides information on the screenline refinement procedure and the LOTUS-based screenline spreadsheet. Optional methods for developing turning movements are explained in the fourth section. For additional information on the screenline refinement procedure or the turning movement procedures, see the referenced sources.

SUMMARY OF THE CORRIDOR ANALYSIS PROCEDURE

GETTING STARTED

Prior to preparing traffic for project design, collect the following data:

- Existing and historic traffic counts for the project and for other facilities in close proximity of the proposed project.
- Existing and proposed land use and special generators along the project.
- Proposed schematic and general information on the project including the type of facility (freeway, arterial, etc.), the number of lanes, type and location of traffic control, and type of operation (one-way vs. two-way).
- TRANPLAN files for the metropolitan area available from the TxDOT Transportation Planning and Programming Division. The TRANPLAN files needed include the *.ANT, *.NET, *.RAD, *.PNA, and *.EXT files for the base year, the intermediate forecast year, and the long-range forecast year.
- Copies of the DOS-executable programs NEWYR, BALANCE, and ALLOCATE. LOTUS-based Screenline Refinement Worksheet available from the Transportation Planning and Programming Division.
- Capacity/speed look-up table for the specific urban area.
- Functional classification code table for the specific urban area.
- Trip production and attraction rates for the specific urban area.

CORRIDOR ANALYSIS PROCEDURE

Three major steps are involved in the corridor analysis procedure for developing detailed traffic and turning movements for project design in urban areas. Each step is briefly described below. Instructions for using TRANPLAN and the DOS NEWYR, BALANCE, and ALLOCATE programs. The screenline refinement procedure methods to develop turning

movements are detailed in the sections following the general procedures.

Step 1 - Prepare Existing Traffic on Existing Network.

In this first step, the existing traffic (current year or the year immediately preceding the current year) and turning movements are developed for the existing roadway system. This existing traffic will be used for comparison in subsequent steps of the process. The decision to define the current year or previous year as the existing year should be based on the specific project needs and the year, if either, for which traffic counts are available. Prior to actually preparing the current traffic, however, several steps should be performed to assist in identifying the links for which counts are needed and to provide data required in subsequent steps.

a. Define the project study area and boundaries.

The study area should be defined so that the major facilities which influence travel patterns within the area of the project are included. The size of the study area for each project will depend on the type of facility and the type of proposed improvements. A major freeway project will usually require a larger study area than a project on a minor arterial roadway. As a general rule, the study area should extend 2 to 3 miles on either side of the project and 1/2 to 1 mile beyond the project termini. It should be remembered, however, that the study area boundaries may extend farther. It is important to include the major facilities, particularly parallel facilities.

b. Prepare a plot of the base year traffic counts, base year capacities, and base year traffic assignment for the study area.

Use TRANPLAN to plot the base year traffic counts, base year capacities, and base year validated assignment for the defined study area. The base year is the year used for the most

recent transportation system forecast for the particular urban area.

c. Prepare a plot of the existing roadway network within the study area.

The network file used in this step will be either the base year network or the intermediate forecast year network, depending on which year is closest to the current year. The intermediate forecast year is the year for which the 10-year system forecast was prepared. Use HNIS in TRANPLAN to revise the selected network within the study area to accurately represent the existing network. If the base year network is used, changes or improvements to the roadways within the study area should be made. If the intermediate forecast year network is used, changes to the network might involve deleting planned improvements that have not actually been implemented or adding improvements that have been implemented but were not included in the last system forecast.

At this time, the coded capacity and speeds of the facilities in the study area network should be reviewed and revised as needed to reflect changed conditions. Typical capacities and speeds for the various types of roadways for each urban area can be obtained from the capacity/speed look-up table for that area. (An example of a capacity/speed table is found in Table A-2 of the Appendix.) This step is not required if no network changes have occurred and the network file being used is the base year. A copy of one of the base year plots prepared above can be used. If the intermediate forecast year network is used and accurately represents the existing network, then only a plot of that network file is needed.

d. Make a preliminary determination of screenlines.

Screenlines may be required in subsequent steps of corridor analysis to refine or smooth traffic produced by TRANPLAN within the study area. The early selection of screenlines will assist in identifying the specific links within the study area for which current traffic counts are required. The base year or current year plot of the study area prepared in one of the previous

steps can be used to select the appropriate screenlines. Screenlines should be selected to include roadways that represent likely alternatives for directional traffic within the study area.

Several general rules should be followed in selecting screenlines:

- Avoid meandering or diagonal roadways.
- Do not include zone connectors crossed by the screenline in the analysis.
- Screenlines should cross a minimum of three roadways and preferably no more than seven roadways.
- Screenlines should be no longer than necessary.
- Screenlines should be placed midway between major roadway crossings or every two miles, whichever is less.

e. Make traffic counts as needed.

Current traffic counts should be made for each link crossed by a screenline, for other links as deemed necessary by the analyst, and for major turning movements.

f. Post the current traffic counts on the plot of the existing network.

The existing traffic counts should be posted on the plot of the existing network. Based on these counts and other available count data, estimates of current traffic should be made and posted for those roadway links on which specific counts were not made. This information will be used in subsequent steps.

g. Prepare a straightline network map of the existing facility.

A straightline map representing the existing facility should be prepared. A straightline map is a simple line drawing representing the facility and all cross facilities, ramps, and/or interchanges. The level of detail included in this straightline representation of the existing facility will vary by project. If this is a new location project, a straightline map does not need

to be prepared.

h. Post the current traffic volumes on the straightline map and develop turning movements.

The traffic count data compiled in Steps 1e and 1f above are posted on the straightline map. If the straightline map includes more detail than the network plot developed in Step 1f, additional estimates of traffic counts for certain links may be required.

Once the current traffic volumes have been posted on each link, turning movements should be developed and posted on the straightline map. If turning movement counts or percentages are not available, one of the methods discussed in the turning movements section can be used to estimate these movements.

i. Prepare a traffic assignment for the current year traffic on the existing network.

1. Use the DOS NEWYR program to develop a new production and attraction file for the current year. This program compares the base year or beginning year productions and attractions to the productions and attractions for the closest forecast year. The program then interpolates the two production and attraction files to create a third production and attraction file for the current year in TRANPLAN format. This new production and attraction file is based on the interpolation of productions and attractions at the zonal level by trip purpose from the base year and future year production and attraction files. NEWYR will also balance the attractions proportionally by zone and trip purpose to productions for the input files so that the new production and attraction file is balanced.
2. Run the long method of the TRANPLAN model.

3. Prepare a plot of the current year traffic assignment.
4. Check the assignment for reasonableness by comparing the assigned traffic to the traffic counts (as prepared in Steps 1e and 1f) for each link. A useful check is to use the baseline assignment deviation analysis results in the screenline analysis spreadsheet. The rationale behind this check is that the maximum allowable deviation of a screenline traffic estimate should be such that a highway design would not vary by more than one roadway lane. If the percentage deviation between the assigned volumes and current counts is unacceptable, correct the problem(s) in the modeling process. The level of growth anticipated during the system forecast may have been too little or too great compared to what actually occurred. Thus, the current year production and attraction file interpolated from the base year and intermediate forecast year may be reflecting too few or too many trips. Or, there may be coding errors in the network. If the productions and/or attractions in certain zones need to be changed to reflect more or less growth than previously forecast, use ALLOCATE to revise.
5. Make the appropriate revisions in the TRANPLAN process and rerun the assignment. Recheck the assignment. If the baseline deviation is acceptable, use the screenline refinement to smooth the volumes.

Step 2 - Prepare Existing Traffic on Proposed Network.

- a. **Prepare a straightline map of the proposed facility/network.**
- b. **Revise the existing network to include the proposed improvement.**

Use TRANPLAN to revise the existing network (prepared in Step 1f) to include the proposed improvement. This may include revising the coded capacity and speed for the facility to reflect changes made by the improvement. If the project is a new location project, the

functional classification code will be needed. This code can be obtained from the functional classification table for the specific urban area in which the project is located. (Table A-1 of the Appendix gives an example functional classification code table.)

c. Assign existing traffic to the improved network.

Use TRANPLAN to assign the current year traffic developed in Step 1i to the improved network developed in Step 2b. Use the screenline traffic refinement procedure to check the assignment for reasonableness and to refine the assignment. First, use the screenline procedure to check the percentage deviation between the current year counts and this assignment. Because this assignment will include network changes from the current network on which the counts were made, some professional judgment will be needed in interpreting the results of this check. If this check indicates a reasonable variation between the counts and the assignment, use the screenline procedure to refine the assignment. When using the procedure to refine the assignment, use the base year counts and assignment as the base year input; and allow the current year assignment to be the forecast year input.

d. Develop turning movements and post the traffic and turning movements on the straightline network map.

Prepare turning movements using the most appropriate method. The turning movements section details various methods that can be used depending on the data available and the type of intersection. Refine turning movements and traffic as needed to balance; post on the straightline map.

Step 3 - Develop and/or Refine Design Year Traffic on the Proposed Network.

a. Revise the design year network.

Compare the project schematic to the 20-year network used in the system forecast. If the network does not include the proposed project schematic or if more detail is needed in the network, update the network using HNIS in TRANPLAN. Coded capacities and speeds should be revised as needed to reflect known changes.

b. Determine adjustments to the design year production and attraction file.

If the project design year is the same as the 20-year system forecast year, the production and attraction file used for the system forecast will be used. This file may need to be adjusted, however, to reflect existing land uses and other anticipated growth if conditions have changed since the system forecast. Adjustments to the productions and attractions can be made to reflect changed conditions using the DOS-executable ALLOCATE program. The production/attraction rates for each trip purpose can be obtained for each specific urban area.

For projects where the design year is different from the system forecast year, the 20-year trip table will need to be adjusted to reflect estimates of productions and attractions for the design year. To make these adjustments, the DOS NEWYR program is used to either extrapolate the future trip table (system 20-year forecast trip table) to a future year. If the design year was prior to the 20-year forecast year, interpolate to a design year between the intermediate and long-range forecast years. If the project design year was prior to the 20-year forecast year, the DOS NEWYR program would be used to determine the factors.

c. Assign design year traffic to the design year network.

Use TRANPLAN to assign the design year trip table (as determined in Step 3b) to the design

year network developed in Step 3a.

d. Refine design year traffic assignment.

Use the screenline refinement procedure to smooth and check the assigned volumes. For the refinement, use current year traffic counts and assignment or base year traffic counts and assignment as the base year volumes.

e. Develop turning movements and post traffic on the straightline network map.

Develop turning movements using the Transportation Planning and Programming Division's turning movement software or one of the other techniques discussed in the turning movements section. Refine the link volumes and turning movements as needed to balance inflows and outflows. Post traffic on the straightline project map developed in Step 2.

USING TRANPLAN AND THE DOS-EXECUTABLE PROGRAMS

This section describes the following corridor analysis procedures:

1. Using the DOS NEWYR program for interpolating a set of production/attraction files to develop a production/attraction file for an intermediate year for which there is no current traffic assignment.
2. Using the DOS NEWYR program for extrapolating a forecast production/attraction file to get a design year production/attraction file for which there is no current assignment.
3. Running the DOS BALANCE program to balance production/attraction files.
4. Running the DOS ALLOCATE program to revise productions/attractions and reallocate productions/attractions to equal the designated urban area control totals.

Additional information provided includes:

1. Helpful network editing procedures.
2. TRANPLAN modeling flow chart.
3. Helpful plotting procedures and example parameters.

RUNNING THE NEWYR PROGRAM

Interpolating a Production/Attraction File

NEWYR is a DOS-executable program (NEWYR.EXE) that compares base year (or beginning year) productions and attractions to future year productions and attractions to produce a new production/attraction file. The program can be run to produce a new production/attraction file ("PNA" file) for an interpolated year between the base year and the forecast year, or it can be run for an extrapolation year beyond the forecast year.

For instance, assume an urban area has been modeled with the Texas Package and the validation year is 1987. Two forecasts have been done, one for 1995 and the other for 2005. But a current (1994) set of traffic data is needed to test a proposed facility. The best method to obtain the data would be to update the network to 1994 and re-run the model with 1994 demographics. This, however, is time consuming. Instead, use NEWYR to produce a 1994 PNA file for input to TRANPLAN.

First, the study area model must be converted to TRANPLAN. When complete for all years, all needed files are ready. Type "NEWYR" from the subdirectory where the TRANPLAN model files reside. The program asks for the following information:

Input the base year PNA file -

(Enter the filename of the 1987 production/attraction file)

Input boundary year TRANPLAN PNA file -

(Enter the filename of the 1995 production/attraction file)

Output adjusted PNA filename -

(Enter the name of the new output adjusted PNA file)

What is the base year?

(Enter "1987")

What is the boundary year?

(Enter "1995")

What is the future/intermediate year?

(Enter "1994")

Will this be (I)nterpolation or (E)xtrapolation?

(Enter "I")

Use (B)ase year or (F)uture year friction factors?

(Enter "B")

The program will begin running and will interpolate the two production/attraction files to create a third PNA file in TRANPLAN format. The new PNA file will be based on an interpolation of productions and attractions at the zonal level, by trip purpose, from the two

input PNA files (base year and boundary year).

The program also ensures that both input PNA files are balanced. NEWYR will balance both input files internally so that the output adjusted PNA file is balanced as well. NEWYR balances all attractions proportionally by zone and trip purpose to productions so that the sum of all attractions in the urban area equals the sum of all productions in the urban area.

Figure 1 shows the overall procedure to develop traffic for a new year using the NEWYR interpolation program and the TRANPLAN model. Figure 2 provides examples for selecting the appropriate base, boundary, and future years for use in the NEWYR program.

The interpolation year (1994 for this example) should fall between the closest base year and boundary year for which there is a full model run or production/attraction files. In our example, the base year was 1987 and the boundary year was 1995. The base year could have been 1995 and the boundary year 2005 if the intermediate (or interpolate) year was 1999 and there was a 1995 forecast model based on demographic forecasting.

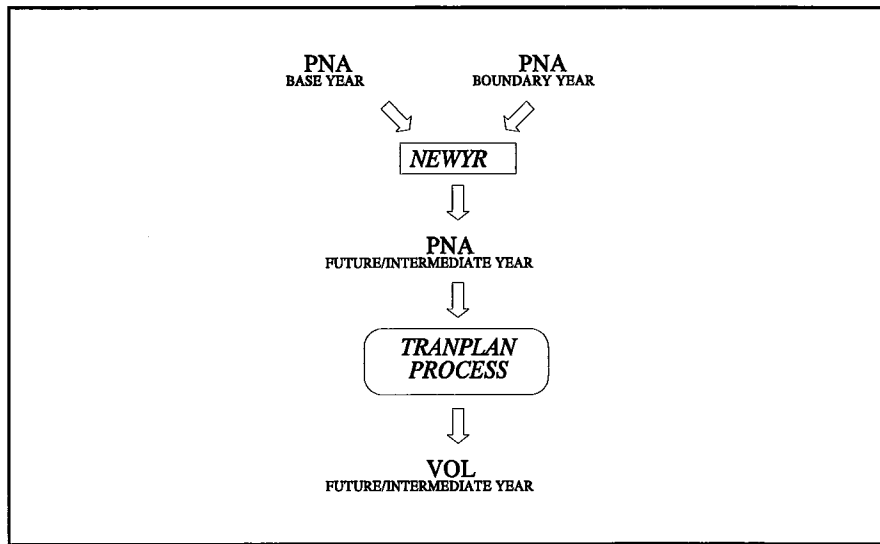


Figure 1. The NEWYR program PNA file interpolation/extrapolation.

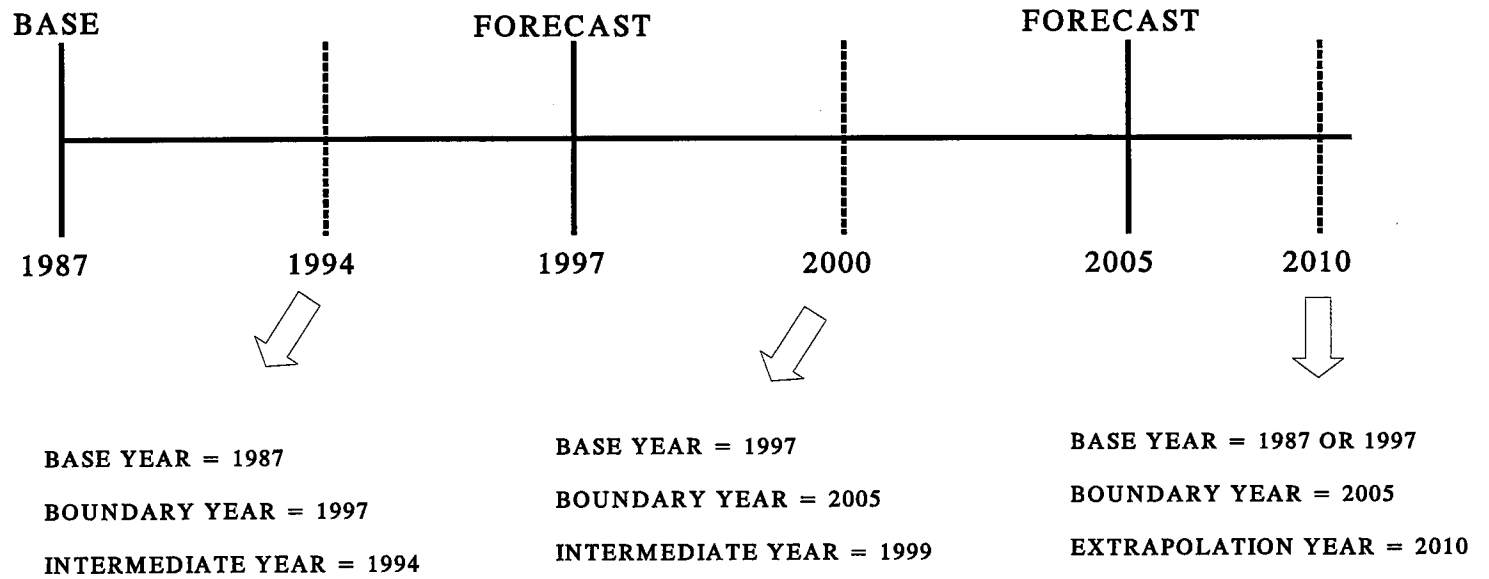
After running the NEWYR program to interpolate two files to an intermediate year, the "new" PNA file is ready to be used in running TRANPLAN. Refer to the *Texas TRANPLAN Application Guide* for instructions on how to run the TRANPLAN model.

Extrapolating a Production/Attraction File

When the design year is beyond the 20-year forecast year, the PNA files for the forecast year are extrapolated to develop the new PNA file. Extrapolating PNA files is also done with the NEWYR program. The only difference between running NEWYR for interpolation vs. extrapolation is that the PNA file must be balanced when extrapolation is done. That is, the file must be modified so that total attractions for the urban area are equal to total productions for the urban area. The DOS BALANCE program described below is used to perform this task.

Figure 2. A conceptual timeline of possible corridor analysis forecasts.

Definition of Base, Boundary, & Future Years



Follow the steps below to run an extrapolation using NEWYR. In this case, assume an urban area has been modeled and the base year (validation year) is 1990. Two forecasts were performed, one for 2000 and one for 2010. The design year of the project is 2012. Enter "NEWYR" from the subdirectory where the TRANPLAN model files reside. The program will then ask for the following information:

Input the base year PNA file -

(Enter the filename of the 1990 production/attraction file)

Input boundary year TRANPLAN PNA file -

(Enter the filename of the 2010 production/attraction file)

Output adjusted PNA filename -

(Enter the name of the new output adjusted PNA file)

What is the base year?

(Enter "1990")

What is the boundary year?

(Enter "2010")

What is the future/intermediate year?

(Enter "2012")

Will this be (I)nterpolation or (E)xtrapolation?

(Enter "E")

Use (B)ase year or (F)uture year friction factors?

(Enter "F")

The program will then extrapolate the 2010 PNA file to create a new PNA file for the desired year in TRANPLAN format. The new PNA file will be based on an extrapolation of productions and attractions at the zonal level, by trip purpose, from the input PNA files. As noted above, however, the PNA file created through the NEWYR extrapolation process must be balanced before it is used in TRANPLAN. This can be accomplished using the DOS BALANCE program described below. The new PNA file can be used in TRANPLAN after it has been balanced. Refer to the *Texas TRANPLAN Application Guide* for instructions on how to run TRANPLAN.

RUNNING THE BALANCE PROGRAM

The BALANCE program is a DOS-executable program that uses the same process as the TRANPLAN \$Gravity Model to balance total attractions to total productions. BALANCE writes out a new, balanced PNA file. The BALANCE program should be run on the PNA file created through the NEWYR extrapolation process. It is not necessary to use BALANCE after creating a file through the NEWYR interpolation.

BALANCE can also be used to ensure that the PNA file being used is, in fact, balanced. If total productions equal total attractions for the urban area, BALANCE will not affect the PNA file. If the total attractions are greater than the total productions for all zones in the model PNA file, BALANCE will decrease the number of attractions in each zone in proportion with the zone's contribution to the total. In other words, if one zone has 20 attractions while another has 200 attractions, the zone with 200 attractions will be decreased greater than the zone with 20 attractions because it contributes to the total to a greater degree.

To run the BALANCE program type "BALANCE" from the subdirectory where the TRANPLAN files reside. The program will then ask for the following information:

Input TRANPLAN PNA File -

(Enter the filename of the unbalanced production/attraction file)

Output Adjusted PNA Filename -

(Enter the filename of the new adjusted production/attraction file)

RUNNING THE ALLOCATE PROGRAM

During corridor analysis it is occasionally necessary to change the number of productions/attractions for a particular zone because of a change in anticipated conditions. For instance, a

visit to the project area may indicate that the traffic levels are greater than what was originally anticipated. This may be the result of a new shopping center, office complex, or subdivision. In this instance, the number of attractions/productions for each affected zone should be revised to reflect current conditions.

One way to make these changes is to edit the TRANPLAN PNA file. However, a problem occurs when the edited PNA file is used in TRANPLAN. On a regional level, the total productions in an urban area must equal the total attractions in that area (except for external trips). If the level of attractions or productions in a zone are changed, the TRANPLAN Gravity Model will automatically balance all attractions or productions proportionally by zone to match the production or attraction total for the region. Thus, the zonal productions/attractions believed to have been revised are then changed automatically by TRANPLAN.

One solution is to manually change the level of attractions (or productions) in other zones so that the control total productions (or attractions) are not violated. For example, a regional shopping mall expected to be developed in a certain zone was instead developed in another zone. The TRANPLAN PNA file can be manually edited to increase the number of attractions in the zone where the development occurred and decrease by the same number the attractions in the zone where it did not occur as expected. If, however, a number of zones are involved and the "trade-off" of productions/attractions between zones is not clear, manually editing the PNA file can be time-consuming and subjective.

The DOS-executable ALLOCATE program was written to reallocate productions or attractions proportionally to or from all zones where changes were not made. ALLOCATE will not change the control total productions or attractions for the urban area. ALLOCATE reads a PNA file in which changes to the productions/attractions have been made for up to ten zones. Only attractions or productions, but not both, can be changed for any one run of ALLOCATE.

Subsequent runs can be performed if both attractions and productions are to be changed or if the attractions or productions for more than ten zones need to be revised.

When modifying a zone's productions or attractions, it is imperative to begin with a balanced production/attraction file, one where total productions equals total attractions. If unsure whether the PNA file being revised is balanced, run BALANCE before making changes to either the productions or attractions. The program will make no changes if the file is balanced. To run the ALLOCATE program, type "ALLOCATE" from the subdirectory where the TRANPLAN files reside. The program will ask for the following information:

Have (P)roductions or (A)ttractions been changed?

Warning: Input PNA File Total Productions Must Equal Total Attractions!

Use BALANCE program Before Altering Attractions!

(Enter P for productions or A for attractions).

Input TRANPLAN PNA File -

(Enter the filename of the balanced and revised production/attraction file).

Output Adjusted PNA Filename -

(Enter the filename for the new adjusted PNA file).

Enter Zone(s) to Keep Attractions (Productions) Constant -

Press Enter when finished...

(These are the zone numbers in which the attractions (productions) were revised to reflect current conditions).

Enter Zone Number or Press Enter

(Enter first zone number in which attractions (productions) are to be kept constant, i.e., "21" and hit Enter).

Enter Zone Number or Press Enter

(Enter next zone number in which attractions (productions) are to be kept constant, i.e., "133". If only one zone was changed, continue to hit Enter through the remaining "Enter Zone Number" inquiries. Remember, up to ten zones may be changed for one run of ALLOCATE).

Reading and Reallocating PNA File Attractions (Productions)...

After running ALLOCATE, run the long method of TRANPLAN on the appropriate, edited

network. Refer to the *Texas TRANPLAN Application Guide* for instructions on running TRANPLAN.

Figures 3 and 4 provide information on using the DOS-executable programs and TRANPLAN to obtain a current year forecast traffic assignment and a design year forecast assignment and to change attractions or productions.

TRANPLAN Corridor Analysis

Texas Package Model Years: 1987, 1997, 2005

Current Year: 1994

Design Year: 2014

OBJECTIVE: GET CURRENT YEAR ASSIGNMENT

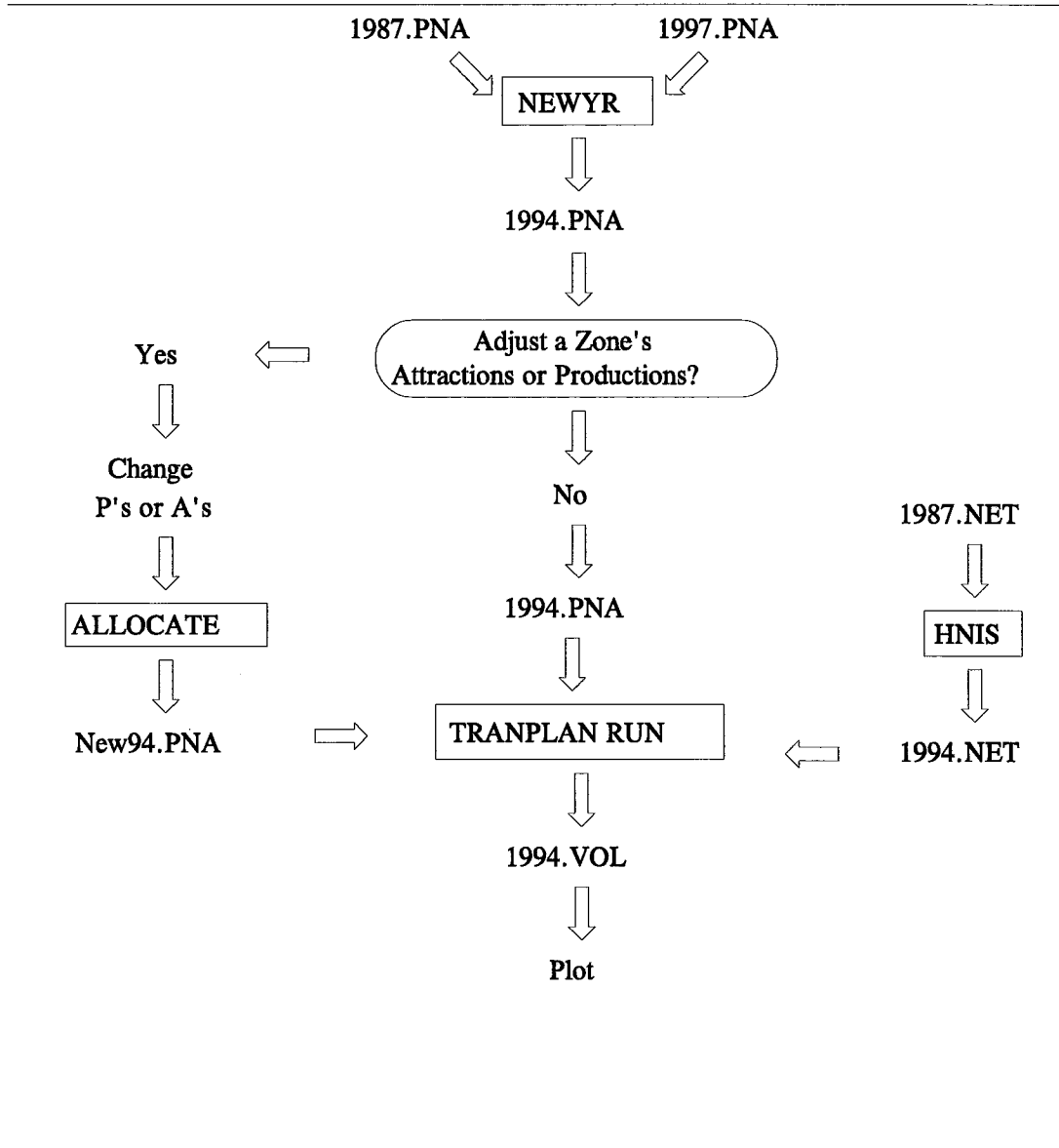


Figure 3. Flowchart of TRANPLAN corridor analysis method to obtain a current year traffic assignment.

TRANPLAN Corridor Analysis

Texas Package Model Years: 1987, 1997, 2005
Current Year: 1994
Design Year: 2014

OBJECTIVE: GET DESIGN YEAR ASSIGNMENT

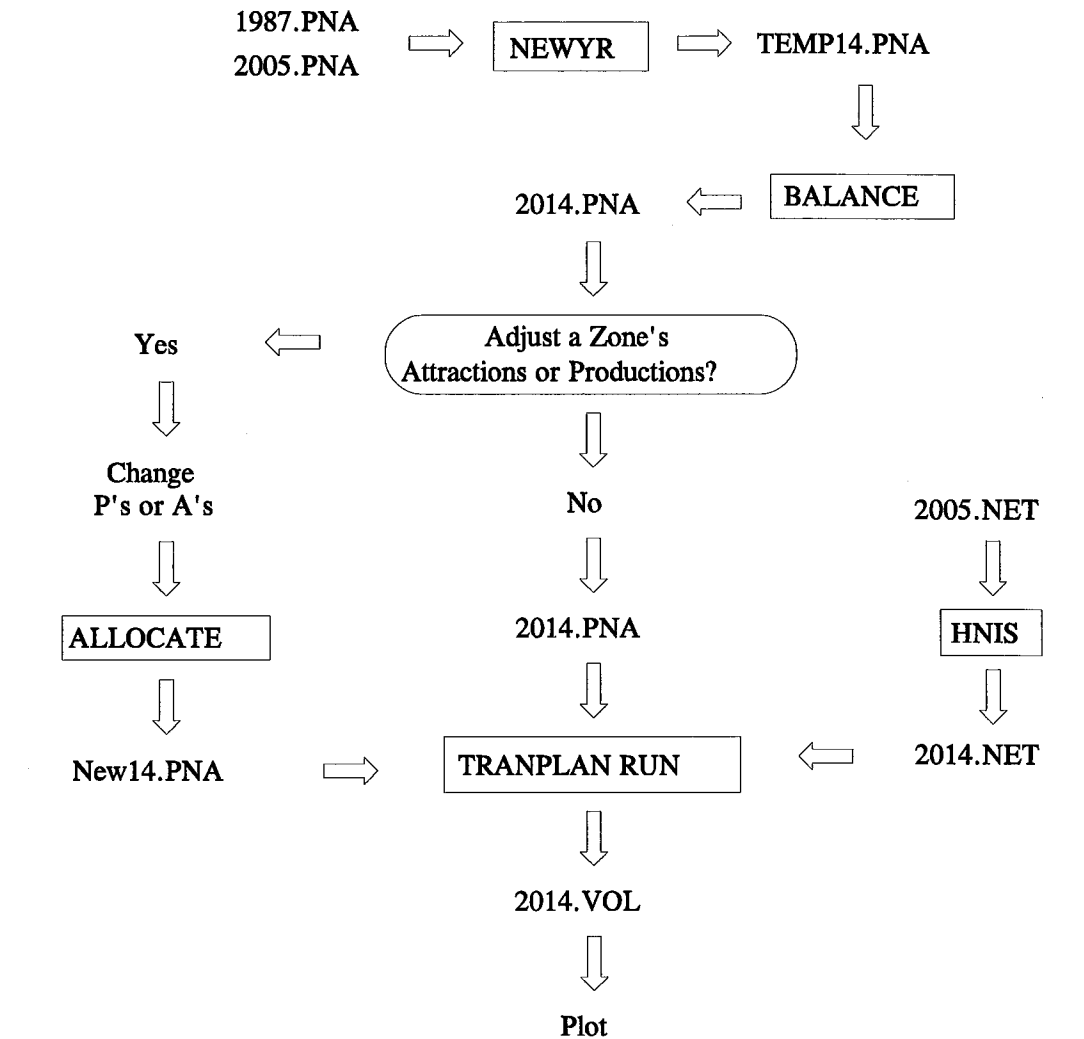


Figure 4. Flowchart of TRANPLAN corridor analysis method to obtain a future design year traffic assignment.

NETWORK EDITING PROCEDURES

Setting Up

Several files and data will be needed to edit and use the TRANPLAN model networks. Proper set-up at the start will save time later in the process. The following items are needed:

- Baseline (or closest year to the interpolated year) TRANPLAN format network (*.NET).
- Schematic or plot of the area where the proposed facility is to be located.
- Area traffic counts including the year counts were taken.
- Speed/capacity look-up table used for the urban area.
- Proposed facility description (number of lanes, type of facility, divided or undivided).

Selecting the Network File

Selecting the TRANPLAN network file will depend on which assignment is being prepared. The chosen network should best reflect the current or anticipated future system of roadways, both within the specific project study area and across the urban area as a whole. As a general rule, select the network coded for the year closest to the assignment year. For example, if the urban area has full model runs for 1987, 1995, and 2005, and traffic is needed for the existing year, 1993, the 1995 network should probably be used. If, however, the 1995 network reflects a number of projects that have not yet been implemented, the 1987 network may be the best choice.

If unsure which network to use, make a plot of the two closest network years with capacities and speeds. These plots should be analyzed and the most appropriate one selected.

Editing the Network

Once the network file has been selected, make a plot of the network with capacities and speeds (if not already done). Note the project study area on the plot. It is most important in the specific study area that the network accurately reflect the current or anticipated roadway links, capacities, and speeds. Portions of the network outside the study area will affect traffic relative to the size of the facility and the distance of the facility from the study area. Thus, it is best to ensure that the network within the first several miles of the study area exhibits the correct characteristics. Any changes to the links, capacities, or speeds should be noted on the plot to assist in the editing process. If this is a new location project, the distance of each link must be identified on the plot as well.

Next edit the links, capacities, and speeds as needed. Follow the procedures outlined in the *Texas TRANPLAN Applications Guide*. Remember to keep track of the name and description of each new network file created. The steps for coding a new facility and other editing procedures are summarized below.

Coding a new facility in HNIS is done by adding nodes along the route of the proposed facility. Sometimes it is best to first draw the facility manually, including all nodes. Add all nodes which are not part of currently existing links, as in Figure 5. Do not redraw the network or these nodes will disappear; POST NODE or FIND NODE must be used to find them again. Add only those nodes for which links are being added.

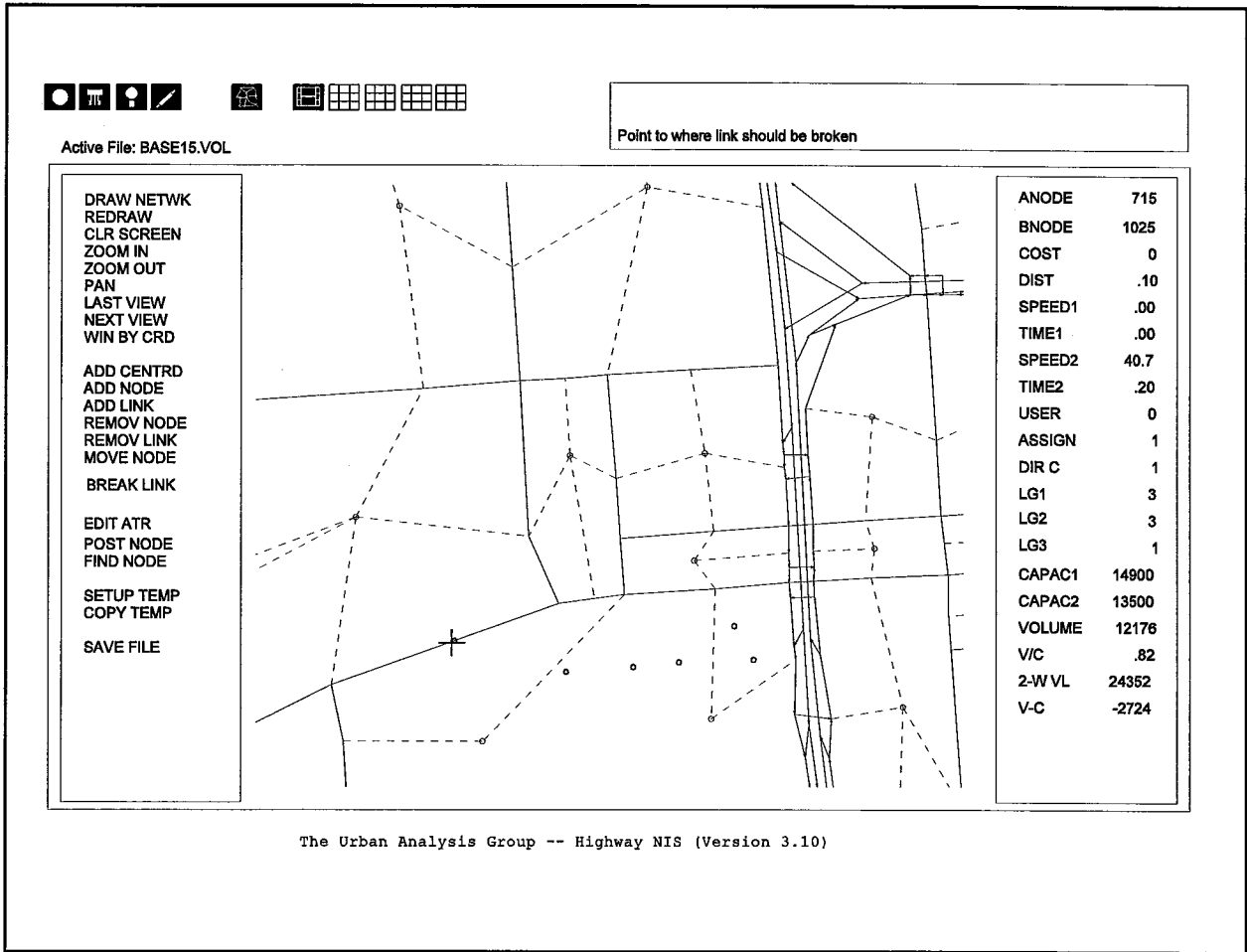


Figure 5. Breaking links with HNIS.

The next step is to break all links where new nodes will be needed because of new intersections. Use the **BREAK LINK** feature to do this step. All distances and attributes are updated on the broken links automatically by HNIS (see Figure 6).

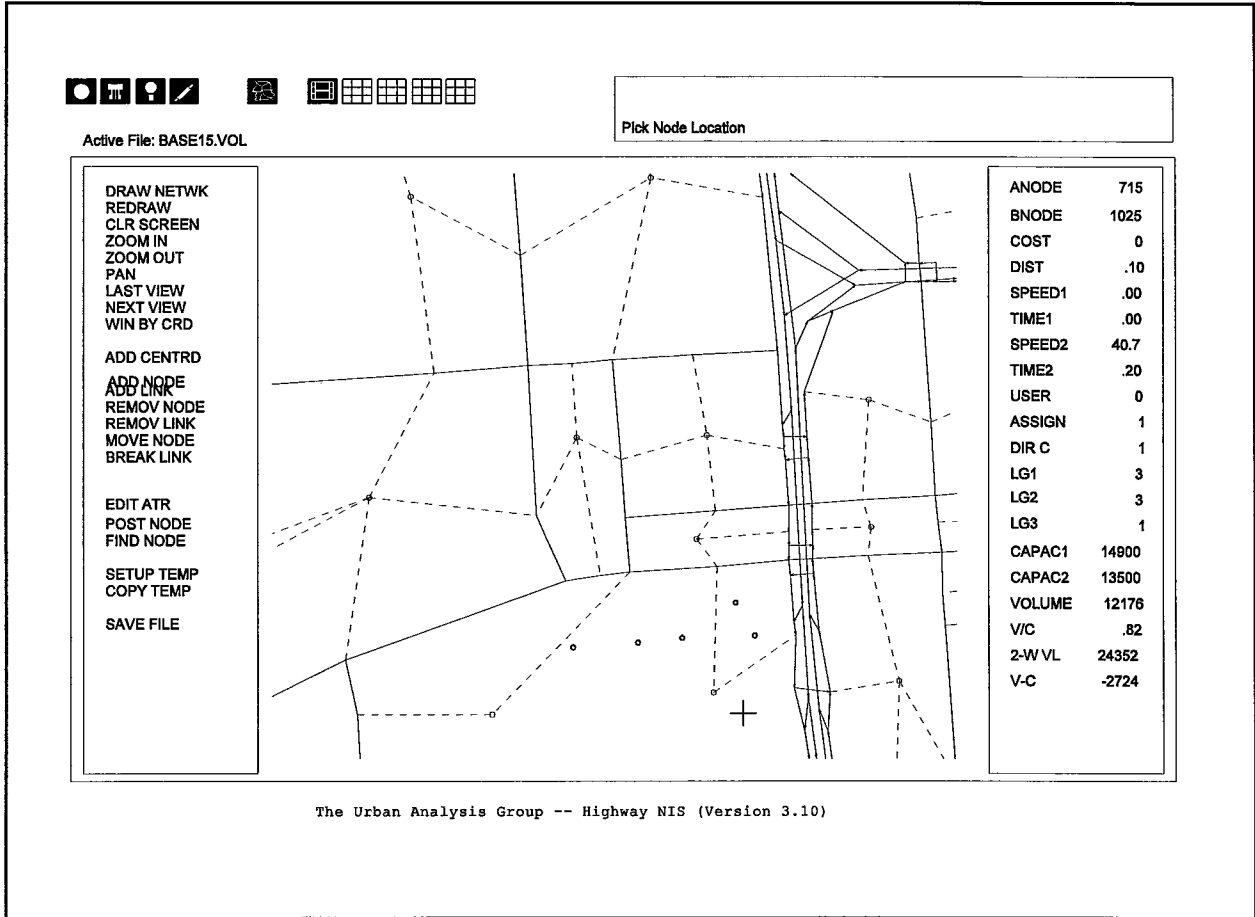


Figure 6. Add nodes first in HNIS.

Next, a template of attributes should be set up so that when links are added, the same attributes don't need to be reentered. Use SETUP TEMP (shown in Figure 7) to create a template for each added facility. Note that a new template must be created for each different facility, because they may have different capacities and speeds.

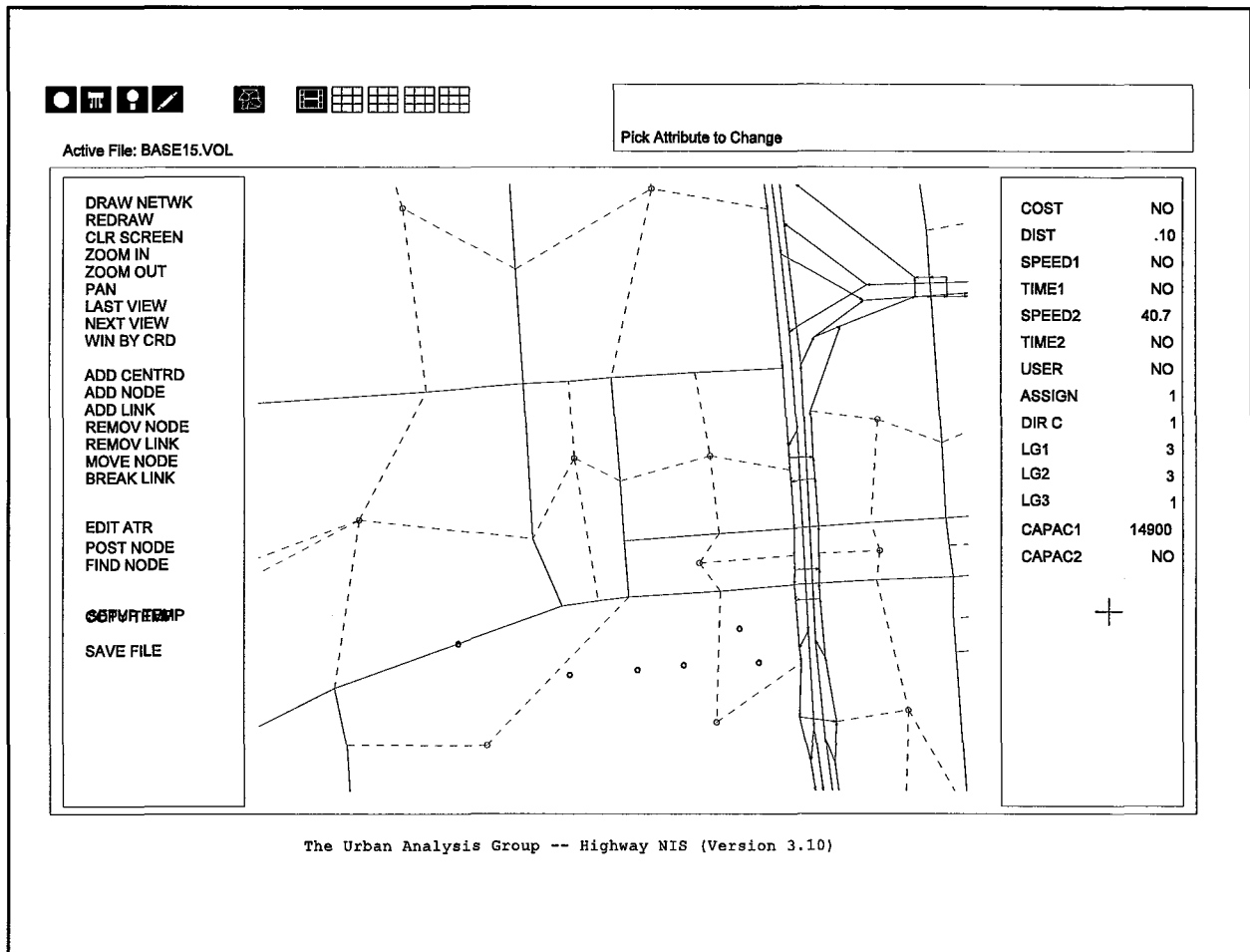


Figure 7. Setting up a "template" of link attributes in HNIS.

Finally, links can be added by pointing to the nodes (see Figure 8). If the links are one-way, remember that the flow of traffic is always in the A-node to B-node direction.

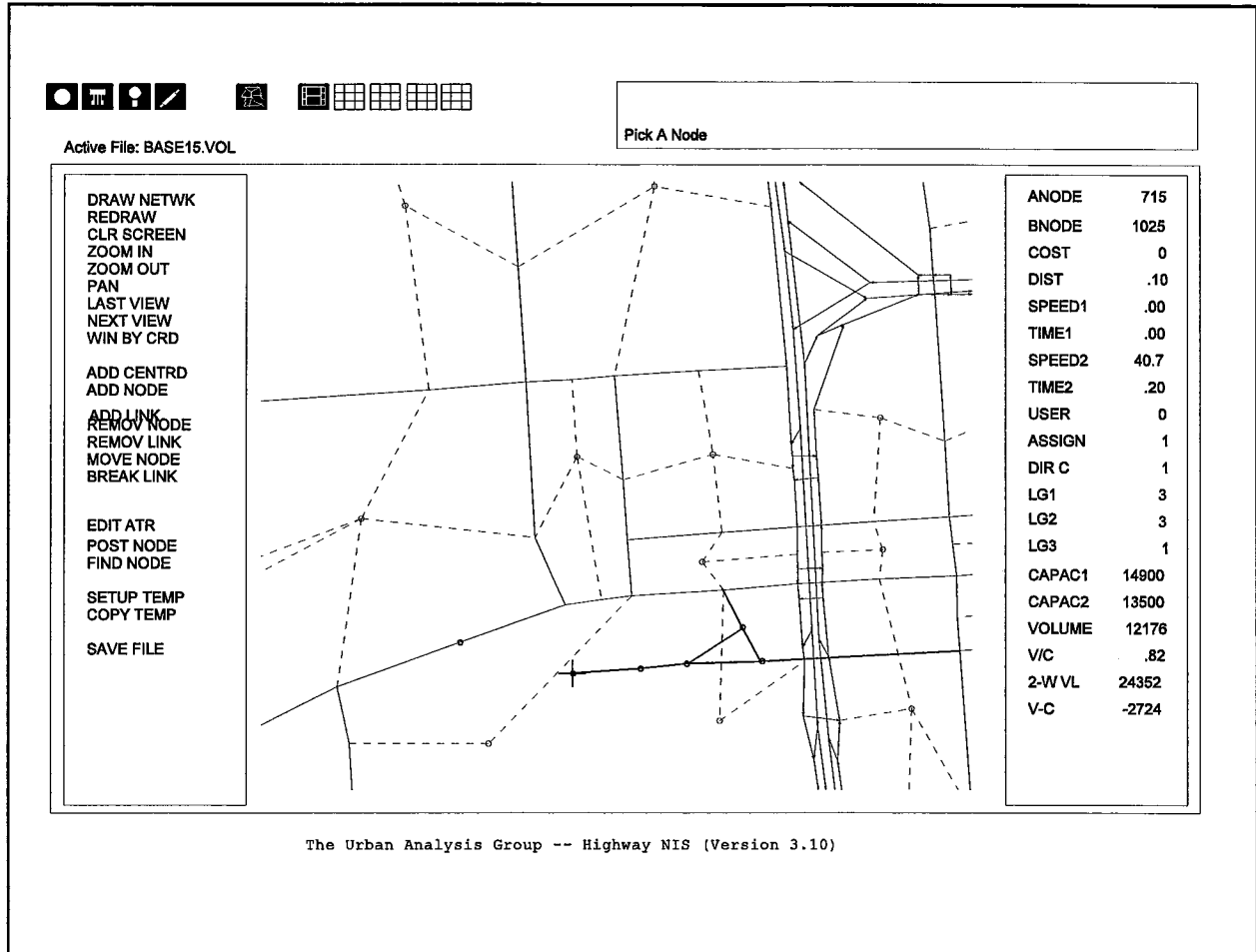


Figure 8. Adding links with HNIS.

After adding all links and nodes, the file must be saved. Use **SAVE FILE** or simply hit the stop button, and the program will prompt for a new filename. Be sure to give the file the proper extension, *.NET, so that it is easily identifiable later as a network.

Another important element of network editing is coding the centroid connectors. When adding a facility, the placement of the centroid connectors will determine the load points of all trips exiting and entering the zone. Centroid connectors should never cross another network. When a new facility is added, the connectors may have to be moved to connect to the new facility.

RUNNING AN ASSIGNMENT

After the PNA file(s) have been updated to reflect any necessary changes to the zonal productions and attractions and/or interpolated/extrapolated to the specified year and the network(s) have been edited, run TRANPLAN to produce the needed assignments. Figure 9 summarizes the steps required in running TRANPLAN. For more detailed information, refer to the *Texas TRANPLAN Application Guide*.

PLOTTING THE ASSIGNMENT

Load the network into HNIS and if the area coordinates are not yet identified, look them up. Use the POST SETUP menu to post the X and Y coordinates for the A-node of a link (AX and AY). The POST LINK option can then be used to post the X and Y coordinates on links in the area to obtain the MAXIMUM X, MAXIMUM Y, MINIMUM X, and MINIMUM Y values to use in the \$PLOT HIGHWAY LOAD function.

The next step is to use \$PLOT HIGHWAY LOAD to plot the assignment for the study area. The following TRANPLAN setup should work well for most HP plotters, although some parameters may need to be changed for specific plotters.

```
$PLOT HIGHWAY LOAD
$FILES
  INPUT FILE = LODHIST, USER ID = $BASELINE.VOL$
  OUTPUT FILE = TPLOT, USER ID = $BASELINE.PLT$
$HEADERS
  1992 JORTS AFTER NEWYR AND BEFORE 1987 NETWORK MODIFICATION
$OPTION
  DASHED CENTROID LINKS
  ONLY CENTROID NODES
  ONE WAY ARROWS
$PARAMETERS
  PLOTTER = HP7475
  PAPER = NORMALA
  PLOT SIZE = 11
  MINIMUM X = 3952000
```

TRANPLAN PROJECT FLOW CHART

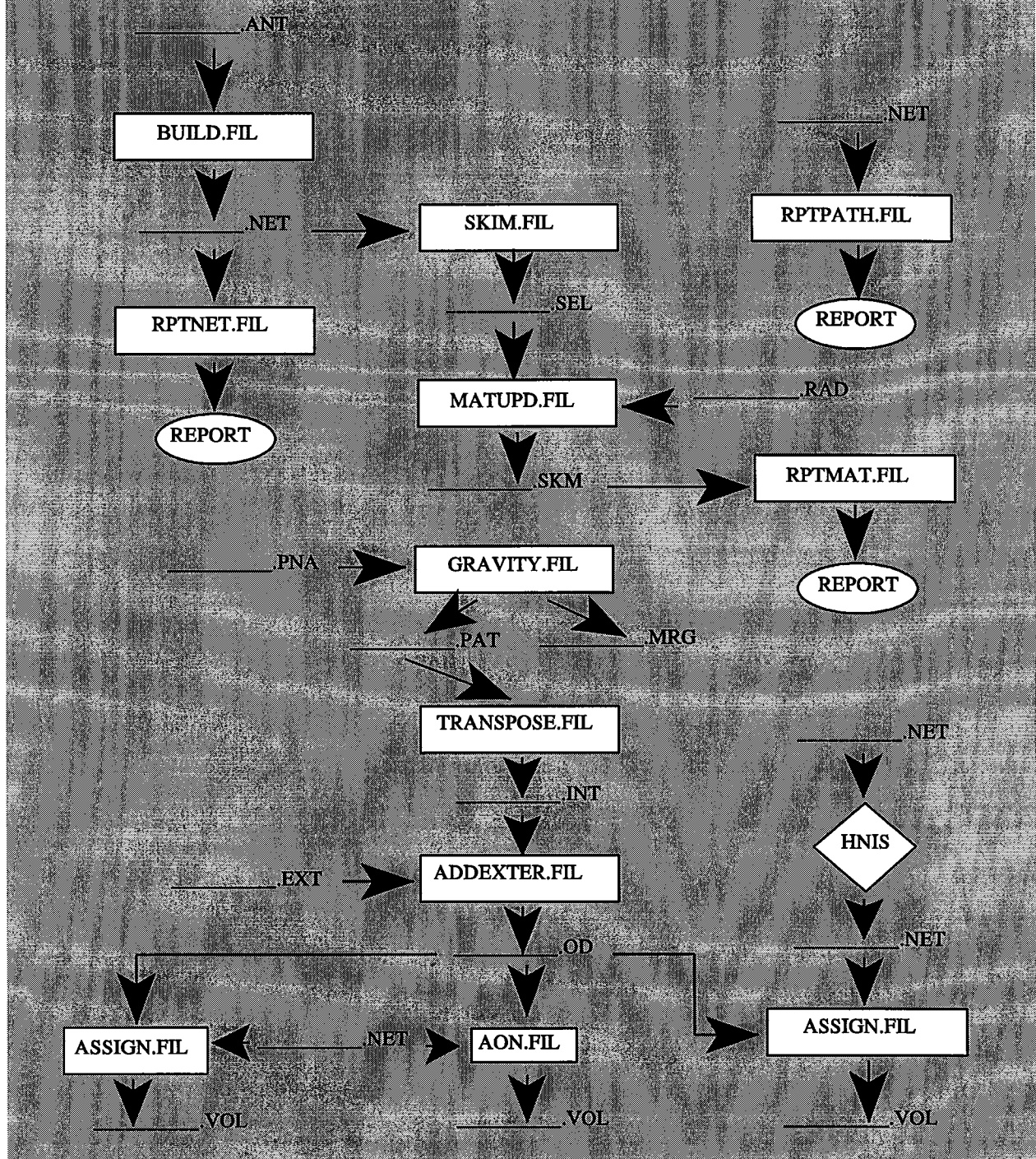
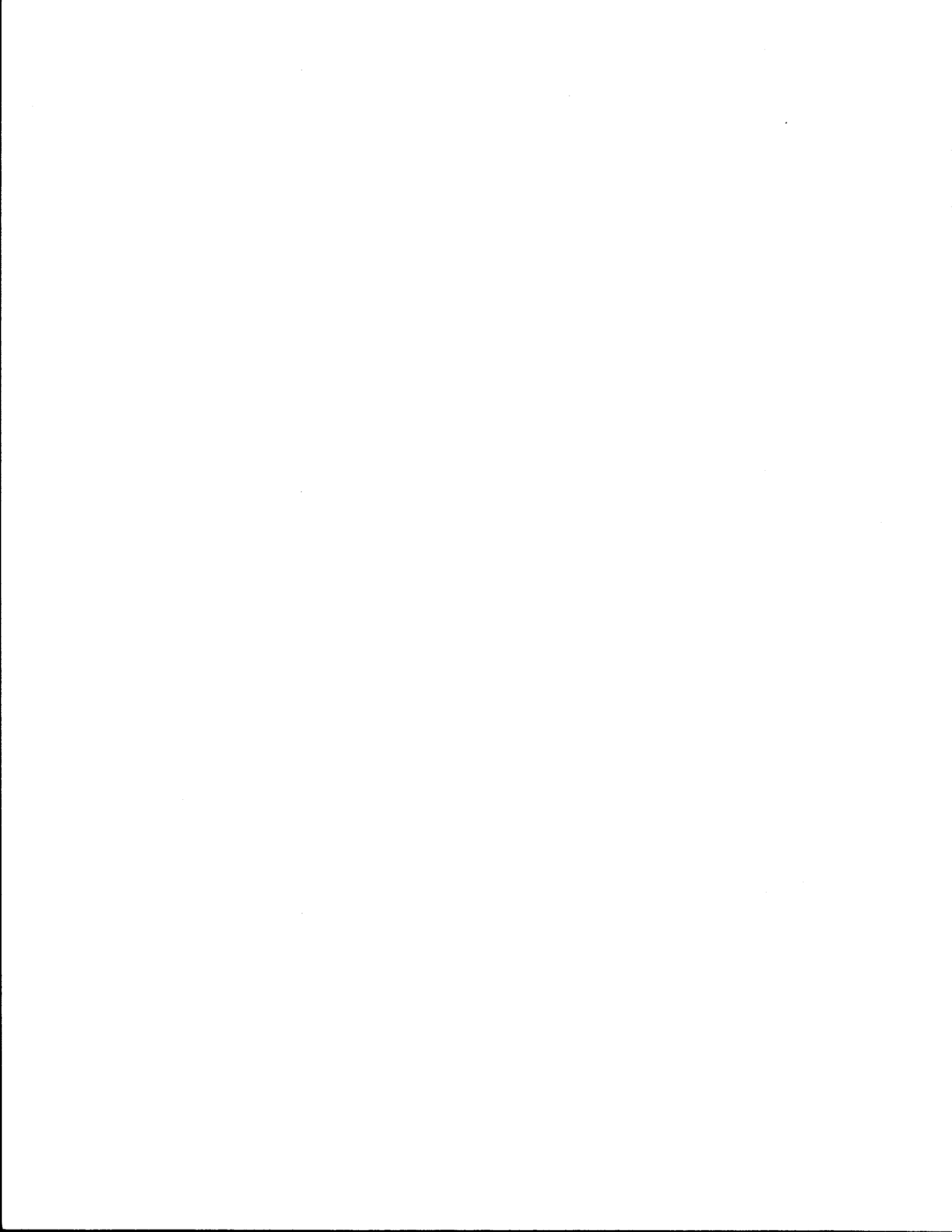


Figure 9. TRANPLAN flow chart.

MAXIMUM X = 3961400
MINIMUM Y = 204000
MAXIMUM Y = 212000
CHARACTER HEIGHT = 0.07
LINK ANNOTATION = TOTAL VOLUME
SELECTION ATTRIBUTE = LINK GROUP 2
\$DATA
COLOR = BLACK, ATTRIBUTE = 0
COLOR = GREEN, ATTRIBUTE = 1-2
COLOR = BLUE, ATTRIBUTE = 3-5
COLOR = RED, ATTRIBUTE = 6
COLOR = YELLOW, ATTRIBUTE = 7-11
\$END TP FUNCTION

For additional information on the various parameters, refer to the *Texas TRANPLAN Applications Guide*.



USING THE SCREENLINE REFINEMENT PROCEDURE

INTRODUCTION

Travel forecasts developed for corridor analysis will require further refinement before being used for detailed project planning or design. To allow these refinements to be made in a rational and consistent manner, the screenline refinement methodology outlined in NCHRP Report 255, *Highway Traffic Data For Urbanized Area Project Planning and Design (2)* was programmed into a LOTUS spreadsheet application. The use of this spreadsheet is summarized in this section. For more information regarding the refinement process, refer to NCHRP Report 255.

BACKGROUND

The purpose of the screenline refinement procedure is to improve the link-by-link traffic forecasts produced by TRANPLAN. In this process, future link volumes are adjusted based on the relationship between base year traffic counts, base year assignments, and future year link capacities. The adjustment is the average of two methods: (1) the ratio between the base year forecast and the actual base year traffic count and (2) the numerical difference between these values. The subsequent adjustment is made to link volumes in which the effects of future year capacity changes are combined with the stabilizing effects of actual base year traffic patterns.

The screenline procedure typically adjusts all volumes crossing the screenline. Thus, it is not suitable for use in situations where only one or two link volumes are in need of refinement. The procedure is also limited to situations where reasonable screenlines can be constructed across parallel facilities. Accuracy is lost when non-parallel facilities such as diagonal roads are introduced into the screenline.

Getting Started

The following data are required as input to the screenline refinement procedure:

- Plots of the following values: These plots can be created using the same X and Y coordinates by simply changing the filenames (*.VOL files) and the parameters and options mentioned.
 1. Base year counts (add \$OPTION "CAPACITY 2" to the plot function file and change LINK ANNOTATION to "TOTAL CAPACITY").
 2. Base or current year assigned volumes without proposed improvement (LINK ANNOTATION = TOTAL VOLUME).
 3. Base or current year assigned volumes with proposed improvements.
 4. Base or current year capacities (delete \$OPTION "CAPACITY 2" and change LINK ANNOTATION to "TOTAL CAPACITY").
 5. Future design year capacities.
 6. Future year forecast .
- Information on current and future land use changes and growth trends (optional).
- LOTUS screenline analysis spreadsheet.

Step 1 - Finalize Screenlines.

The screenlines established at the beginning of the corridor analysis procedures should be finalized. A screenline must cross each of the facilities whose volumes are to be refined. The following will assist in developing the appropriate screenlines:

- Determine the context in which the screenline will be used. For corridor analysis, either small area analysis or wide corridor analysis situations will apply. The scale of the analysis will determine the appropriate length and number of screenlines to be used.
- Avoid meandering or diagonal roadways.

- Do not include zone connectors crossed by a screenline. (In some cases zone connectors may need to be included, but this would occur only under special conditions.)
- Screenlines should cross a minimum of three roadways and preferably no more than seven roadways. Screenlines should be no longer than necessary.
- Screenlines should be placed midway between roadway crossings or every two miles, whichever is less.

Step 2 - Check Current Year Assignment Volumes.

To determine if the current year assignment is a reasonable representation of corridor traffic, total traffic crossing the screenline should be compared between the base year assignment and actual base year traffic counts. To do this, use the baseline assignment deviation analysis results in the screenline analysis spreadsheet. This check is based on the rationale that the maximum allowable deviation of a screenline traffic estimate should be such that a highway design would not vary by more than one roadway lane. At lower screenline volumes, the permitted volume deviation is quite large because such deviation would not result in significant design differences. At higher volumes, however, a lower deviation is desired to validate design decisions. If the percentage deviation between the assigned volumes and current counts is unacceptable, correct the problem(s) in the modeling process.

To perform the baseline deviation analysis results, load the LOTUS spreadsheet file "scrnline.wk1". Enter current year traffic counts and current year assignment volumes for each link crossed by the screenline. The spreadsheet will total the volumes and calculate the percentage deviation in the assignment deviation chart as shown in Figure 10. In the spreadsheet, this chart is located on the right, below the main screenline computation analysis chart. If the screenline totals are within the maximum desirable deviation, the screenline computations can be continued. If the assignment year volumes exceed the maximum desirable deviation, additional analysis is required before proceeding. Several actions are

appropriate to correct the assignment problem(s):

- For large discrepancies, correct deficiencies in the modeling process and rerun TRANPLAN. Errors may occur in trip generation, trip distribution, or network coding.
- Extend the screenline length to include additional facilities. This action tends to reduce the deviation across the screenline.
- Manually factor the screenline volumes up or down by the amount which the base year assignment differs from the actual base year traffic counts.

Step 3 - Perform Screenline Analysis.

Use the LOTUS spreadsheet to perform the screenline analysis when the assignment results indicate the need to smooth the volumes across the screenline(s). Load the file "scrnline.wk1" in LOTUS. The screenline analysis input chart will appear as shown in

Baseline Assignment Percent Deviation Test				
Maximum Desirable Deviation	Original % Deviation	Original Result	Adjusted % Deviation	Adjusted Result
TOTAL				

Figure 10. Screenline assignment derivation.

Figure 11. Definitions for each of the columns are given in Table 1. First enter the project name (under "Study Area"), screenline designation, and the base and future years specific to the analysis. Next enter the roadway names for each facility crossed by the screenline. Then enter the base year traffic counts, assignment volumes, and capacities for each screenline link. Do the same (except for counts) for the assignment year. The spreadsheet will perform the following calculations:

- Adjustments to the forecast due to base year assignment (RA). These computations adjust the future year link assignments to account for probable assignment errors. The underlying assumption is that errors occurring in a base year assignment will continue to occur proportionally in any future year forecasts. This adjustment need not be applied in all situations. If the percentage deviation analysis (above) indicates that the base year screenline values fall within the desired range, this step in the calculation can be ignored with little loss of accuracy.

Screenline Refinement Procedure

Study Area: _____
 Screenline: _____

Base Year: _____
 Forecast Year: _____

Road Name	0			0		Adjusted Forecast		Combined Adjusted Ra(f)	% TCount	% TC(f)	RA(f) C(f)	Adjustment		New Facilities FA(f)	Existing Facilities FA(f)	FA(f) C(f)	COUNT C(b)	Original V/C
	Traffic COUNT	Assign A(b)	Capacity C(f)	Assign A(f)	Capacity C(f)	Ratio	Diff					Capacity	Base Count					
Road A																		
Road B																		
Road C																		
Road D																		
Road E																		
Road F																		
Road G																		
Road H																		
Road I																		
Road J																		

Figure 11. Screenline analysis input chart.

Table 1
Definitions of Screenline Refinement Procedure Terms

Variable	Definition
COUNT	Actual base year traffic count.
TCOUNT	Screenline total of actual base year traffic counts.
%TCOUNT	Proportion of total screenline base year traffic count occurring on a particular link.
A_b	Base year traffic assignment.
TA_b	Screenline total base year traffic assignment.
A_f	Future year traffic forecast.
TA_f	Screenline total future year traffic forecast.
RATIO Adjustment	$(COUNT/A_b) * A_f$.
DIFFERENCE Adjustment	$(COUNT - A_b) + A_f$.
RA_f	Adjusted future year traffic forecast (equals average of RATIO and DIFFERENCE adjustments).
TRA_f	Screenline total adjusted future year traffic forecast.
C_b	Base year capacity at level-of-service E.
TC_b	Screenline total base year capacity at level-of-service E.
C_f	Future year capacity at level-of-service E.
TC_f	Screenline total future year capacity at level-of-service E.
% TC_f	Proportion (in decimals) of total screenline future year capacity occurring on a particular link.
RA_f/C_f	Ratio of the adjusted future year traffic forecast to the future year capacity.
TRA_f/TC_f	Ratio of total screenline adjusted future year traffic forecast to total future year screenline capacity.
CAPACITY Adjustment	Portion of a link's final refined future year traffic forecast resulting from its proportional future year capacity.
BASECOUNT Adjustment	Portion of a link's final refined future year traffic forecast resulting from its proportional base year traffic count.
FA_f	Final refined future year traffic forecast.
TF_f	Screenline total final refined future year traffic forecast.
FA_f/C_f	Ratio of the final refined future year traffic forecast to future year capacity.
TFA_f/TC_f	Ratio of total screenline refined future year traffic forecast to total future year screenline capacity.
$COUNT/C_b$	Ratio of actual base year traffic count to base year capacity.
$TCOUNT/TC_b$	Ratio of total screenline actual base year traffic counts to total screenline base year capacity.

- Proportion of total screenline base year traffic count occurring on a particular link (%TCOUNT).
- Proportion of total screenline future year capacity occurring on a particular link (%TC).
- Ratio between the adjusted future year traffic forecast assignment (RA_f) and the future year capacity (C_f). For links not adjusted due to the base year assignment, the adjusted future year traffic forecast (RA_f) equals the future year forecast (A_f).
- Ratio of base year volume (COUNT) to capacity (C_f).
- Capacity and base count adjustment. These adjustments are based on the assumption that future year volumes are influenced by the actual base year traffic patterns, by the addition or modification of roadway capacity, and by the level of overall congestion that will occur. All other factors being equal, where negligible capacity changes or capacity constraints are expected to occur across a screenline, the future year assignment should closely replicate the actual base year traffic patterns. At the other extreme, where significant roadway capacity changes are proposed, the future year assignment is expected to be altered accordingly. Additionally, as congestion worsens across a series of facilities, traffic will tend to distribute itself more evenly along all facilities in search of less congested routes. Two adjustment factors are used. The FCOUNT is the relative weight given to the base year traffic count distribution. FCAP represents the weight given to future year distribution of roadway capacity.
- Final adjusted assignment (FA_f). Two different calculations are performed depending on whether the roadway is a new facility or an existing facility. On new facilities the final refined assignment is proportional only to its capacity. No adjustment for base year counts is made for a new facility because it did not

exist during the base year. On existing facilities the final adjusted assignment is proportioned based on its relative future year capacity and its base year traffic count.

- Refined future year volume to capacity (v/c) ratios. These values are used to check and verify refined assignments.

Step 4 - Perform Final Checks.

The refined forecast that has been smoothed should be checked for general reasonableness before being used in further planning and design. The reasonableness checks include a review of the v/c ratios for the links on the screenline, a check of the link assignment with those of other screenlines that may have intersected the same link, and a review of the relative importance of each link.

If the refinement procedure has been successful, the range of refined v/c ratios for the links on the screenline should have been narrowed compared to existing v/c ratios.

The check involving other screenline results includes looking at links common to two or more screenlines to ensure that volumes are compatible between screenlines. Where significant differences occur, one or more of the screenlines may need to be restricted. In most cases, however, any differences can be adjusted using knowledge of the expected conditions and facilities.

A useful check when new links are part of the screenline involves comparing the $\%TC_f$ and $\%TCOUNT$. The $\%TCOUNT$ for each link can be interpreted as the intensity of relative use, while the $\%TC_f$ can be interpreted as potential of relative use. This comparison assists in understanding how new facilities can affect the redistribution of future traffic volumes.

DEVELOPING TURNING MOVEMENTS

Turning movements are required for planning and designing roadway intersections and interchanges. However, computerized travel demand models do not usually provide reliable turning movement volumes. As a result, future turning movements must be developed using other techniques.

This section describes how turning movements from TRANPLAN may be used and provides guidance on the use of several methods for estimating future turning movements detailed in NCHRP Report 255, *Highway Traffic Data For Urbanized Area Project Planning and Design*.

SELECTING THE APPROPRIATE PROCEDURE

Selecting the specific turning movement estimation procedure will depend on several factors. In some cases more than one procedure should be used. Consider the following in determining the appropriate procedure:

- Type of project (project planning or design) for which the volumes are being developed.
- Availability of base year turning movement counts or percentages.
- Availability and suitability of future year turning movement assigned volumes.
- Type of assignment available: directional or nondirectional link volumes.
- Number of intersection approaches.

Regardless of which procedure is selected, professional judgment should be used throughout the process of developing estimates of future turning movements to ensure reasonable results.

TURNING MOVEMENTS FROM TRANPLAN

Although the turning movements from TRANPLAN assignments should not be used directly for planning or design, the turning movement results can be used as input to other methods described in this section or for comparing results obtained through other turning movement estimation procedures. To develop turning movements in TRANPLAN, the \$PARAMETER "SAVE TURNS" should be entered in the \$LOAD HIGHWAY NETWORK function file with the node numbers of the intersections where turning movements are desired. (The node numbers can be viewed in HNIS with the "POST SETUP" and "POST LINK" selections.) Subsequent to the assignment process, HNIS can be used to view the TRANPLAN turning movements on screen by selecting the "TURN MOVES" option. The turning movements developed by TRANPLAN cannot be plotted to paper. Thus, they must be copied manually while viewed in HNIS.

FACTORING METHOD

The factoring method used to develop turning movements for a future year is based on the principle that the discrepancy between a base year turning movement count and a base year assignment of turning movements is likely to be of the same magnitude in the future year turning movement assignment. Thus, the future year turning movement assignment can be modified using the relative ratios and/or differences between base year turning movement counts and the base year assignment of turning movements. This procedure uses the average of both a ratio and a difference factoring process. The data required to estimate future turning movements using the factoring method include:

- Future year TRANPLAN turning movement forecast.
- Base year TRANPLAN turning movement assignment.
- Base year turning movement counts.

One of the key features of this procedure is its simplicity. However, this simplicity means that some important factors are not considered in the estimation process. When used alone, the

factoring procedure is appropriate for developing future turning movement estimates for feasibility studies, project planning studies, and preliminary design studies.

Ratio Factoring Method

In this part of the factoring procedure, each turning movement in the future assignment is factored by the ratio of the base year actual traffic count to the base year assignment using the following calculation:

$$V_{ri} = F_i * (B_{ci}/B_{ai})$$

where:

- V_{ri} = ratio adjusted future year volume turning movement i.
- F_i = future year forecast volume for turning movement i.
- B_{ci} = base year traffic count for turning movement i.
- B_{ai} = base year assigned volume for turning movement i.

Each turning movement and through volume is adjusted separately for each approach and then summed to produce the adjusted total approach volumes.

Difference Factoring Method

For the difference method, each turning movement in the future year assignment is factored by the difference between the base year actual turning movement count and the base year assigned turning movements. The following calculation is used:

$$V_{di} = F_i + (B_{ci} - B_{ai})$$

where:

- V_{di} = difference adjusted future year volume for turning movement i.
- F_i = future year forecast volume for turning movement i.
- B_{ci} = base year traffic count for turning movement i.
- B_{ai} = base year assigned volume for turning movement i.

Each turning movement and through volume on each approach is adjusted separately and then summed to produce an adjusted total approach volume.

Combined Method

The combined method joins the results of the ratio and difference factoring procedures. This averaged method tends to reduce the extremes experienced by the individual methods.

$$V_{fi} = (V_{ri} + V_{di}) / 2$$

where:

- V_{ri} = ratio adjusted future year volume for turning movement i.
- V_{di} = difference adjusted future year volume for turning movement i.
- V_{fi} = final averaged future year volume for turning movement i.

Special Consideration - Lack of Base Year Turning Volumes

If base year turning volumes are not available, total approach link volumes may be substituted for B_{ci} and B_{ai} in the ratio method only. This technique will not produce an adjustment that is as specific as that produced through the comparison of individual base year turning movements. Note that the difference method and, thus, the combined method, cannot be used if base year turning movement counts are not available.

$$V_{ri} = F_i * (B_{ci} / B_{ai})$$

where:

- V_{ri} = ratio adjusted future year volume for turning movement i.
 F_i = future year forecast volume for turning movement i.
 B_{ci} = base year actual approach volume (link volume) for turning movement i.
 B_{ai} = base year assigned approach volume (link volume) for turning movement i.

Factoring procedure example

The following example illustrates the factoring procedure for developing future year turning movements.

Project: Determine year 2000 turn movements at the intersection of Texas Avenue and University Drive in the city of College Station using the factoring procedure.

Data: Base year (BY) turning movement count (1985)
 Base year (BY) turning movement assignment (1985)
 Future year (FY) turning movement assignment (2000)

Method: Ratio: $V_r = \text{FY assigned turns} * (\text{BY count} / \text{BY assignment})$
 Difference: $Y_d = \text{FY assigned turns} + (\text{BY count} - \text{BY assignment})$
 Combined: $V_f = (V_r + V_d) / 2$

**Table 2
Factoring Procedure Result**

Approach	Turn Movement	BY Count	BY Assignment	FY Assignment	Adjusted Future Volume		
					Ratio Method	Difference Method	Combined Method
NB	Left	362	447	514	416	429	422
	Thru	805	1666	1965	949	1104	1027
	Right	399	424	508	478	483	480
SB	Left	148	195	234	178	187	183
	Thru	703	1611	1901	830	993	912
	Right	133	369	424	153	188	171
EB	Left	422	375	457	514	504	509
	Thru	763	799	951	908	915	912
	Right	249	581	703	201	371	336
WB	Left	433	436	527	523	524	524
	Thru	535	849	1010	636	696	666
	Right	164	184	224	200	204	202

ITERATIVE PROCEDURE

Two variations of the iterative procedure for estimating turning movements are presented. One procedure provides turning movement estimates from directional approach link volumes, and one provides estimates from nondirectional approach link volumes. Both procedures develop turning movements using a specified approach link volume and an initial estimate of turning percentages. The number of iterations necessary to produce an acceptable set of turning volumes is dependent on the ability to make reasonable a priori estimates of turning movements. These procedures are most useful when a specified future year link volume must be retained for each intersection approach. For example, if the future year link volumes have been refined and are considered acceptable, this procedure would estimate turning movements without changing the approach link volumes.

Directional Volume Iterative Procedure

The directional volume method is based on a basic iteration technique developed by Furness (3) and modified for intersection flows by Mekky (4). This procedure uses an iterative computational technique in which the rows (approach link inflows) and columns (link outflows) of a turning movement matrix are alternately balanced until an acceptable convergence is obtained. Normally, a maximum of six to ten iterations requiring one or two person-hours per intersection are required.

This procedure requires the following input data:

- Future year TRANPLAN directional link volumes (developed through the corridor analysis and refinement process).
- Either base year actual or base year assigned directional turning movements or an initial estimate of future year directional turning movements.

Base year traffic count data are preferred, but turning data from a base year assignment may be used. If base year data are not available, make an initial estimate of future year turning percentages based on an examination of adjacent land uses (current and future) and/or the turning movements at similar intersections.

The directional volume method consists of five steps in which the following notations are used in the calculations:

- n = number of links emanating from the intersection.
- O_{ib} = base year (b) inflow to the intersection on link i.
- O_{if} = future year (f) inflow to the intersection on link i.
- D_{jb} = base year (b) outflow from the intersection on link j.
- D_{jf} = future year (f) outflow from the intersection on link j.
- T_{ijb} = base year (b) traffic flow entering through link i and leaving through link j.

- T_{ijt} = future year (f) traffic flow entering through link i and leaving through link j.
- P_{ijf} = future year (f) estimated percentage of traffic flow from link i to link j.
- * = adjusted values in each iteration.

Step 1 - Construct Initial Turning Movement Matrix.

An initial matrix of turning movements to be used in the iterations must be constructed. If base year data are known (either counts or assigned volumes), construct a turning movement matrix of base year turning volumes (T_{ijb}) as shown below.

**Table 3
Turning Movement Matrix of Base Year Turning Volumes**

		Columns (Outflows) D_{ib}				Total Link Inflows O_{ib} (O_{if})
		To Link 1	To Link 2	To Link 3	To Link 4	
Rows (Inflows) T_{ijb}	From Link 1					
	From Link 2					
	From Link 3					
	From Link 4					
Total Outflows D_{ib} (D_{if})						

Insert the row and column totals next. The row totals should represent inflows (O_{ib}) and column totals. The row totals should represent outflows (D_{jb}).

The sum of the volumes across each row and down each column should equal the O_{ib} and O_{jb} , respectively. The sum of the diagonal totals should equal zero. Once the base year volumes have been placed in the matrix, note in parentheses the future year total link inflow volume (O_{if}) and future year total link outflow volume (D_{if}).

If base year volumes are not known, construct an initial matrix of future year turning volumes (T_{ijf}) using estimated turning percentages. The T_{ijf} is developed by the following calculation: $T_{ijf} = O_{if} * P_{ijf}$. The matrix will appear as above, although no future volumes will be noted in parentheses. In this matrix, the row totals will be equal to the approach link inflow volume. The column totals may not, however, equal the outflow volumes for each link. The adjusted column totals (D_{jf}^*) should be compared with the future year link outflows (D_{if}). If these adjusted outflows are acceptable (usually within ± 10 percent of the D_{if}), the procedure is complete. If they are not acceptable, further iterations will be necessary and the procedure should continue beginning with Step 3.

Step 2 - Perform the First Row Iteration.

This step is second in the procedure using base year volumes. If the initial matrix is constructed using future year volumes, omit this step. Make a copy of the matrix developed in Step 1 and replace the base year inflows (O_{ib}) with the future year inflows (O_{if}). Then adjust each individual turning movement according to the following:

$$T_{ijf}^* = (O_{if} / O_{ib}) * T_{ijb}$$

where:

$$T_{ijf}^* = \text{adjusted future volume for this iteration.}$$

Construct a new matrix consisting of T_{ijf}^* and O_{if} and calculate the new D_{ji}^* by summing the T_{ijf}^* in each column. The matrix at this stage is shown below. The D_{jf}^* should be compared with the desired D_{jf} from Step 1. If the difference between these values is acceptable, the procedure is complete. Typically, a difference of +10 percent is considered to be acceptable. If a large discrepancy is apparent, continue with further iteration(s).

Table 4
Adjusted Matrix

		Columns (Outflows) D_{jf}^*				Total Link Inflows O_{if}^*
		To Link 1	To Link 2	To Link 3	To Link 4	
Rows (Inflows) T_{ijf}^*	From Link 1					
	From Link 2					
	From Link 3					
	From Link 4					
Total Outflows D_{jf}^*						

Step 3 - Perform the First Column Iteration.

This step is performed on the adjusted turning movement matrix developed in Step 2 or on the initial matrix developed in Step 1 when base year data are not available. Make a copy of the last matrix developed in the procedure. Replace the adjusted outflows (D_{jf}^*) with the original D_{jf} in this matrix. Then adjust each individual movement according to the following:

$$T_{ijf}^{*new} = (D_{jf} / D_{jf}^*) T_{ijf}^{*old}$$

where:

T_{ijf}^{*old} = T_{ijf}^* value in the matrix developed in Step 2.

T_{ijf}^{*new} = adjusted T_{ijf} after column iteration.

(The T_{ijf}^{*new} becomes the T_{ijf}^{*old} in subsequent iterations).

Next construct a new matrix consisting of the T_{ijf}^{*new} and D_{jf} . Then calculate the adjusted O_{if}^* by summing the T_{ijf}^{*new} in each row.

Table 5
Adjusted Matrix

		Columns (Outflows) D_{jf}^*				Total Link Inflows O_{if}^*
		To Link 1	To Link 2	To Link 3	To Link 4	
Rows (Inflows) T_{ijf}^{*new}	From Link 1					
	From Link 2					
	From Link 3					
	From Link 4					
Total Outflows D_{jf}^*						

The O_{if}^* should be compared with the O_{if} in the first matrix to check the acceptability of the value differences. Typically, a value of ± 10 percent is considered acceptable. If large discrepancy is apparent, continue with further iteration(s).

Step 4 - Repeat Row Iteration.

If needed, repeat Step 2 for row iterations. Calculate new values for T_{ijf}^{*new} and D_{jf}^* ; then compare D_{jf}^* with D_{jf} .

Step 5 - Repeat Column Iteration.

If needed after Step 4, repeat the Step 3 column iteration procedure. Calculate new values for T_{ijt}^{*new} and O_{if}^* ; then compare O_{if}^* with O_{if} .

The T_{ijt}^* values in the final iteration matrix represent the final adjusted directional turning and through movements.

Directional volume iterative example

The following example illustrates the directional turning movement procedure where base year volumes are available.

- Project:** Determine year 2000 turning movements at the intersection of Texas Avenue and University Drive in the city of College Station using the directional iterative method.
- Data:** Base year (BY) turning movements (1985) and future year (FY) directional link volumes (2000) as shown in the following figure.

PEAK HOUR
5:30 TO 6:30

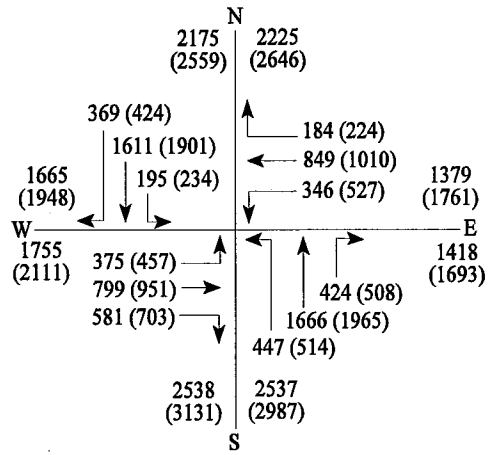


Table 6
Step 1: Initial Turning Movement Matrix

		Columns (Outflows) D_{jb}				Total Link Inflows O_{ib} (O_{if})
		To Link N	To Link S	To Link E	To Link W	
Rows (Inflows) T_{jib}	From Link N	0	1611	195	369	2175 (2559)
	From Link S	1666	0	424	447	2537 (2987)
	From Link E	184	346	0	849	1379 (1761)
	From Link W	375	581	799	0	1755 (2111)
Total Outflows D_{jb} (D_{if})		2225 (2646)	2538 (3131)	1418 (1693)	1665 (1948)	

Table 7
Step 2: First Row Iteration

		Columns (Outflows) D_{jf}				Total Link Inflows O_{if}^*
		To Link N	To Link S	To Link E	To Link W	
Rows (Inflows) T_{jif}^*	From Link N	0	1895	229	435	2559
	From Link S	1961	0	500	527	2988
	From Link E	235	443	0	1087	1765
	From Link W	451	697	958	0	2106
Total Outflows D_{if}^*		2647	3035	1687	2049	

Compare the adjusted future volume outflow for each link (D_{if}^*) to the desired future volume outflow (D_{if}) in Step 1. As shown in Table 8 below, the adjusted volumes are within ± 10 percent; and the results are considered acceptable. No further iterations are needed.

Table 8
Comparison of Adjusted and Desired Outflows

	Columns (Outflows)											
	To Link N			To Link S			To Link E			To Link W		
	D_{if}	D_{if}^*	% Diff.	D_{if}	D_{if}^*	% Diff.	D_{if}	D_{if}^*	% Diff.	D_{if}	D_{if}^*	% Diff.
From Link N	0	0	0	1901	1895	-3	234	229	-2	424	435	+3
From Link S	1965	1961	-2	0	0	0	508	500	-2	514	527	+3
From Link E	224	235	+5	527	423	-20	0	0	0	1010	1087	+8
From Link W	457	451	-1	703	443	-37	951	958	+7	0	0	0
	2646	2647	+0.04	3131	2761	-12	1693	1687	-3	1948	2049	+5

Table 9
Step 3: First Column Iteration

		Columns (Outflows) D_{jr}^*				Total Link Inflows O_{if}^*
		To Link N	To Link S	To Link E	To Link W	
Rows (Inflows) T_{ijr}^{*new}	From Link N	0	1955	230	414	2599
	From Link S	1960	0	502	501	2963
	From Link E	235	457	0	1033	1725
	From Link W	451	719	961	0	2131
Total Outflows D_{if}^*		2646	3131	1693	1948	

Now compare the O_{if}^{*new} to the O_{if} from Matrix 1 as shown in Table 10. If the results are acceptable (± 10 percent), no further iteration(s) are needed.

Table 10
Comparison of Adjusted and Desired Inflows

	Total Inflows		
	O_{if}	O_{if}^{*new}	Percent Difference
From Link N	2559	2599	+1.5
From Link S	2987	2963	-.8
From Link E	1761	1725	-2.0
From Link W	2111	2131	+10

These values are within ± 10 percent. If the values are considered acceptable, the iterations are complete. If closer results are desired, the iterative process may continue by performing a second row iteration as in Step 2, a comparison of the D_{jr} and D_{jr}^{*new} , followed by a second

column iteration as in Step 3, a comparison of the O_{if} and O_{if}^{*new} , and so forth.

Nondirectional Iterative Procedure

The nondirectional volume method is adapted from an unpublished technique developed by Richard Marshment for the Middle Rio Grande Council of Governments (5). This method has no theoretical basis or unique solution. Rather, the method produces a reasonable turning movement scenario based on the assumption that the traffic volume on a given approach of an intersection is a function of the land use attractions and productions downstream of the intersection. This procedure relies heavily on professional judgment to select reasonable turning movement percentages and make final adjustments to the volumes after completing the calculations. Therefore, this procedure should be used for project-level planning purposes.

The procedure produces two-way turning volumes and an estimate of the total vehicle turning percentage. The method provides a five-step sequence and may have to be performed iteratively to achieve a balanced distribution of turning and through movements. The number of iterations will vary, but three to four iterations requiring one to three person-hours will be sufficient.

The data required to estimate turns using this procedure include nondirectional link volumes (i.e., total both directions) on each approach.

Step 1 - Estimate Total Turning Percentage.

The first step is to determine the percentage of total inflowing traffic which turns (either right or left). The turning percentage value is estimated based on the unique characteristics of the intersection and comparable intersections from other parts of the urban area. If it is an existing signalized intersection and the actual green times given to individual turning movements are known at the subject intersection, these values can be used instead of the

estimated percentage for the entire intersection.

The turning movement percentage is estimated relative to the sum of only inflowing (i.e., one direction) volume. The inflowing volume equals one-half the total nondirectional volume. Thus, sum the nondirectional link volumes for each intersection approach and divide by 2 to estimate the total inflowing volume.

$$V_1 + V_2 + V_3 + V_4 = V_T$$

$$V_T / 2 = V_I$$

$$V_{\text{Turns}} + V_{\text{Thru}} = V_I$$

$$V_I * V_{\text{TP}} = V_{\text{Turns}}$$

$$V_I - V_{\text{Turns}} = V_{\text{Thru}}$$

where:

$V_1 \dots V_4$	=	nondirectional volume on each intersection approach.
V_T	=	total nondirectional volume on all intersection approaches.
V_I	=	total inflowing volume on all intersection approaches.
V_{Turns}	=	volume of inflowing traffic making right and left turns.
V_{Thru}	=	volume of nonturning inflowing intersection traffic.
V_{TP}	=	estimated percentage of turning volume.

Step 2 - Calculate the Relative Weight of Each Intersection Approach.

To calculate the relative weight of each approach, sum all nondirectional volumes on all intersection approaches. Express the volume on a particular approach as a proportion of total volume. The proportions (or relative weights) on all approaches must sum to 1.00.

$$V_1 / V_T = RW_1$$

$$RW_1 + RW_2 + RW_3 + RW_4 = 1.00$$

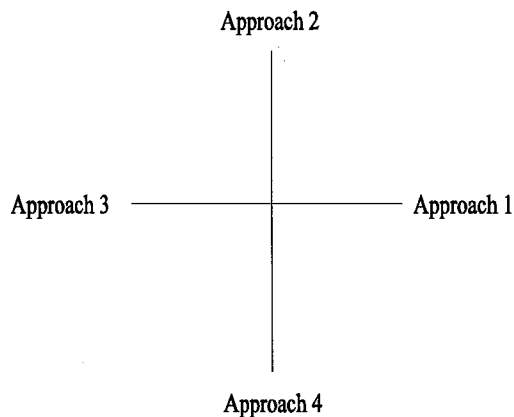
where:

- $V_1 \dots V_4$ = nondirectional volume on each intersection approach.
- $RW_1 \dots RW_4$ = relative weight (or proportion) of each intersection volume to total intersection volume.

Step 3 - Perform Initial Allocation of Turns.

In this step, the volume in each approach is allocated to the other intersection approaches. Multiply the total volume on an approach by the relative weights (as computed in Step 2) for the remaining approaches which involve turns. Do not perform this calculation for the through movements. Thus, for a 4-legged intersection, each approach volume would be multiplied by the relative weight of the approach to the right and the relative weight of the approach to the left. This calculation should be performed for each intersection approach to produce turns to other approaches. The following applies for the intersection below:

- $V_1 * RW_2 = V_{12}$
- $V_1 * RW_4 = V_{14}$
- $V_2 * RW_3 = V_{23}$
- $V_2 * RW_1 = V_{21}$
- $V_3 * RW_2 = V_{32}$
- $V_3 * RW_4 = V_{34}$
- $V_4 * RW_3 = V_{43}$
- $V_4 * RW_1 = V_{41}$



where:

- V_1 = total nondirectional volume on Intersection Approach 1.
- RW_1 = relative weight of Intersection Approach 1.
- V_{12} = volume of nondirectional traffic on Approach 1 turning to Approach 2.

The above calculation produces two sets of turning volumes between each turning opportunity (i.e., Approach 1 to Approach 2 and Approach 2 to Approach 1). To avoid doubling the turning volume, the volumes calculated above for each turning opportunity should be averaged to produce one nondirectional turning volume for each turning movement.

Step 4 - Adjust Turning Volumes Based on Turning Percentage.

The total volume of turns generated in Step 3 will typically exceed the likely volume of turns at the intersection. To adjust the Step 3 estimates, a turning adjustment must be imposed.

The adjustment involves the following computations:

- (a) Write down the total inflowing volume (Step 1).
- (b) Write down the total turn percentage (Step 1).
- (c) Compute the total expected volume of turns as (a) * (b).
- (d) Sum the turning volumes calculated during Step 3.
- (e) Adjust the individual turns from Step 3 using either a difference method or ratio method.

Difference method: Subtract (d) from (c) and divide by the number of intersection turning movements. (A 4-legged intersection involves four turning movements, so divide by 4). Then add or subtract this from each turning volume developed in Step 3. This method may result in a negative turning volume if the initial intersection turning percentage was too low.

Ratio method: Divide (c) by (d) and multiply each turning volume from Step 3 by this number.

At the end of this step, the sum of the individual turning volumes will equal the expected turning volume from Step 1.

Step 5 - Balance the Approach Volumes and Adjusted Turning Volumes.

The preceding steps will yield a turning movement estimate that conforms to the estimated turning percentage established in Step 1. In many situations, however, the method will not result in an intersection scenario that accounts for all the traffic traversing the intersection. To test for this situation, take each approach of the intersection and do the following:

- (a) Write down the total approach volume.
- (b) Subtract the turns made to/from that approach from cross streets.
- (c) Add the turns made to/from the approach on the opposite side of the intersection.

If the intersection clears all traffic, the total volume on the opposing approach of the intersection should equal the volume estimated from the above test. If these volumes do not correspond, an adjustment must be made to out-of-balance numbers to bring the analysis into equilibrium. Two situations are normally encountered in this analysis:

- 1) The opposite intersection approaches show a greater difference in adjusted volume (Step 5) than was evident in the original volumes (Step 2).
- 2) The two opposing intersection approaches have adjusted volumes (Step 5) that are closer to each other than was evident in the original volume (Step 2).

In the first situation, iterating the entire procedure from Step 2 using new approach volumes will narrow the volume difference between two opposing intersection approaches.

The second situation is more complicated: the difference in volume on opposing approaches must be increased. The following computations will provide an adjustment to increase the difference between the opposing volumes.

- (a) Sum volumes on the two opposing approaches using original volumes input at the outset of the analysis (Step 2).
- (b) Determine the proportion of this volume (a) represented by each of the two opposing approaches. This must sum to 1.00.
- (c) Determine the approach volume difference between the adjusted and the original

estimates.

- (d) Multiply the proportions (b) by the volume difference (c). Add/subtract this number to/from the calculated volumes as appropriate.

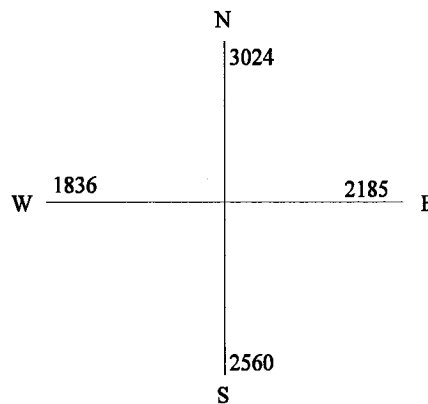
The above adjustments should be applied to each intersection approach to ensure that the approach volumes are in scale relative to the completed turning volumes.

Nondirectional volume iterative example

The following problem illustrates the nondirectional iterative procedure:

Project: Determine the year 2000 turning movement at the intersection of Texas Avenue and University Drive in the City of College Station using the nondirectional iterative procedure.

Data: Future year 2000 nondirectional approach link volumes as shown below.



Step 1 - Estimate the Total Turning Percentage.

$$V_T = 3024 + 2560 + 2185 + 1836 = 9605.$$

$$V_I = \text{total inflowing volume (50\% of total)} = 9605/2 = 4802.$$

$$V_{TP} = \text{percentage of total inflowing volume making turns} = 20\%.$$

$$V_{\text{Turns}} = \text{turning volume} = 4802 * .20 = 960.$$

$$V_{\text{Thru}} = \text{through volume} = 4803 - 960 = 3843.$$

Step 2 - Calculate Relative Weight of Total Turning Percentage for Each Approach.

$$\text{Approach E: } 2185/9605 = 0.23$$

$$\text{Approach N: } 3024/9605 = 0.31$$

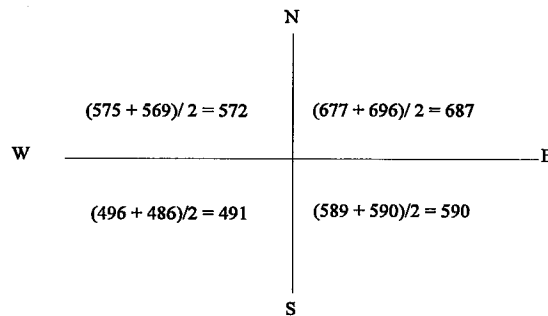
$$\text{Approach W: } 1836/9605 = 0.19$$

$$\text{Approach S: } 2560/9605 = 0.27$$

Table 11
Step 3: Initial Allocation of Turns

From Approach	To Approach	Calculation
E	N	$2185 * 0.31 = 677$
	S	$2185 * 0.27 = 590$
N	E	$3024 * 0.23 = 696$
	W	$3024 * 0.19 = 575$
W	N	$1836 * 0.31 = 569$
	S	$1836 * 0.27 = 496$
S	E	$2560 * 0.23 = 589$
	W	$2560 * 0.19 = 486$

Average the volumes as shown below.

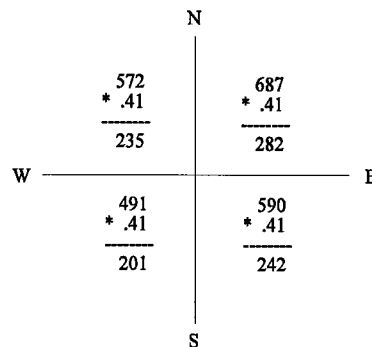


Step 4 - Adjust Turning Volumes Based on Turning Percentage.

- (a) Total inflowing volume of turns = 4802.
- (b) Total turn percentage = 0.20.
- (c) Expected turn volume: (a*b) = 4802 * .20 = 960.
- (d) Sum of turn volumes from Step 3: 572 + 491 + 687 + 590 = 2340
- (e) Adjustment:

Difference method: $(960 - 2340) / 4 = (-345)$.

Ratio method: $960/2340 = 0.41$



Step 5 - Balance Approach Volume and Adjusted Turn Volumes.

Difference method:

$$E: 2185 - 342 - 245 + 227 + 146 = 1971$$

$$N: 3024 - 342 - 227 + 146 + 245 = 2846$$

$$W: 1836 - 227 - 146 + 342 + 245 = 2050$$

$$S: 2560 - 146 - 245 + 227 + 342 = 2738$$

Ratio method:

$$E: 2185 - 282 - 242 + 235 + 201 = 2097$$

$$N: 3024 - 282 - 235 + 201 + 242 = 2950$$

$$W: 1836 - 235 - 201 + 282 + 242 = 1924$$

$$S: 2560 - 201 - 245 + 282 + 235 = 2631$$

Using either the ratio or difference method, compare the original approach volume difference between opposing approaches and the adjusted approach volume difference. In this example, the ratio adjusted volumes are used.

**Table 12
Comparison of Approach Volumes**

Approach	Original Volume Difference	Adjusted Volume Difference	Conclusion
E / W	$2185 - 1836 = 349$	$2097 - 1924 = 173$	Increase Difference
N / S	$3024 - 2560 = 464$	$2950 - 2631 = 319$	Increase Difference

Make adjustments as follows:

- (a) Sum original approach volumes.

$$E + W = 2185 + 1836 = 4021$$

$$N + S = 3024 + 2560 = 5584$$

- (b) Determine proportion of volume to opposing volume.

$$2185/4021 = .54$$

$$1836/4021 = .46$$

$$3024/5584 = .54$$

$$2560/5584 = .46$$

- (c) Determine approach volume difference.

$$E: 2185 - 2097 = 88$$

$$W: 1836 - 1924 = - 88$$

$$N: 3024 - 2950 = 74$$

$$S: 2560 - 2631 = - 71$$

- (d) Multiply difference by proportion.

$$E: 88 * .54 = 48$$

$$W: - 88 * .46 = - 40$$

$$N: 74 * .54 = 40$$

$$S: - 74 * .46 = - 34$$

- (e) Subtract value calculated in d above from the adjusted volume.

$$E: 2097 - 48 = 2049$$

$$W: 1924 - (- 40) = 1964$$

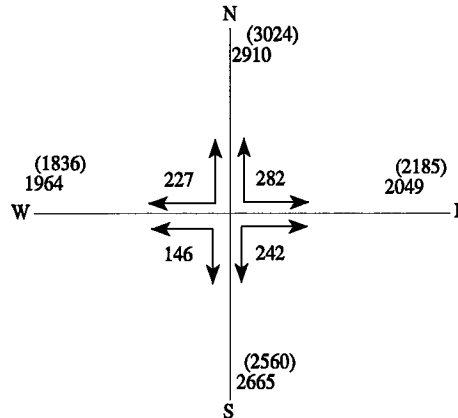
$$N: 2950 - 40 = 2910$$

$$S: 2631 - (- 34) = 2665$$

$$2049 + 1964 + 2910 + 2665 = 9588$$

Now compare the total adjusted approach volumes from (e) above, 9,588, to the original total approach volumes, 9,605. The difference between these is only 17, or 0.18 percent, and is not considered to be significant. However, in many cases, additional adjustments may be needed.

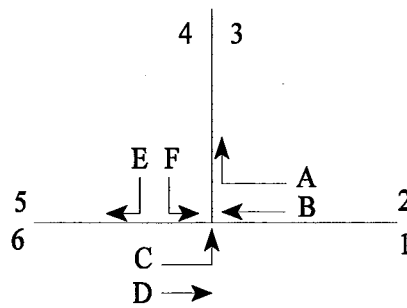
Results:



DIRECTIONAL TURNING MOVEMENTS FOR A "T" INTERSECTION

Turning movement volumes at "T" intersections can be determined from the intersection directional link volumes and one turning movement count. Because a "T" intersection involves only six directional movements, simple mathematics are used to derive equations to aid in the solution. The data required for this procedure include the six directional link volumes for each approach (i.e., the inflow and outflow volume of each approach), and one of the six turning volumes must be known or estimated.

Based on the intersection configuration below, a typical solution for unknown volumes A, B, C, D, and E, where the volumes for F and links 1 through 6 are known, can be calculated as follows.



$$\begin{aligned}
 \text{Volume E} &= \text{Volume 4} - \text{F} \\
 \text{Volume A} &= \text{Volume 5} - \text{E} \\
 \text{Volume B} &= \text{Volume 2} - \text{A} \\
 \text{Volume C} &= \text{Volume 3} - \text{B} \\
 \text{Volume D} &= \text{Volume 6} - \text{C}
 \end{aligned}$$

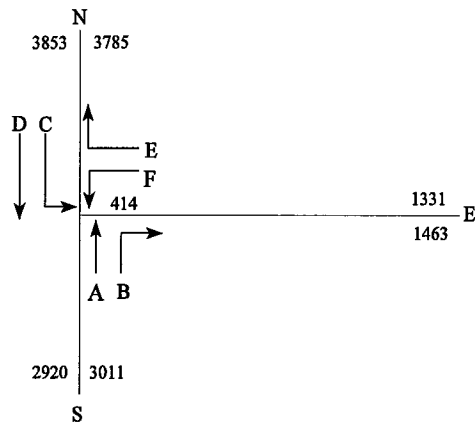
To solve for the turning movements, use the known link volumes and volume for Movement F. Calculate the remaining volumes sequentially.

Directional "T" intersection procedure example

An example of the directional "T" intersection turning movement estimation procedure is given below.

Project: Determine turn movements at the "T" intersection of Texas Avenue and Harvey Road in the City of College Station.

Data: Six directional link volumes for (1985)
One directional turn movement (1985 count)



$$\begin{aligned}
 \text{Volume E} &= 1331 - 414 = 917 \\
 \text{Volume A} &= 3785 - 917 = 2868 \\
 \text{Volume B} &= 3011 - 2868 = 143 \\
 \text{Volume C} &= 1463 - 143 = 1320 \\
 \text{Volume D} &= 3853 - 1320 = 2533
 \end{aligned}$$

NONDIRECTIONAL TURNING MOVEMENT FOR A "T" INTERSECTION

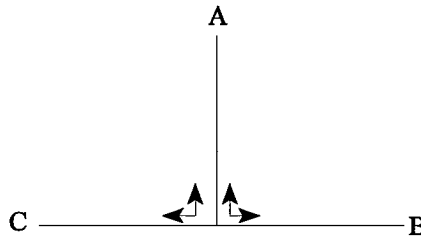
Nondirectional turn volumes can be easily computed if nondirectional link volumes on the three approaches are known. The nondirectional method is mathematically based on algebraic relationships. The two unknown turning volumes can be directly obtained from two independent equations.

Input data required for this method are nondirectional link volumes for each of the three approaches.

Referring to the intersection shown below for notations, the following equations are used:

$$X = (A - B + C)/2$$

$$Y = (C - A + B)/2$$



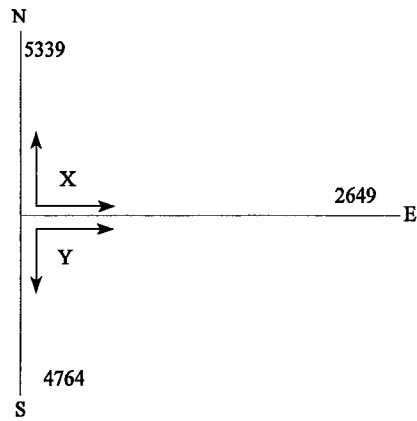
Where A, B, and C are link volumes, and X and Y are desired turning movements.

Nondirectional "T" intersection example

An example of the nondirectional "T" intersection turning movement estimation procedure is given below.

Project: Determine the turning movements at the intersection of Texas Avenue and Harvey Road in the City of College Station using the nondirectional "T" intersection procedure.

Data: Nondirectional link volume (1985)



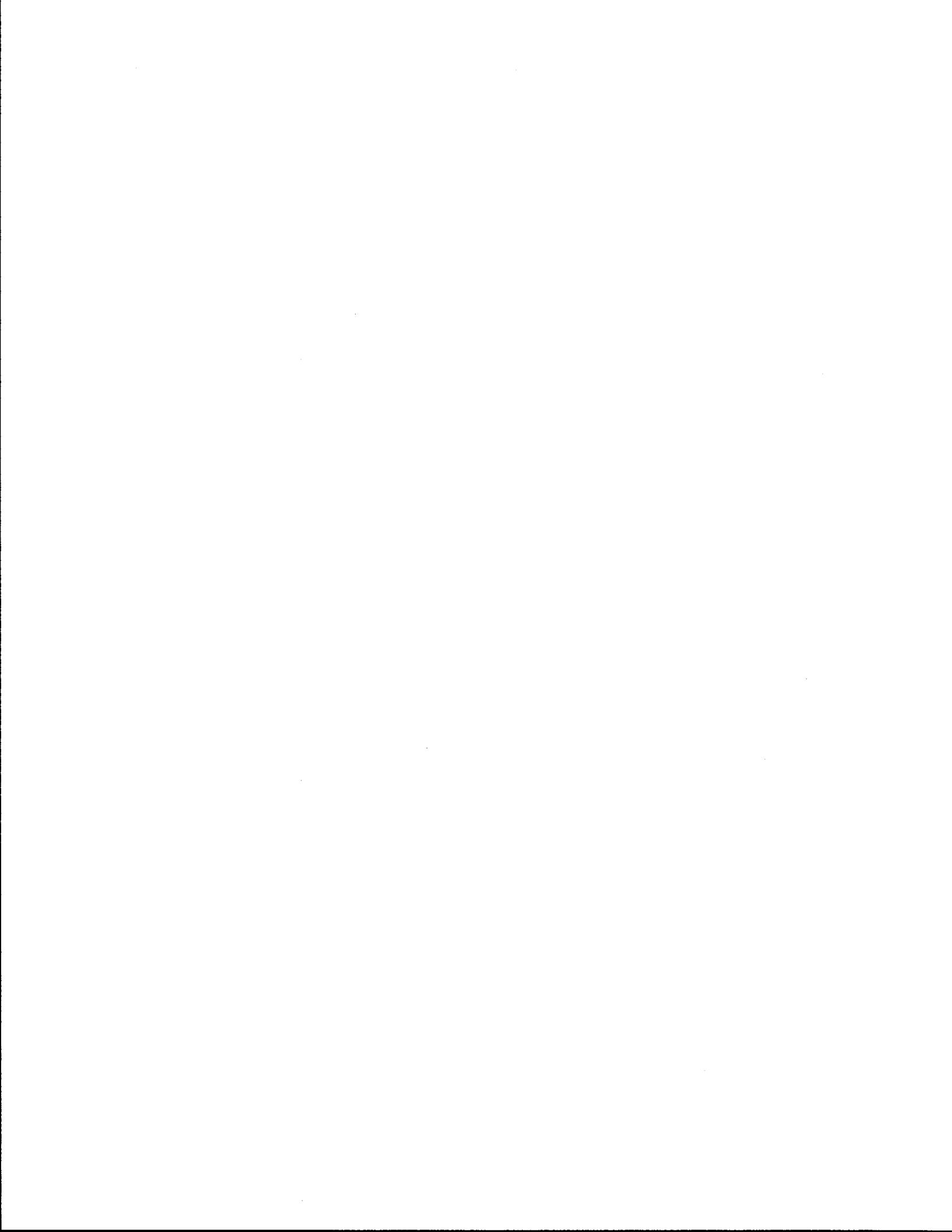
Calculation:

$$X = (N - S + E) / 2.$$

$$X = (5339 - 4764 + 2649) / 2 = 1612.$$

$$Y = (E - N + S) / 2.$$

$$Y = (2649 - 5339 + 4764) / 2 = 1037.$$



This appendix contains examples of several standard look-up tables needed in the corridor analysis procedure.

**Table A-1
Example of Texas Functional Classification**

Functional Classification Code	Functional Classification (Dallas-Ft. Worth)	Alternate Facility Description (Bryan-College Station)
0	Centroid Connector	Interstate
1	Freeway	Major Arterial, 4 Lanes Divided
2	Principle Arterial	Major Arterial, 4 Lanes Undivided
3	Minor Arterial	Major Arterial, 2 Lanes
4	Collector	Minor Arterial, 6 Lanes Divided
5	Strategic Regional Arterial	Minor Arterial, 4 Lanes Divided
6	Ramp	Minor Arterial, 4 Lanes Undivided
7	Frontage Road	Minor Arterial, 2 Lanes Undivided
8	HOV Lane	Collector, 2 Lanes
9	None	Local
A	None	Frontage Road
B	None	Ramp
C	None	Centroid Connector

**Table A-2
Typical Speed/Capacity Look-Up Table
(Bryan-College Station Urban Transportation Study)**

Description	Lanes	Func. Class	Area Type					
			CBD	CBD Fringe	Urban	Suburban	Suburban Fringe	Rural
Interstate	4D	0	45 103500	45 87200	50 75000	55 49700	55 28400	60 23600
Major Arterial	4D	1	40 N/A	40 N/A	45 N/A	50 25600	50 25600	55 28400
	4U	2	40 N/A	40 N/A	45 N/A	50 22800	50 22800	55 27000
	2U	3	40 N/A	40 N/A	45 N/A	50 10600	50 5800	55 5200
Minor Arterial	6D	4	37 64200	37 5300	42 44700	47 28300	47 17700	52 N/A
	4D	5	36 42800	36 35300	41 29800	46 18900	46 11800	51 N/A
	4U	6	33 38000	33 31400	38 26500	43 16800	43 10300	48 N/A
	2U	7	30 15800	30 13100	35 11000	40 6900	40 4200	45 N/A
Collector	2U	8	25 14100	25 11600	30 9700	35 5900	35 3500	40 2300
Local	2U	9	20 14100	20 11600	25 9700	30 5900	30 3500	35 2300
Frontage	2U	A	35 16900	35 14200	40 12100	45 10600	45 5800	50 5200
Ramps	2U	B	35 16900	35 14200	40 12100	45 10600	45 5800	50 5200
Centroid Connector		C	15	15	20	25	25	30

Table A-3
Example of Roadway Characteristics For Capacities
(Bryan-College Station Urban Transportation Study)

Characteristic	Func. Class	Area Type					
		CBD	CBD Fringe	Urban	Suburban	Suburban Fringe	Rural
Level of Service	0-6, A-B	D	D	D	C	B	B
	7-9	C	C	C	B	A	A
Peak Hour Factor	0 - F	0.95	0.94	0.93	0.92	0.91	0.90
K-Factor	0 - F	0.06	0.07	0.08	0.09	0.10	0.11
Directional Split	0 - F	0.55	0.55	0.55	0.60	0.65	0.70
Percent Trucks	0 - F	0.05	0.06	0.07	0.08	0.09	0.10
Green Cycle Ratio	0-3, A-B	N/A	N/A	N/A	N/A	N/A	N/A
	4-6	0.47	0.46	0.45	0.40	0.35	0.30
	7	0.42	0.41	0.40	0.35	0.30	0.25
	8-9	0.37	0.36	0.35	0.30	0.25	0.20

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