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16. ABSTRACT

The Washington State Department of Transportation has produced this guide to improve the development of traffic forecasts used by Department engineers and planners. The guide is intended to help standardize the methodology for developing forecasts, provide an "audit trail" of the steps and assumptions behind each forecast, and ensure that the assumptions underlying the forecasting process have been carefully considered.

The guide is split into two volumes. The first volume describes the forecasting process and reviews the issues that must be addressed. The second volume provides detailed instructions for the forecasting process.

Volume 1 contains background information on the steps involved in forecasting and the factors that must be considered as part of a traffic forecast. It should be used to introduce staff to the traffic forecasting process. It will also help identify the resources required to forecast traffic and then assist in analyzing and applying those resources.

Volume 2 of the guide contains a more precise description of how to perform the forecast. In addition, the Volume 2 appendices contain copies of the worksheets that should accompany any forecasts engineers perform and instructions on using several Lotus 1-2-3 spreadsheets that were designed to ease the forecasting process. Lastly, Volume 2 contains a copy of the Lotus 1-2-3 templates for use by engineers and planners.

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Traffic Forecasting Guide

WSDOT TRAFFIC FORECASTING GUIDE
VOLUME 1
INTRODUCTION TO THE FORECASTING PROCESS

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May 1991

DISCLAIMER

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FOREWORD

The Washington State Department of Transportation (also referred to as WSDOT or the Department) has produced this guide to aid in the development of traffic forecasts that you, the Department engineer or planner, use. The guide is intended to help standardize the methodology for developing forecasts, provide an "audit trail" of the steps and assumptions behind each forecast, and ensure that the assumptions underlying the forecasting process have been carefully considered.

The guide is split into two volumes.

- The first volume describes the forecasting process and reviews the issues that must be addressed.
- The second volume provides more detailed instructions for the forecasting process.

While persons familiar with the entire forecast and design process do not need background information, it should be beneficial to you if you are new to either the forecasting or design areas. Those already familiar with the issues involved in forecasting can turn directly to Volume 2 of the guide to obtain step by step forecasting instructions and a series of worksheets and checklists designed to meet review and documentation requirements.

These worksheets and checklists will not only remind forecasters of the importance of various assumptions, they will also provide a record of these assumptions for later reference. The audit trail and review process will help ensure that the Department provides realistic estimates of traffic, and will allow oversight agencies to more quickly review and approve project designs. Finally, by retaining the assumptions and other information on which the project designs were based, the Department will gain a better understanding of the performance of its pavements relative to the traffic estimates used to produce those designs.

The last function of this forecast guide is to help you, the engineer or planner, identify the resources you require to forecast traffic and then to assist you in analyzing and applying those resources. To that end, the guide includes references (both published reports and names and telephone numbers of resource personnel) you may use while performing forecasts.

CHAPTER 1

INTRODUCTION

BACKGROUND

By nature, forecasting is an inexact science. The results are never "correct," although a good forecast can be considered "accurate." Historically, forecast work has been given much less attention than most other aspects of the design process. Consequently, forecasting has sometimes been done haphazardly, resulting in forecasts that have borne little resemblance to eventual traffic levels. Persons untrained in forecasting and unaware of its impacts may use too little information and pay too little attention to basic assumptions (such as the expected growth of truck traffic) that can significantly affect highway design, construction, and performance.

This volume contains background information on the steps involved in forecasting and the factors that must be considered as part of a traffic forecast. It should be used to introduce WSDOT staff to the traffic forecasting process.

STEPS IN THE FORECASTING PROCESS

The forecasting process is illustrated in Figure 1-1. As a forecaster, you should follow the steps listed below:

- become familiar with the project and the project area,
- determine the scope of the project to be performed,
- perform a preliminary review of available data,
- select the tools to perform the project,
- gather preliminary information concerning the project's requirements and review the selection of the forecasting tools in cases where sufficient data do not exist to allow their use,
- ask a series of project specific questions to examine the potential factors that might affect the forecasts for that project,

- perform the forecast (including internal reviews),
- submit the forecast results for review by staff external to the forecasting process and respond to their review comments, and
- submit the forecast to the requesting person or division for use.

Each of these steps is discussed in detail within this two-volume guide.

FACTORS IN PERFORMING FORECASTS

A variety of factors affect the traffic volumes and characteristics that a section of highway will experience during its design life. These factors are often inter-connected, and their relationship to traffic is often complex and poorly understood. Predicting these impacts requires making a variety of assumptions and then predicting how those assumptions will impact expected traffic levels.

For example, suppose a new concrete plant will be built next to a project highway. You must assume when the plant will open, how many vehicles trips it will generate, what size those vehicles will be, and in which direction they will travel to and from the plant. These assumptions affect a wide variety of design factors for the project, including the depth of the pavement, the possible need for truck climbing lanes (if the area is mountainous), the number of lanes required for the facility (if the number of expected heavy trucks might degrade traffic performance), and the need for geometric design changes (whether the highway should include a turning lane into the facility or a merge lane for vehicles exiting the plant).

Because forecast assumptions such as these play a major role in developing traffic estimates, each assumption must be clearly stated and its basis and impacts must be reviewed. Among the factors that you may need to examine and consider are the following:

- population growth;
- economic trends, activity, and development;

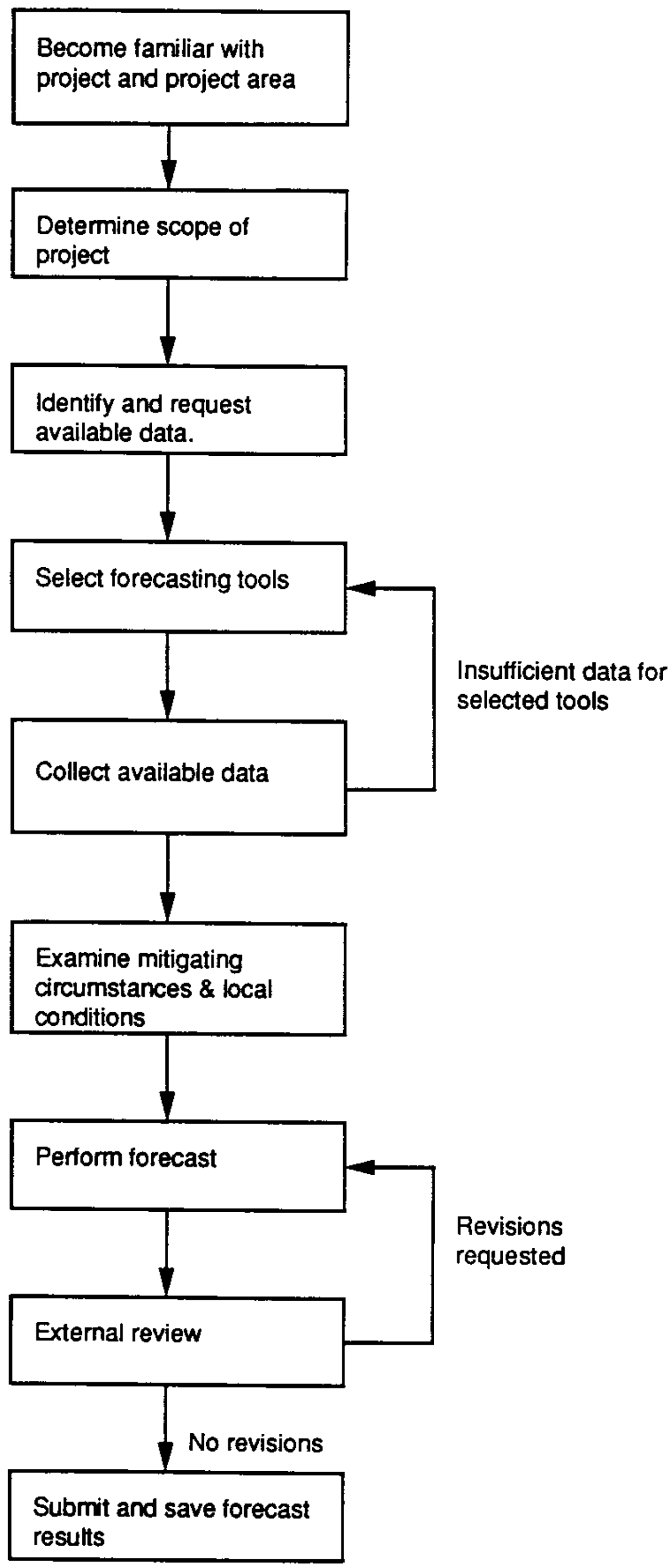

Figure 1-1. Forecasting Process

- planned or potential railroad line abandonments;
- the anticipated rate of change (straight-line, exponential, or S-curve growth patterns),
- changes to the vehicle fleet mix and the associated truck size and weight laws;
- statewide and national trends in vehicle miles traveled;
- other transportation laws and regulations (tolls, taxes, regulations, route limits); and
- expected levels of automobile ownership.

The need for each of these factors and its potential impacts is discussed in Chapter 2.

DESCRIPTION OF GUIDE

Volume 1 of the guide is separated into six chapters:

- Introduction,
- Factors To Consider When You Perform Forecasts,
- Beginning the Forecasting Process,
- Selecting Forecasting Techniques,
- Performing the Forecast, and
- Reviewing and Presenting the Forecast.

Following these chapters are several appendices. These include a dictionary of terms, a short guide to WSDOT training courses and technical assistance, information about some of the computer programs that can be used in the forecasting process, and a summary of traditional data sources used in traffic forecasting.

Volume 2 of the guide contains a more precise description of how to perform the forecast. The Volume 2 appendices contain copies of the worksheets that should accompany any forecasts you perform and instructions on using several Lotus 1-2-3 spreadsheets that were designed to ease the forecasting process. Lastly, Volume 2 contains a copy of the Lotus 1-2-3 templates for use by engineers and planners.

LAYOUT OF VOLUME 1

This volume does not provide detailed instructions for developing forecasts; those instructions are contained in Volume 2.

The second chapter of this volume describes the factors that most significantly impact forecasts. It examines how economic, geographic, and political factors affect the traffic volumes and characteristics of a given road or corridor. Anyone just entering the traffic forecasting field should read this chapter carefully, and those familiar with the forecasting process should review it periodically to remind themselves of the wide variety of factors that can affect traffic volumes and characteristics.

The remaining chapters in this guide briefly describe the specific steps in the forecasting process. Each of these steps should be documented as part of the forecasting process.

Chapter 3 describes the beginning of the forecasting process. It leads you through the steps necessary to determine the scope of the effort required and assists you in identifying the information available, desired, and/or required to perform the project, given available time and resources.

Chapter 4 leads you through the steps necessary to select the appropriate tool(s) for performing the forecast. It presents the strengths and weaknesses of the available forecasting techniques, as well as their basic capabilities and data requirements. Using this information, along with the data acquired as a result of the instructions in Chapter 3, you can select the analysis process that most appropriately meets your needs, both in terms of output reports and the time required to perform the analyses.

Chapter 5 introduces the forecasting process itself. More complete instructions on this process are contained in Volume 2. Also included in this chapter is a description of the reviews that are necessary to ensure that the forecast estimates are reasonable. These include self review, internal review, and sensitivity review.

Chapter 6 describes the external reviews that are necessary to ensure that the forecast estimates are reasonable. External reviews are important to reduce conflicts between the Department and other agencies and jurisdictions.

CHAPTER 2

FACTORS TO CONSIDER WHEN YOU PERFORM FORECASTS

INTRODUCTION

Transportation is not an end product. It is simply a means for accomplishing some other end. It is necessary only to allow some other action to take place. Thus, traffic levels are not independent values, but are dependent on the level of activity that produces the demand for travel.

However, because travel is important to so many activities, traffic levels are not a simple reflection of a small number of independent factors (e.g., population). The demand for travel is a complex function of a large number of factors relating to the general economic activity of a large geographic area and the total number of people available to travel. In simpler terms, traffic levels are a function of the number of people who want to travel, the cost of travel, the ease with which they can travel, and the availability of roads.

While this combination of factors is complex, our advantage when we perform traffic forecasts is that we can measure the the demand for traffic under present conditions. Then we must only forecast how traffic levels might change over time, given expected changes in population and economic activity. Thus, the forecaster must understand the current level of traffic demand on a project facility and then determine how that level of demand may change, on the basis of expected economic and population forecasts.

These changes in population and economic activity will have a variety of impacts on travel demand. Some of these changes will take place quickly (a new factory opens, traffic levels increase immediately on the road that leads to it); some will take place slowly (as the population in an urban area increases over time, traffic levels increase as those new residents make trips); and other factors will have an impact somewhere in between.

In addition, traffic levels are not constant over time. Recreational facilities in rural areas produce high traffic volumes during peak recreational seasons, but moderate to low volumes in off-peak periods. Urban office space developments create high traffic demand during weekday commute periods but little traffic during late night and weekend periods. Therefore the forecaster must be aware that different factors cause a wide variety of traffic impacts.

Not all of the factors discussed in this chapter affect each forecast. Some forecasts are quite simple and require relatively little analysis and review. However, other forecasts, particularly for larger projects, require consideration of most or all of the issues discussed in this chapter. For some projects, traffic projections play a significant role in design decisions and can be the source of political conflict. In these latter cases, more care must be given to the assumptions that are made and the analyses and reviews that are performed.

In most cases a traffic forecast (and the load estimates that result from that forecast) consists of the estimation of three separate but related quantities for each of the roads (or road sections) within the project boundaries for each of the design years. These forecast quantities are

- traffic volumes,
- traffic composition (vehicle classification), and
- vehicle weights or pavement damage factors, expressed as Equivalent Standard Axle Loads, or ESALs.

Not all forecasts require each type of data, and some place more emphasis on one type of information than on others. (See Scope of Project in Chapter 4)

In addition, each of these categories of information can be broken into several subcategories needed for a forecast. For example, traffic volumes must often be expressed in terms of hourly volumes, design hour volumes, and average annual daily traffic. Each of these means of describing traffic conditions plays an important role in a type of analysis. (For example, the design hour volume is used in determining the required capacity of a road but is not useful for designing pavement depth. Average annual daily traffic is often used to help calculate total traffic loadings for pavement depth, but by itself it is not useful for performing geometric design analyses.)

Therefore, the content and form of the forecast will vary from forecast to forecast. The requirements of each forecast will reflect the specific needs of each project. A guide to the data required for each type of forecast is shown in Table 2-1. Chapter 4 describes the steps required to estimate each of these values. This chapter provides background on the factors that you should consider when you follow those steps. It explains how each of these factors impacts traffic conditions, and why it is important to the forecast effort.

TRAFFIC VOLUMES

Traffic volumes are the most commonly required measure of highway use. As discussed above, traffic volumes are affected by a variety of factors, and the impact of these factors takes place over a variety of time frames. While it is impossible to discuss all factors that affect traffic demand in this brief chapter, the most significant factors that influence traffic volumes will be described. Among the more important categories of factors are the following:

- changes in population, or recreational, commercial and/or industrial activity along the roadway or near the roadway,
- changes in population and recreational and industrial activity in areas that produce through traffic on the roadway,
- changes in capacity or the volume to capacity ratio of alternative routes parallel to the roadway, and

TABLE 2-1

FORECAST DATA REQUIRED FOR EACH TYPE OF ANALYSIS[1]

Type of Analysis	Required Output
Corridor Analysis (urban areas)	Projected AADT's Projected design hour volumes
Corridor Analysis (rural areas)	Projected AADT's Projected design hour volumes
Design Analysis (rural and urban)	Current and projected AADT Current and projected annual truck traffic Current and projected design hour traffic (trucks and auto volumes ESALS projected for the design life of the pavement
Pavement Only Projects	Current and projected AADT Current and projected annual truck traffic ESALS projected for the design life of the pavement
New Development Review	Current and projected peak hour traffic (truck and auto volumes) ESALS projected for the design life of the pavement
3R Work	ESALS projected for the design life of the pavement Current and projected design hour traffic (trucks and auto volumes)
Project Scoping	Varies with the project
Signalization Projects	Hourly Traffic Volumes

- changes in trip making characteristics caused by external factors (e.g., the price and availability of gasoline or the availability of other modes of transportation).

Each of these categories can be split into many detailed variables. This document can not explore in depth all of the variables that affect traffic levels and travel behavior. Instead, the paragraphs below will describe how each of the above categories can affect travel. As part of that discussion, this chapter will provide basic instructions for reviewing available information and estimating the impacts the expected changes will have on future traffic volumes. These instructions are described in more detail in Chapter 4.

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[1] A definition of terms used in this table is presented in Appendix A of Volume 1 of this Guide.

Impacts of Localized Population and Employment Changes

Changes in population and/or changes in the activities that occur along a route are the most obvious causes of change in traffic levels along a road. Traffic generated by these changes often enters the traffic stream on the project roadway. Incorporating these traffic estimates in future traffic volume estimates is simply a matter of estimating the trip generation characteristics of each of the population/employment changes and adding (or subtracting) that change to the existing traffic volume.

The most common source for estimating traffic generation rates is the ITE Trip Generation handbook. While this book is not perfect (it presents averages and ranges of traffic generation rates from a variety of locations around the country, not absolute values representative of each part of Washington), it serves as a good beginning in the absence of better information. When local traffic generation rates are available (from some previous study or impact statement) these values can be used to estimate expected traffic growth as a function of existing conditions.

Traffic generation rates for specific land uses (i.e., the traffic volumes produced by local activities) tend to remain fairly constant over time. Consequently, small changes in economic activity or population can be assumed to generate proportional changes in traffic volumes. (That is, if the population increases by 3 percent, the proportion of traffic generated by population will increase by roughly 3 percent.) However, very large increases in either population or economic activity may generate traffic in excess of that suggested by existing conditions. Similarly, simultaneous changes in population and economic activity may produce volume growth greater than any growth that changes in the population or industrial activity would have produced separately. This synergy is caused by the generation of trips that had previously not occurred but are now possible because of the new land uses. (For example, the addition of a shopping mall with a restaurant near an office park might generate new lunch hour traffic from the office park.)

After the number (or change in the number) of trips generated by changes in population or economic activities has been estimated, it is necessary to allocate those trips to the project facility. If the facility is the only road that abuts the new development, all of the trips generated will use the project facility. If other roads or transportation facilities lead to the new development, then only a portion of the new trips will use the project roadway.

The percentage of the trips that use the project roadway will depend on the number of alternative facilities available to the trip makers and the relative advantage (i.e., in time or distance) those trip makers will get by using each of the alternative facilities.

Impacts of External Population and Employment Changes

Changing population and economic levels farther from a project also affect the traffic levels a project experiences. In many cases, particularly in rural areas, through traffic (i.e., traffic that is generated outside of the boundaries of the study area) may contribute more to traffic volumes crossing a project than traffic generated locally.

While rural roads are often more affected by through traffic than urban roads, the impacts of through traffic are often more important in congested urban areas, where the traffic causes heated political battles between adjacent cities, than in rural areas.

Through traffic is more difficult to estimate than local traffic because traffic levels usually cannot be adequately traced to specific changes in population and economic activity in distant areas. In urban areas, through traffic can be estimated with traditional, four-step transportation planning models. Through their trip generation, distribution, and traffic assignment phases, these models provide one method for estimating traffic flows from one section of an urban area through a selected section of links.

In rural areas, where through traffic is generated from areas much farther away (perhaps from different states), planners generally estimate through traffic by observing long-term trends on the project itself and related roadways and by looking at national and statewide traffic and economic forecasts and trends.

These trends include statewide population growth, increasing levels of car ownership in the country as a whole, changes in gasoline prices, and other population-wide changes in the way people travel.

Through trips are generally estimated without regard to locally generated traffic, and total traffic volumes are then computed by adding through trips (traditionally called "external trips") to local trips.

Alternative Routes

Traffic on a specific route may be affected by available capacity on parallel facilities. For example, if a new interstate highway is built, traffic volumes on the older highways that previously served those trips will decline. Similarly, traffic congestion on one facility will often cause vehicles to divert to parallel facilities. Thus, traffic may increase on a facility because of diversion from other routes in the area, rather than because of traffic growth in distant areas or growth attributable to land use changes surrounding the facility.

Diversion onto the facility being studied may also result from growth (population or economic) near parallel facilities or reduced capacity on those facilities (e.g., a permanent bridge closure), which may cause increased congestion on those facilities. On the other hand, this same phenomenon may reduce traffic volume on the project facility. For example, if other roads in the area are being improved and those roads will provide a faster, more direct route between points served by the study facility, the traffic levels on your facility may decline after the work on the parallel facility has been completed.

Computer models (both four-step planning models and models such as The Highway Emulator) can be used to examine the impacts of parallel facilities. In large urban areas, the four-step planning models are more likely to be used. In smaller urban areas and rural settings, the simpler Highway Emulator is usually a more appropriate choice.

External Factors

Factors external to the basic variables of economic activity and population level can also affect expected traffic volumes. These impacts were most visibly demonstrated in the decline in travel associated with the energy crises of the 1970s and the short-term reductions in travel in many parts of the state that accompanied the Mt. St. Helens eruption. During the gasoline shortages, the increased cost of gasoline and the limited supply of gas in some areas significantly reduced travel. Even more dramatic reductions in travel occurred as a result of the ash fall produced by Mt. St. Helens.

Not all external factors are as dramatic as national gasoline shortages and volcanos. Variables such as an increasing tendency for Americans to own fuel efficient vehicles but to drive those vehicles more miles each year cause a slow but steady increase in volumes on the state's highways. Changes to state and federal laws may also be reflected in increases and decreases in travel. For example, the 65 mph speed limit will likely produce a small increase in the use of the rural interstate system. An increase in both the federal and state gasoline tax may slow the per capita increase in vehicle miles of travel expected over the following few years. One major external factor is the presence of other modes of travel, particularly for freight transportation. A change in the availability of a freight rail line can have significant effects on the truck traffic expected on a parallel roadway.

While it is difficult, if not impossible, to forecast energy shortages and volcanic eruptions, it is possible to consider expected legislative changes or other state or national trends as part of the forecast process. It is also possible to consider the impact of on-going, short term events. For example, a project forecast based on current traffic in southwestern Washington immediately after the Mount St. Helens volcano might significantly underestimate traffic. By specifically considering the time required for traffic levels on the impacted roads to completely return to "normal," a good forecast should be able to provide a better estimate of total traffic for each year of the forecast.

VEHICLE CLASSIFICATION

As with general traffic volumes, the vehicle classification mix on a section of highway is a function of both the economic activity surrounding the highway and the traffic that uses that facility to travel through the study region. Unlike simple traffic volume forecasts, a forecast of vehicle classification mix must not only consider the number of vehicles being predicted but the changing configurations of those vehicles.

For example, a gravel pit may be expected to produce X tons of gravel a day. But will that gravel be carried by three-axle, single unit dump trucks, or will it be carried by half as many larger, five-axle combination vehicles? This change in vehicle configuration is important. Different types of vehicles have different performance considerations (acceleration, deceleration) and pavement loading patterns (ESALs/truck), and these factors impact the design of the roadway.

The vehicle mix over the last ten years has changed dramatically; more large combination vehicles have appeared on the road, while the number of smaller trucks has remained constant. In addition, the overall growth of truck traffic has exceeded the growth in passenger car volumes. Because trucks are a major cause of pavement deterioration and because little attention has been paid to estimating truck traffic in the past, a number of pavement sections around the country have deteriorated prematurely because the truck traffic they have been carrying has been far greater than the truck traffic forecast for those roads as part of the pavement design process.

Unfortunately, information on truck volumes, trucking trends, and the changing vehicle mix is not comparable in quantity or quality to information available on traffic volumes in general. This is particularly true of historical truck volume information, truck traffic trip generation estimates, and the relationships of truck traffic to economic development (i.e., there is no ITE Trip Generation information for the number of truck trips generated per vehicle type by specific land uses). As a result, more effort is needed on the forecaster's part to estimate the number and types of vehicles that will be generated by new economic activity.

Because truck traffic plays such an important role in determining the design of pavement depths, and to a lesser extent roadway capacity, the forecaster needs to be aware of the sensitivity of the project to the vehicle mix estimates that are forecast. For example, on a low volume rural road, a change in the percentage of trucks from 8 to 10 percent may result in the need for an additional inch of asphalt for the road. On a heavily traveled interstate, a change from 8 to 10 percent of trucks may not affect the depth of pavement at all. When the forecast will be used to evaluate signal warrants or lighting warrants, the truck traffic estimate is usually not as important as when such an estimate will be used for pavement design.

When forecasting for projects whose design is sensitive to changes in vehicle mix, the forecaster should both pay closer attention to the estimates that are used and identify to the project engineers the areas of the project that are subject to change as a result of uncertainty in the forecast. This is particularly true where existing truck traffic levels place a project facility near a "level of development" (LOD) boundary. (See the WSDOT Level of Development Plan for the subject route and Section 440.06 of the Department's Design Manual for more information on level of development boundaries.)

When a level of development boundary is crossed, a new standard for design becomes applicable. For example, for a multilane, undivided, 3-R designated highway project, if the AADT exceeds 4,000 vehicles but the percentage of trucks is less than 10 percent, the design standard for lane width is 11 feet. If the truck percentage is estimated as 10 percent, the lane width standard is 12 feet. If the forecast produces an estimate of 9.5 percent trucks, the precision of the forecast becomes important. With slightly different assumptions, the forecast might easily be 10.1 percent. The impacts of these different assumptions on lane width, bridge width, and other design factors, combined with the uncertainty of the forecasting process, make it imperative that the forecaster discuss the implications of specific assumptions and results with the requesting project engineer. These individuals should then jointly determine whether mitigating circumstances, such as recreational vehicles with trailers or potential political decisions, should be used to determine that side of the level of development boundary on which the forecast (and thus the design) should fall.

The uncertainty of changing vehicle mixes makes knowledge of existing traffic conditions all the more important. If you are able to obtain a good estimate of current truck traffic, the odds of poorly estimating future traffic characteristics are greatly reduced. This is particularly important for pavement design, which is directly affected by the number and weight of vehicles expected to use the facility. Thus, the controlling factor in a forecast of truck traffic is a good estimate of current truck traffic volumes. Other factors that you should consider when estimating truck traffic volumes are discussed below.

Impacts of Local Economic Activity

As noted above, truck traffic volumes are affected by both the economic activity surrounding the project facility and activity that occurs in areas that feed traffic through the project. For example, a large increase in activity at the Port of Seattle may have an impact on the number of trucks using I-90, as trucks bring containers to and from the port.

As with traffic volumes, local economic activity has the most obvious impact on truck usage of a specific facility. As part of the forecast effort, the forecaster should learn about the expected development along the facility and the impacts that the development is expected to create on the level of truck traffic. Questions that a forecaster should ask are as follows:

- Are new industrial/commercial facilities planned for this route?
- Are new industrial/commercial facilities planned for neighboring routes, or in urban areas through which this road passes?
- Are facility closures planned?

Answers to these questions are particularly important if the project area is industrial or has the potential to become industrial.

If the industrial base near the project facility is subject to changing levels of activity (i.e., the answer to one of the above questions is yes), the forecaster needs to determine the following:

- the types of trucks generated by that industry (cement trucks, two-axle, single-unit delivery trucks, etc.),
- the expected number of vehicle trips such a facility will generate in an average day,
- the expected number of vehicle trips generated during the peak traffic periods,
- whether the truck traffic produced at the new industrial facilities differs from that already being carried by the facility,
- whether the truck traffic movement is directional (e.g., is the facility a cement plant, where all of the trucks leave loaded, and return empty?),
- whether the project facility is subject to traffic from possible railroad line abandonment, and
- whether legal restrictions exist for the weights or types of vehicles allowed on the roads in the project.

By accounting for the truck volume changes that will be caused by these factors, the forecaster can add discrete volumes to an otherwise stable truck population, or add them to the through truck population described later in this chapter.

Alternative Routes

Having established the level of locally generated truck traffic, you must allocate these vehicles among possible routes. Depending on the nature of surrounding land uses and the availability of alternative routes, this process may be very simple or may require the use of simple computerized network modeling packages. In most cases, good judgment and an understanding of where the trucks are going and where they are coming from will provide the necessary information to determine their likely routes.

Traffic assignment models can be used to calculate the shortest paths through a network to help examine potential truck routes, but the trip generation and distribution functions of these models were not designed to deal with trucks and are of limited use for this purpose.

Try using a series of "what if" scenarios to examine the impacts of reasonable alternative truck volume assignments if truck routes are not readily apparent. The "what if" scenarios can help determine whether specific assignments will significantly impact the design characteristics of the project. If the assignments do matter, more data can be gathered (through site visits, discussions with people familiar with the area, or discussions with local industrial firms) to provide additional guidance on the final assignments.

External Factors, Through Traffic and Statewide Trends

As with traffic volumes, the level of through truck traffic is dependent on economic activity in areas outside of the project area because distant activities may cause truck traffic to traverse the study area. Growth in areas outside of the project's boundaries is almost always beyond the scope of the forecast effort, and the forecaster must therefore rely on the "standard estimates" adopted by the Department for use in estimating future levels of through truck traffic.

The "classic" estimate for through truck traffic is that the truck mix (expressed as a percentage of traffic) will not change over time. That is, the volume of each truck type will increase or decrease at the same rate as traffic volume in general. While this may be a reasonable initial assumption, it is often not very accurate, and it is not recommended for use by WSDOT forecasters.

Studies have shown that truck traffic is increasing at a greater rate than general traffic. Traffic volumes of specific types of heavy vehicles (notably the 3S2 and double bottom categories) are increasing the fastest. To improve on its base truck growth estimates, the WSDOT Transportation Data Office will begin to produce estimates of truck traffic growth for the state highway network. These "background" estimates will be based on an ongoing data collection process and will not include estimates of local changes in economic activity. To estimate total truck traffic on the project facility, you will have to add changes in truck travel due to local conditions to the estimates developed by WSDOT headquarters. Once they have been developed, the background estimates will be available through the Transportation Data Office or through the TRIPS database.

While the background default estimates on truck growth will be an initial estimate, that estimate may need to be altered for specific projects or to examine specific truck growth scenarios. For example, a forecaster might want to examine the impact of regulations that would increase the legal size and weight of trucks and the probable impact of those regulations on specific highways. To do this, the forecaster would want to increase the expected growth rate of certain configurations of trucks.

You should remember that these truck estimates do not include estimates for changes in locally generated truck traffic volumes. Finally, remember that as with locally generated truck traffic, through volumes are subject to alternative route choices. Thus the basic estimate obtained from the TDO or TRIPS must be interpreted with respect to other potential facilities (e.g., a new interstate) and expected highway system changes.

Classification Schemes

The FHWA uses 13 classes of vehicles for the majority of its reports, data submittals, and equipment specifications. Of these 13 classes, nine are truck classes and a tenth class (buses) is usually included for estimating design loads. (Table 2-2 shows the definitions of these truck classes.) The majority of the portable vehicle classification counts done by the Department use this classification scheme. The other classification scheme the Department uses splits volumes into four classes, automobiles, single unit trucks, combinations, and trains. The majority of information on seasonal changes in truck volumes is classified this way.

Whenever possible, the forecaster should provide truck volume estimates in one of these two classification schemes. (It is acceptable to aggregate the 13-classification scheme into the four-category scheme as part of the forecasting process.) In all cases, FHWA now requires that forecasts use at least two truck categories: trucks with fewer than 5 axles and trucks with 5 or more axles.

Seasonal Changes

The seasonality of truck traffic for each project should also be examined. Truck volume patterns are often different than total traffic volumes, and you need to consider these patterns. For example, is the facility used in the fall for heavy harvest loads? Is truck traffic reduced during the spring as a result of loading restrictions?

TABLE 2-2

FHWA TRUCK CLASSIFICATIONS

Passenger Vehicles	Single-Trailer Trucks
Motorcycles	4-axle or less
Passenger Cars	5-axle
2-axle/4-tire vehicles	6-axle or more
Buses	
Single Unit Trucks	**Multi-Trailer Trucks**
2-axle/6-tire	5-axle or less
3-axle	6-axle
4 -axle or more	7-axle or more

The Transportation Data Office has recently begun collecting year round truck information at a number of permanent counting sites, and this counting effort is expected to be expanded through 1992. These data will be available through TRIPS and (potentially) the Annual Traffic Report and should be used for examining the fluctuations in truck traffic that occur near the project and on roads of similar functional class and recreational nature in other parts of the state.

Knowledge of seasonality must also be used when you examine truck volumes from available traffic counts. For example, if the only count from an agricultural part of the state occurred in the early spring, an adjustment to the truck volumes measured by that count might be required to adequately account for the volume of trucks expected in the fall harvest.

Time of Day Changes

For some analyses (particularly those that use hourly traffic estimates for capacity analyses), fluctuations in truck volumes by time of day are even more important than changes in truck volumes by season. In congested areas, truck volumes (expressed as a percentage of total traffic) often decrease during the peak periods. This change is due to both to a large increase in automobile traffic associated with commuting in urban areas and vacation travel in recreational areas, and to a decrease in through truck travel that occurs because long haul truckers stop for fuel and food during congested periods to make the best use of their time.

You should consider these changes when you estimate truck percentages for design hour capacity analyses or other work that requires hourly estimates of trucks and passenger cars. Whenever possible, request and examine hourly vehicle classification counts for a project to determine the truck volumes that can be expected in the peak periods or other periods of interest.

TRUCK WEIGHTS

Truck weight estimates are used in conjunction with the heavy vehicle volumes to calculate the loadings a stretch of pavement will sustain during its design life. (The actual load estimation process is often performed by the Materials Lab, but the Materials Lab should consult with the person providing the truck forecast.) As part of the design process, estimates of truck axle weights are converted into a measure of standard units called Equivalent Standard Axle Loads, or ESALs. ESALs represent the damage a particular vehicle or set of vehicles is expected to cause to the highway. Research has shown that the damage caused by a truck increases exponentially (to the fourth power) with the weight of the axles of that vehicle. In most cases the ESAL per truck value you use in the traffic design will be the official value calculated by the Materials Lab. The Materials Lab designates ESAL estimates for both the 13 FHWA classes and the three simpler classes (singles, combinations, and trains) described previously.

The "average" estimates maintained at the Materials Lab represent vehicles weighed as part of the Department's normal weight data collection process. Thus, vehicles used to develop these numbers represent a variety of truck styles and cargoes. While they represent the state as a whole, these values are not always appropriate when large numbers of a specific truck type are present in the traffic stream. For example, a three-axle delivery van is in the same FHWA vehicle classification as a three axle-cement mixer, but it weighs considerably less. Thus a road on which cement trucks are the predominant three-axle truck type should have a different average ESAL per three-axle truck than a road that predominantly carries delivery trucks.

In addition, the percentage of trucks that operate loaded or unloaded also significantly impacts the average ESALs per truck. The most illustrative example of this is the road that leads into a cement plant. In the direction leading to the plant, the cement trucks are empty, the ESAL per truck is low, and the road shows little distress. In the direction leading away from the cement plant, the trucks are loaded, the ESAL per truck is heavy, and the road deteriorates quickly.

As a result, the design engineer who develops the load estimates (working in conjunction with the person who performs the truck volume forecast) should carefully consider the types of trucks that will use the facility and adjust the "average" ESAL estimate when such action is appropriate. The Materials Lab maintains estimates of average ESAL per unit for some types of vehicles common in the state (i.e., log trucks), and these values can be used to adjust most "average" estimates.

The forecaster and design engineer should also be aware of truck weights that are seasonal. Seasonal load restrictions may impact the weights that are carried by trucks on a road, whether or not that road has a restriction. (The road that leads to the project may have a load limit.) These factors are hard to quantify because of a lack of data on the subject, but seasonality is still a factor for the forecaster and the design engineer to consider.

CHAPTER 3

BEGINNING THE FORECASTING PROCESS

This chapter describes the initial steps in the forecasting process, which are illustrated in Figure 3-1. These steps include the following:

- becoming familiar with the project area,
- understanding the scope, level of effort, and time frame of the project, and
- determining the end results that are required from a specific forecast.

Upon completion of these steps, you will be ready to select the appropriate forecasting technique(s) for the project. Their selection is covered in Chapter 4.

BECOME FAMILIAR WITH THE PROJECT

While this portion of forecasting may seem obvious, the importance of familiarity with the project and the geographic area surrounding it cannot be understated. Because forecasting is an art as much as a science, you need to understand all of the factors that may influence how traffic along a road may change. This knowledge is necessary to help you develop forecasts that are realistic and to assist you in developing reasonable assumptions for the forecasting process. While understanding the project area does not guarantee a good forecast, it does provide you with a greater sense of the potential changes to be considered in the forecast.

Specific areas that you should investigate as part of the process of becoming familiar with a project area are described below and are provided as a checklist in the appendices. The relationship of these changes to traffic has been briefly described in Chapter 2. Steps in exploring important areas are the following:

- Determine what the proposed project is supposed to accomplish.
- Obtain a map of the general area around the project and become familiar with the roads that intersect or are parallel to the roads in the project.

- Become familiar with existing roadway conditions on the project facility and the facilities identified above.
- Investigate the current plans for those facilities.
- Determine the amount of development in the general area and in geographic areas that feed traffic to the project facility.
- Determine the jurisdictions that are involved in the project or are located in areas that generate traffic using the project facility.
- Investigate predicted growth and development in the geographic areas identified above.

These items are discussed in the sections below.

The Road System

Becoming familiar with the local road system is the first requirement of forecasting. You must understand where potential traffic will come from, where congestion must be alleviated, how congestion could be reduced, and how the project facility fits into the surrounding area.

Maps are the simplest means of investigating the surrounding road system. Many maps are available within the Transportation Data Office, the various District offices, and the Headquarter's State Aid Office. In the event that the appropriate maps are not available from these sources, contact the local agencies and/or counties that will be affected by the project. In addition to maps, the Department maintains a video log of the entire state highway system. The video log provides a great deal of visual information about the existing state highway system, and to a lesser extent, the land use immediately adjacent to the highway system. While it is not a substitute for maps, the video log is an excellent resource for becoming acquainted with a highway.

Existing Roadway Conditions

The next step is to determine the existing volumes and level of service on both the project facility and the adjacent road systems. Existing traffic volume information is a

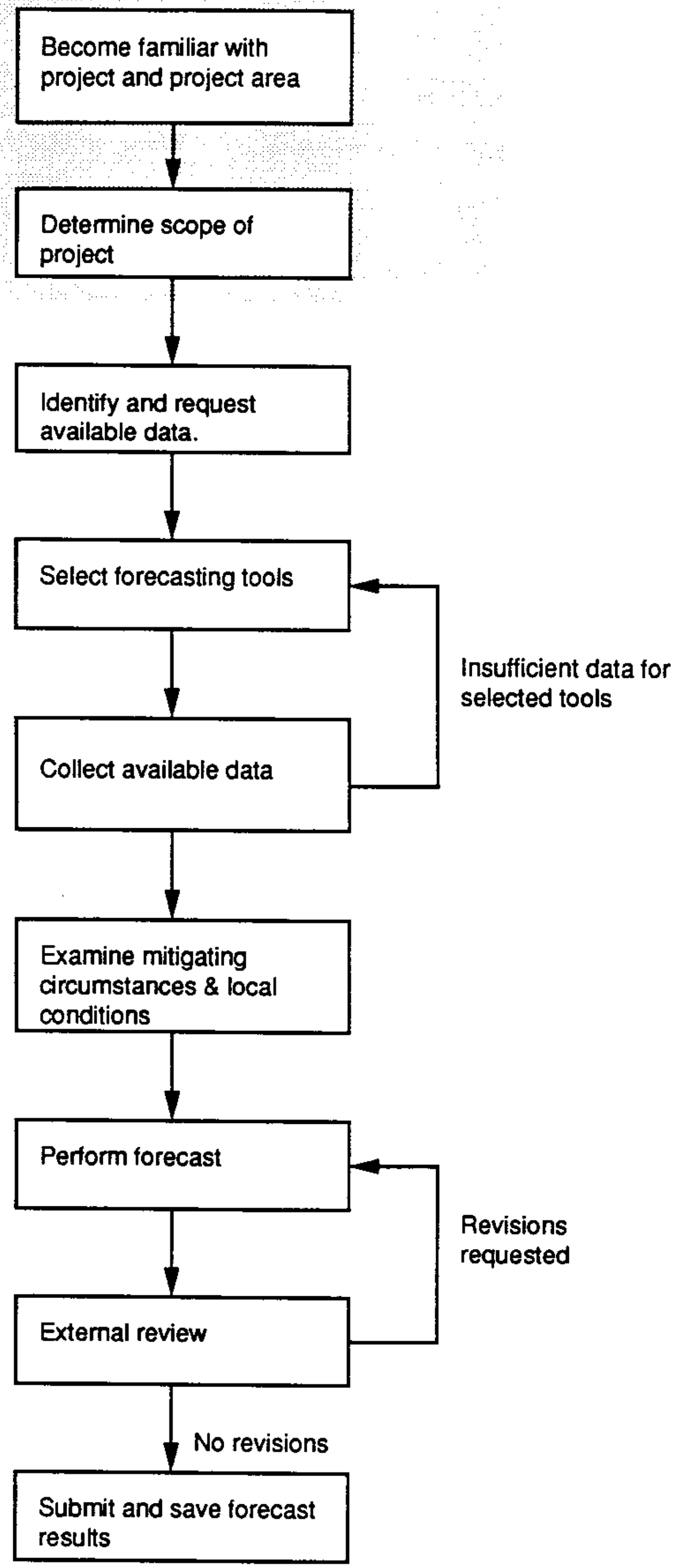

Figure 3-1. Forecasting Process

vital start to the forecasting process. A simple review of existing level of service (a verbal description by a professional with firsthand knowledge of the facility is sufficient) helps determine whether capacity constraints will impact the forecast design hour flows.

This information can be obtained by

- collecting data on the existing traffic flows,
- reviewing previous traffic studies performed by either the Department, MPO, or local agencies, or
- discussing level of service with Departmental and local jurisdiction staff familiar with traffic flow in the area.

All of these methods produce valuable information. A traffic study provides the most reliable data, but it costs the most and requires sufficient lead time to perform. Existing studies provide data of almost equal quality, but they may not exist for the specific project location required or may not provide information on the specific data items needed for this project. Personal opinion is an excellent data source for understanding the subjective attitude of some people towards the project (do they feel existing traffic is a problem, how will they react to the proposed project?), but is often not based on objective facts and can be misleading to a technically correct examination. (However, note that a good design must consider not only the measured and estimated numbers but the public's subjective perception of that project.)

One of the major areas of concern is the Level-of-Development (LOD) category for the roads involved in the project. You should determine the existing LOD and the expected LOD for the project at this stage of the forecast. As part of making this determination, you should contact the project engineer and include their input in the LOD determination.

Planned Area Enhancements

You should be aware of other plans or projects that might impact the study area. To do this, determine

- what jurisdiction(s) will be impacted by the proposed project,
- what roadway plans (for major maintenance or roadway expansion) the Department has made or is considering for that area (either for the road being studied or for any roads that might carry traffic to/from the road being studied or are parallel to the route being studied), and
- what roadway improvements other jurisdictions and agencies have planned or are considering for the project area (or immediately surrounding areas) that might produce changes to the existing traffic stream.

Existing plans for road expansion will give you a good indication of the size of the growth expected in the region and the importance of that road in the travel patterns of the area. Expanded roadways should also be accounted for in any modeling work that is done as part of the forecast, or else predicted congestion levels will be inaccurate.

At this point in the forecasting effort, you do not need to actually collect all of the data involved in these studies, although it is a good idea to order plans and documents that are not readily available through the Department. Instead, the goal of the effort is to become aware of other planned projects that will have an impact on your forecast.

Projected Economic Growth

After you have identified the jurisdictions that contain traffic generators that may impact the proposed facility, investigate whether those jurisdictions (or the state) have projections for economic activity, population estimates, or travel forecasts for those areas. These predictions will be used to estimate the extent of traffic growth on the project and should have been used as part of any planned improvements in the region that you examined above.

Projected economic growth should be outlined in many of the local jurisdiction's development plan documents. Datasets required for four-step transportation modeling (which are defined in Chapter 4) are usually available through the local jurisdictions governing growth in the region, although many of these datasets are already available at the Department, and other economic forecasts can be obtained from urban metropolitan planning organizations (MPOs) and other local agencies.

As with the road improvement plans, the primary intent of the economic data gathering activity at this stage of the forecast is to provide a feel for growth in the region. It is most important at this time that you become aware of the level of change occurring in the project area. At a minimum, you should be aware of whether the study area is growing, declining, or remaining constant. If it is changing, are those changes taking place quickly? Is there potential for great change, even if that change is not currently taking place (is there a factory that might close or speculation that a new factory might be built)? This type of information is essential to the development of the reasonable input assumptions required by the forecasting process.

UNDERSTAND THE SCOPE, LEVEL OF EFFORT, AND TIME FRAME

You create a successful forecast by producing reasonable numbers appropriate for the job assigned within the budget and time frame available. To do this, you must know the traffic estimates that are required for a project and the effort that is necessary to produce them. Thus, you must fit the analysis performed to the scope of the project and the level of effort available for that forecast.

In this section, the various levels of forecasting projects are defined and examined, and the basic traffic requirements needed for each level of forecasting effort are described. Most forecasting projects fit into one of these levels of effort, but some will be hard to categorize. For projects that do not fit into any of the categories, review the needs of the two categories that most closely resemble the scope of the project, and develop a "specialized" process that fits your specific request.

Departmental forecasting needs can be defined by seven basic levels of forecasting effort. These levels are as follows:

- Project Scoping,
- Corridor Analyses,
- Design Analysis,
- Rehabilitation, Reconstruction and Restoration (3R),
- Signal Jobs,
- Pavement Only (i.e., a simple overlay project), and
- New Development Analysis and Review.

Note that 3R, Signal and Pavement jobs are really subsets of the more generic Design Analysis effort. In addition, Route Development Plans fall under the category of Corridor analyses. Table 3-1 summarizes these types of analyses, the type of traffic data necessary to perform them, the types of issues you must examine, and the tools you will normally use. Each of the analysis categories is detailed below.

Project Scoping

Project scoping analyses are performed when a potential project is first identified by a District, the priority array, or some other process. They are intended to provide "first cut" estimates of traffic for the project so that the true scope of the prospective effort can be determined. The results of the project scoping include a definition of the work to be performed when the project is designed and the initial estimated cost of the project. These estimates are used in the prioritization and budget processes. Traffic estimates used in the scoping are later revised as part of the design process (see Design Analysis, Signal Jobs, and others).

For example, a project may be initially identified because the highway's pavement surface is deteriorating. A traffic forecast is necessary to determine if a simple pavement overlay is appropriate for that location, or if traffic levels will increase to a point at which congestion will become a factor before the overlay design life has been exceeded. If congestion will be a problem, the project scope may be expanded to include pavement

TABLE 3-1

TYPES OF ANALYSES AND THEIR REQUIREMENTS

Type of Analysis	Required Output	Areas of Interest	Tools to Use
Project Scoping	Projected AADTs Projected peak hour volumes ESALs projected for the design life of the project.	Capacity constraints Impacts of parrallel facilities and predicted growth Impacts of new development Level of development designation	QRS II CINCH Highway Emulator Spreadsheet Calculator
Corridor Analysis (rural areas)	Projected AADT's Projected peak hour volumes	Capacity constraints Impacts of parallel facilities and predicted growth	QRS II Spreadsheet calculator Higway Emulator
Corridor Analysis (urban areas)	Projected AADT's Projected peak hour volumes	Capacity constraints Impacts of parallel facilities and predicted growth Impacts of new development Level of development designation	QRS II CINCH Highway Emulator TMODEL2 Traffic modeling software (TRANSYT-7, PASSER)
Design Analysis (rural and urban)	Current and projected AADT Current and projected annual truck traffic Current and projected design hour traffic (trucks and auto volumes ESALS projected for the design life of the pavement	Capacity constraints Impacts of parallel facilities Impacts of new development Level of development designation Impacts of alternative truck traffic predictions on pavement depth Shape of the growth curve	QRS II CINCH Highway Emulator Spreadsheet Calculator Traffic Modeling software (TRANSYT-7)

TABLE 3-1

TYPES OF ANALYSES AND THEIR REQUIREMENTS (Continued)

Type of Analysis	Required Output	Areas of Interest	Tools to Use
3R Work	ESALS projected for the design life of the pavement Current and projected peak hour traffic (trucks and auto volumes	Capacity constraints Impacts of parrallel facilities and predicted growth Impacts of new development Level of development designation	
Pavement Only Projects	Current and projected AADT Current and projected annual truck traffic ESALS projected for the design life of the pavement	Level of development designation Impacts of alternative truck traffic predictions on pavement depth	Spreadsheet Calculator
Signalization Projects	Hourly Traffic Volumes	Impacts of new development	CINCH Highway Emulator Traffic Models (TRANSYT-7)
New Development Review	Current and projected peak hour traffic (trucks and auto volumes ESALS projected for the design life of the pavement	Capacity constraints Impacts of new development Level of development designation	

widening, signals, or other capacity enhancements to be added at the same time the pavement surface is repaired.

Traffic forecasts for project scoping purposes are usually done on a short turn-around basis. These forecasts do not include sophisticated modeling, but should include a thorough review of anticipated growth in the region and anticipated changes in the transportation infra-structure in the surrounding area. Peak and design hour volume estimates are based on existing traffic and simplistic projections of traffic volumes.

Techniques commonly used in the scoping process are quick response tools. These include trend analysis of historic data, review of previously performed forecasts for the facility or region, and simplified highway sketch planning models.

Corridor Analyses

A corridor analysis is a planning effort designed to examine the long-term growth potential of a corridor or group of highways. It is intended to give the Department a better understanding of the growth potential in the corridor being examined and to show how that growth will, or can, be distributed between alternative facilities. Finally, it is intended to provide a basic plan for route development within the plan's boundaries, which local jurisdictions and private developers placing new facilities can use as guidance. This same process should be used by WSDOT personnel involved Route Development Plans, and regional transportation plans if the state is given responsibility for those efforts.

Corridor plans can be done for either urban or rural areas. They usually require the following actions:

- at least a minimal amount of network modeling (large amounts in many urban cases),
- the collection of, population and employment data and forecasts for the surrounding area,

- the review and input of regional agencies (cities, counties, and regional governments), and
- specific attention to the plans that have been made for the future construction of new facilities and expansion of existing roads in the study area.

Corridor analyses cannot be done in a short time frame. They often require a considerable time-lag to allow for collection of the appropriate data, calibration of the models, review of alternative scenarios, and discussion of preliminary and final results with affected jurisdictions.

Tools used for corridor analyses are usually macroscopic, four-step transportation planning models (TModel 2, EMME II, QRS II). In some cases, microscopic analyses (usually signal timing plans) are also examined as part of corridor analyses.

<u>Design Analysis</u>

The design analysis provides traffic forecasts for construction or pre-construction activities. This level of work includes all major highway construction projects, particularly those in urban areas. Any projects that require environmental impact statements, include HOV lanes, require air or noise impact assessments, or include wetlands fall under this category.

This category also differs significantly from the first two categories in that the design analysis provides traffic information directly to a design, rather than as a planning function. As a result, the traffic outputs from the design analysis are more detailed than those for a corridor analysis or project scoping analysis and need to be done with more care and consideration.

Ideally, the amount of time between notice being given to the date for delivering the forecast estimates is several months for a design analysis. This time allows for the collection of a strong base of current traffic data to be collected, if such information is not already on file. However, in some cases the required turn-around is several days. These deadlines can only be met if the vast majority of information to be used in the forecast has already been collected and is readily available.

In most cases, the size of the project and the time frame of the traffic request determine the types of analyses performed as part of the design analysis. For large urban areas, a complete design analysis includes the use of a four-step transportation planning model, and the outputs from that model are used in more detailed applications, such as signal timing software or the pavement loading calculation spreadsheet software described in the appendices of Volume 2 if this guide. For smaller urban areas and rural applications, four-step planning models (or the data for these models) may not be available or applicable, but the same type of "network level" examination of the impact of alternative routes and roads is a necessary part of the forecasting process.

Rehabilitation, Reconstruction and Restoration (3R)

This level of forecast information is similar to the design analysis above, but it contains less detail and must often be performed with less rigor because of a lack of funds or a short time-frame for completing the forecast. A 3R project can be either urban or rural. It normally involves the repair of existing facilities, particularly where those repairs and/or new facilities have no significant impact on parallel or perpendicular facilities.

The data required for a 3R project include both general volume and truck traffic. Volume data are required in both hourly format and as AADT estimates. These values are used in a variety of capacity, safety and geometric analyses. Truck volumes are important from the pavement design standpoint and within the context of roadway capacity where signals or hilly terrain are involved.

Where adequate time and budget exist, a simplified four-step model is a good approach for 3R work, particularly in urban and suburban areas. In rural areas, it is often more productive to perform a sensitivity type analysis. (For example, if I assume 3 percent truck growth, how many inches of pavement do I need? What if I assume 4 percent truck growth?) Sensitivity of the pavement depth and/or roadway capacity to estimated truck volumes is within the jurisdiction of the design engineers, but as a forecaster, you may still use these same techniques and calculations to explore the impacts of alternative growth scenarios as part of the forecasting process.

Staff working on 3R projects need to be aware of Level of Development designations and how the forecast results affect the design standards of the facility designated under the Level of Development guidelines. When a forecast for a 3R project indicates that a road is going to change LOD categories, you should reexamine the assumptions of the forecast, discuss those assumptions with the involved Departmental and local jurisdiction personnel, and make sure all persons understand and agree on (or have at least had a fair say in) the assumptions used in that forecast. Other areas of importance are the need for additional roadway capacity, new signals, or geometric changes.

Signal Jobs

Signal jobs are forecast efforts for which the primary emphasis is either providing new or improved signal timing plans, determining whether or when the warrants for a signal have been (or will be) met at a particular intersection, or as part of determining roadway geometric configuration changes that can improve capacity problems. The forecasting effort in this case is directed primarily at predicting hourly traffic volumes to see how they compare with the Department's warrants and existing or planned street capacity. (Signal work also tends to be directed towards current conditions more than forecast conditions, or forecast conditions in the near future.)

Truck volumes are usually only important when enough trucks are present to affect the capacity of the intersection. This occurs when a high percentage of the traffic stream are trucks or when trucks (especially large trucks) are liable to be performing turning movements across traffic already at level of service C or worse.

When you perform a signal warrant forecast, it is important that you examine not just the general change in traffic volumes but how that change will be distributed across the hours of a day. Does the peak hour spread in future years? Does a new traffic generator change or impact the peak hour? Does the presence of trucks at a particular hour create the need for additional green time in the study intersections?

Pavement Only

Pavement only forecasts are for smaller, rural roads for which roadway capacity is not a problem and likely land use changes are insignificant to the roadway design. In other words, these are roads for which the probability of observing large changes in traffic volumes is low; the need to add additional lanes, climbing lanes, or traffic control devices is small; and the overwhelming majority of projects involve the provision of an asphalt overlay. This overlay requires an estimate of traffic loadings before its depth can be estimated.

The most important element of these forecasts are the estimates of trucks. These estimates are primarily needed for daily (or annual) totals. Particular attention must be paid to the type (and weight) of the predicted truck volumes. That is, are the trucks small delivery vans or conventional five-axle, 18 wheel tractor semi-trailers (called 3S2's in traffic counting parlance)?.

Tools used in this last scenario are almost always straight line estimations based on historical information, and statewide growth rates. The spreadsheet calculator described in Appendix A is designed to improve this aspect of forecasting.

New Development Analysis and Review

This level of forecast is used when a forecast of traffic is provided for a new development. The same procedures may be used to review the traffic submittals consultants make on behalf of developers. In most cases, the development of traffic impact estimates requires several months, but reviews of previously submitted developer impacts can often be done in a matter of days.

The data most commonly required for these analyses are hourly and daily volumes and estimates of truck traffic generated by new facilities. The intent of these estimates are to determine whether the added traffic will degrade traffic operation on the affected streets, or whether newly generated truck traffic will significantly decrease pavement life. (The pavement life analyses are less common, only being important when the development being reviewed generates a significant volume of trucks.)

Techniques and tools for this type of analysis rely heavily upon the guidelines developed jointly by FHWA and the ITE. You can obtain trip generation rates from a number of sources (most often the ITE Trip Generation notebook), and those trips are then distributed over the local street system. In most urban cases, a model such as The Highway Emulator is appropriate for this type of analysis. For small urban and rural developments, you can often carry out the trip assignment process manually by proportionately dividing the trips between the few potential travel routes.

Actually calculating the impact of the development may include more than the simple estimation of future traffic. In particular, the development analysis may require the use of one of the intersection analysis computer programs (HCM, TRANSYT-7F) or other capacity related computations.

For reviewing developer supplied analyses, these same tools and procedures are useful. Compare the submitted data against the "norms" found in the ITE notebook and against any data available within the Department which describes the actual impacts of similar developments. Also compare these norms against the specific site. (Is there something unusual about the site that will make it generate larger or smaller traffic levels than the norm?) Review any developer provided model output for "reasonability" and common sense.

On area of concern with development impact reviews is how much of the development's traffic is already included in the "background" growth already expected for a site. There is no simple answer for this question. Whenever possible, site specific traffic should be separated from other sources of traffic so that these impacts can be viewed both separately and as a whole.

Further information on the questions that should be answered as part of the review process for all forecasts (whether developer supplied or Department performed) can be found in Volume 2 of this guide.

DETERMINE THE FORECAST REQUIREMENTS

Determining the information required for any given project is usually a simple matter of responding to the letter requesting assistance in performing a forecast. In addition to the information requested in such a letter, you should also be aware of the engineer's need for different types of information when performing different types of work. Table 3-2 briefly outlines the data required to perform a variety of common planning and design functions.

It is possible that the engineer/planners who make the request for traffic information may need more (or less) information than they have asked for. As part of familiarizing yourself with the forecast to be made, it may become apparent that the engineer may need more (or less) data than s/he requested. It is important that you structure your forecasting efforts to supply the information needed, rather than just the information requested. It is often helpful to schedule a meeting with the project designer to discuss forecasting procedures and data requirements, particularly if the apparent needs are different from the original request.

In addition, you may need to provide some explanation along with the traffic estimate that you supply. Supplying additional information is not limited to providing AADTs with a request for design hour traffic because the engineer forgot to request them. It is more important that you explain the sensitivity of the estimates you are providing. For example, if you are providing estimates of AADT and truck percentage, and those estimates almost exceed an LOD boundary, you must tell the engineer that with a slightly higher estimate of traffic (or truck) growth, this facility will warrant a higher LOD rating. The engineer/planner receiving this information can then include that additional information in his/her project design, and build the road appropriately.

TABLE 3-2

DATA REQUIRED TO PERFORM COMMON WSDOT DESIGN AND PLANNING FUNCTIONS[2]

Function	Data Required
Bridge Design	AADT Average Daily Truck Traffic
Long Range Planning	AADTs Peak Period Volumes or K and D factors
Noise Analysis	Peak Hour Volume Average Daily Volume of Heavy Trucks in the Traffic Stream Number of Heavy Trucks Over 10,000 pounds Vehicle Speeds
Project Level Forecasts	AADT Peak Hour Volumes K D T Design Hour Volume Directional Design Hour Volumes Volumes by Vehicle Classification
Resurfacing	Number of Vehicles by Vehicle Classification For Each Year of the Design Period. Damage Factor (ESAL) by Vehicle Classification
Signal Warrants	Hourly Traffic Volumes
System Level Bridge Design	AADT Average Daily Truck Traffic

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2 A definition of terms used in this table is presented in Appendix A of Volume 1 of this Guide.

CHAPTER 4

SELECTING FORECASTING TECHNIQUES

INTRODUCTION

This chapter describes the steps you should follow to select the appropriate tools for developing estimates that meet the needs determined in Chapter 3. Figure 4-1 illustrates the steps in the forecasting process covered in this chapter. This guide describes a four-phase process:

- identify and request the data available for the forecast,
- make a preliminary selection of the forecasting technique to be used,
- collect and review the input information, and
- revise the selection of forecasting technique(s) as necessary.

These steps are explained in detail later in this chapter. Some of these steps are inter-related, and as a result, this process is often more of an iterative procedure than a sequential one. For example, the preliminary review of the available data, along with the project scope and time-frame from the previous chapter, may indicate that a particular model is appropriate for a specific job. However, under closer examination, the data may prove to be unreliable and thus may be insufficient to run the model selected. In addition, the time frame and budget for the project may prevent additional data collection, and as a result, you may have to select an alternative forecasting process to match the available information.

Often, more than one forecasting technique is used as part of the forecast effort, and you have the opportunity to examine two "independent" estimates of predicted traffic. You are able to test the impacts of different types of model assumptions. (For example, one model may be sensitive to population growth but may include a poor traffic assignment technique. Another model may have an excellent traffic assignment component, but may be weak at estimating changes in trip making resulting from

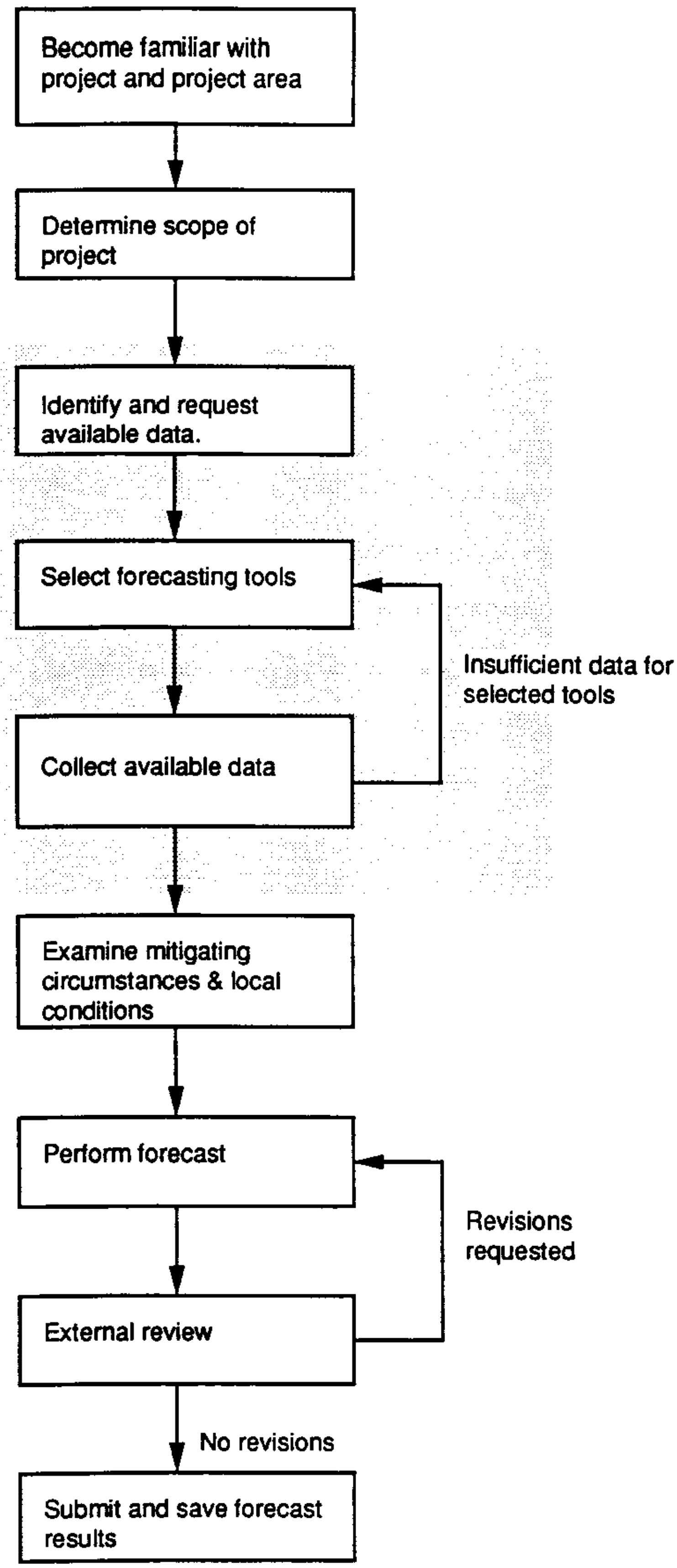

Figure 4-1. Forecasting Process

population growth.) Often, by using multiple techniques, you can avoid the weaknesses inherent in any one model or technique and thus gain a better understanding of the potential for traffic growth on a road. Armed with this knowledge, you can more easily produce a more realistic estimate of future traffic levels.

A brief description of five of the microcomputer models available for performing traffic forecasting is included in the appendices to Volume 2 of this guide. In addition, the Volume 2 appendices contain a description and user instructions for six Lotus 1-2-3 spreadsheets designed to provide easier methods for performing simple trend line and compound growth analyses.

IDENTIFY AND REQUEST THE AVAILABLE DATA

The data available for performing the forecast are the most important components in the process of selecting a forecasting technique. Table 4-1 provides a summary of some of the major types of data and their sources. Every forecasting technique requires a minimum level of data to produce reasonable results. The more complete and accurate the information you use as input to the forecasting process, the better your chance will be for accurately predicting future volumes and vehicle mix. Essentially, all forecasting techniques require the following information:

- an estimate of current (or base year) traffic,
- an estimate of current socio-economic factors (e.g., land use), and
- an estimate of future growth or change.

The specific format of these estimates varies according to the size of the project, the forecasting technique to be used, and the availability of data. These three subjects are described in more detail below.

Current Traffic Estimates

All forecast techniques require good estimates of current traffic levels. Trying to predict the traffic that will use a facility without understanding the traffic that

TABLE 4-1

DATA AVAILABLE FOR USE IN FORECASTING*

Type of Data	Location(s)	Use For Data
Short Duration Traffic Volume Counts	TRIPS database Transportation Data Office Annual Traffic Report New data collection	Estimate current traffic volumes Review historical trends
Permanent Traffic Recorders	TRIPS database Annual Traffic Report	Examine seasonal changes Review historical trends
Vehicle Classification Counts	TRIPS database Transportation Data Office Annual Traffic Report New data collection	Estimate current traffic volumes Review historical trends
Truck Weight Surveys	Transportation Data Office	Examine pavement loading aspects of trucks using the project facilities.
Origin / Destination Surveys	Transportation Data Office MPOs New Data Collection	Input to model calibration process Examine impact of new roads on specific movements made by target areas of population and industry.
Turning Movement Counts	TRIPS database Transportation Data Office	Intersection analysis
Population Estimates	MPOs WSDOT Planning Office Transportation Data Office Census Bureau Local counties and cities OFM	Input to planning models Estimates of predicted growth and growth rates Estimating trip generation
Employment Estimates	MPOs WSDOT Planning Office Local counties and cities Employment Security Labor and Industries	Input to planning models Estimates of predicted growth and growth rates Estimating trip generation
Industrial / Agricultural Activity Estimates	County Offices Reebie Ass. Trans. Consultants Woods & Poole Economics, Inc. WSU (Casavant)	Input to planning models Estimates of predicted growth and growth rates Estimating trip generation
Transit / HOV Information	MPOs Local Transit authorities Transportation Planning Office	Estimating mode split Examining the impact of HOV incentives
Statewide Growth Esitmates	TRIPS database Transportation Data Office OFM	Background (through) traffic growth estimates for rural roads

* The terms used in this table are defined in Appendix A of Volume 1 of this report.

currently used that facility is exceptionally difficult. Therefore, every forecast should start with an accurate measurement of current traffic on the project's facilities.

All traffic counts taken since 1985 (or within the last ten years, whichever is less) on any stretch of state highway are listed on the TRIPS traffic database. Examine the traffic file of this database to determine what count information has been previously collected and where that information is located. In particular, look for

- the most recent traffic count,
- any available vehicle classification counts and their dates,
- the availability of manual turning movement counts if one or more intersections are included within the project boundaries,
- the extent of the history of counts at that location or immediately up or downstream of the project, and
- the location of PTRs (permanent traffic recorders) on that same highway or on nearby roads.

Also check whether truck weight measurements have been made near the project on the state highway being examined. If hourly count information is available (and needed) but not contained within TRIPS, order the appropriate data from the Transportation Data Office.

Whenever possible, if traffic counts have not been made within the project boundaries in the past year, new counts should be requested for each forecast to be performed. At no time should a traffic forecast be based solely on traffic data over three years old, although data older than three years may be used within the forecasting process. (In other words, current count information is required as the basis for forecasting. If funds or timing prevent the collection of that information, data up to three years old can serve as the basis for current year estimates. However, the use of older data degrades the reliability of the forecast estimates. This is particularly true in high growth areas. Data older than three years is not appropriate as the basis for performing design analyses.) Request new traffic counts through either the Transportation Data Office in headquarters or through each District's traffic counting section (some Districts perform their own traffic counts, others use headquarters personnel).

If trucks play an important part in the traffic analysis you are performing (e.g., the project includes laying new pavement), at least one 24- or 48-hour vehicle classification count should have been taken within the last 3 years on the road under study. (The 48-hour count is preferred.) That count must be sufficiently close to the project area that traffic mix does not significantly change between the count location and the project. (In rural areas where interchanges and truck traffic generators are widely spaced, this distance might be quite large; in industrial areas, it might only be to the next major freeway interchange.) As with volume data, a new count should be requested if one does not already exist.

These requests for data should be made as soon as a potential project is identified to allow the orderly scheduling of that count. Waiting until work on the project begins to request additional traffic counts may prevent those counts from occurring in time for them to be used in forecasting process.

Traffic count information can also be obtained from involved jurisdictions. This is especially true in urban areas. Traffic information is often needed for roads crossing state highways, in addition to volumes on the state routes themselves. When using data from local jurisdictions, be aware of the equipment and techniques used to provide those estimates, as the quality of the traffic data varies greatly between jurisdictions.

Obtain Current Non-Traffic Volume Information

In addition to the traffic count data described above, other data must be collected to define current conditions within the project area. Each analysis technique requires a slightly different mix of input data, but for the most part, these non-traffic data relate to population, employment and land use. The types of information that are normally required as inputs for each type of forecasting technique are shown in Table 4-2.

TABLE 4-2

INPUT DATA NEEDED FOR FORECAST TECHNIQUES

Forecast Technique	Population/Employment Data	Traffic Estimates	Other Data
QRS II	Base year & forecast year estimates of average income or auto ownership, retail and non-retail employment and dwelling units by zone	None, except for calibration and comparison against base year estimates.	Map of the study area and/or coordinates of nodes in the transportation system. Minimum travel times between zones. Percent travel on arterials within zones.
SPF	Production and Attraction estimates by zone Population of urban area.	None, except for calibration and comparison against base year estimates.	Endpoint coordinates of project being analyzed.
MicroTRIPS	Base year & forecast year estimates of pop. and emp. by zone	None, except for calibration and comparison against base year estimates.	Highway network file or highway description (distances, number of lanes, etc.)
TModel2	Base year & forecast year estimates of pop. and emp. by zone	None, except for calibration and comparison against base year estimates.	Highway network file or highway description (distances, number of lanes, etc.)
EMME II	Base year & forecast year estimates by zone	None, except for calibration and comparison against base year estimates.	Highway network file or highway description (distances, number of lanes, etc.)
UTPS	Base year & forecast year estimates by zone	None, except for calibration and comparison against base year estimates.	Highway network file or highway description (distances, number of lanes, etc.) Trip generation rate equations Mode split model.
Spreadsheet Calculator	None, except for general consideration	Base year AADT Estimates Base year truck volumes by vehicle class	Estimated growth rate Type of growth expected (straight line, compound, etc.) Truck volumes
CINCH	None, except for general consideration	Base year hourly volumes Base year turning movements Number of Buses Percentage of heavy vehicles	Pedestrian Movements Signal Timing Plans Parking Movements Geometric Data
Highway Emulator	Number of Households By Income Range By Zone Rtail and Non-retail Employment By Zone	Base year hourly volumes Cordon line volumes	Link Distances and Speeds Hourly Capacity Any Additional Impedances

TABLE 4-3
QUESTIONS TO BE ANSWERED AS PART OF THE DATA COLLECTION PROCESS

GENERAL CONSIDERATIONS

(To be asked of all projects.)

Are there significant changes to the road system planned in the area of the project? For example, are there new roads planned in the surrounding area? Is an existing road going to be closed?

Are there any "special circumstances" that you want to take into account during this forecast. For example, a doubling of the price of gasoline, or a new set of truck size and weight regulations?

PAVEMENT CONSIDERATIONS

(To be asked when new pavement will be placed on an existing road.)

Does the Pavement Management System show average, slow or fast deterioration of the previously laid pavement?

Are there railroad lines in the area whose abandonment might impact the level of truck traffic on the study facilities? If so, are the rail lines branch lines or trunk lines? How likely are those rail lines to be abandoned?

Are there new industrial or other facilities being built along or near the right-of-way of this road (including outside the project limits)? If so, how big are those facilities, and when will they be built?

Are there new industrial or other facilities being built in geographic areas served by this road or connected roads? If so, how big are those facilities, and when will they be built? What are the road connections to the project highway?

CAPACITY DESIGN CONSIDERATIONS

(To be asked when future conditions may result in traffic congestion.)

Is the existing road currently suffering congestion problems at some point during the day? If so, when, and at what level of service is it operating?

Is the traffic on the facility subject to large changes in volume as a result of seasonal fluctuations? (e.g., does the road provide access to a recreational area?)

Are there new industrial or other facilities or population centers being built along or near the right-of-way of this road (including outside the project limits)? If so, how big are those facilities, and when will they be built? Are these facilities likely to add truck traffic of a particular vehicle classification? Will this traffic occur at specific times of the day?

Are there new industrial or other facilities or population centers being built in geographic areas served by this road or connecting roads? If so, how big are those facilities, and when will they be built? Are these facilities likely to add truck traffic of a particular kind to the project? Will this traffic peak at specific times of the day?

OTHER CONSIDERATIONS

(To be asked to help determine the scope of the forecasting project.)

Does the project require an EIS?

Does the project require air or noise studies?

Has economic and/or traffic volume growth in the project area been increasing or decreasing over the last five years? Is the study area nearing maturity in terms of growth and available land?

For example, sophisticated computerized models require land use and population forecasts within specific geographic boundaries and reasonably complete descriptions of the surrounding road network (link lengths, number of lanes, speed limits, etc.) as input. These data can sometimes be obtained, already coded for use by a specific model, from the following sources:

- the MPO for an urban area,
- the WSDOT headquarters Transportation Planning Office,
- the WSDOT Transportation Data Office,
- a county transportation office, or
- the District office in charge of traffic forecasts.

More likely, you will obtain these data in some format other than what your forecasting technique requires, (i.e., a format for a different computer model or paper forms) and you must convert them into the desired format.

The non-traffic information you collect must describe the current condition of factors that impact traffic generation and distribution. Some of this information, such as population estimates, may be used directly in a computerized model (to generate person trips). Other pieces of information simply serve as baselines against which future growth can be compared (e.g., a factory is not functioning at this time, but the local planners believe that it will re-open in two years). Table 4-3 provides a list of questions to be answered as part of the data collection process.

In addition, for larger projects you may have to perform one or more special studies to collect a variety of types of data that will improve the validity of the forecast. For example, you may have to perform an origin/destination study to determine the travel patterns within a study area. This information can be used to determine the impact a new development may have on a road 20 miles away. (The study may be designed to determine how many people from area X travel on a particular road.) Table 4-4 lists

TABLE 4-4

STUDIES FOR COLLECTING FORECASTING INFORMATION

Origin/destination studies
MPO small area studies
Vehicle speed studies
Pedestrian studies
Special volume count studies (turning movement counts, cordon line counts, etc.)
Traffic delay studies
Vehicle classification studies
Truck weight studies
License plate study of on-ramp to exit ramp flows
Study of gasoline sales in a region
Travel time studies

other studies that might provide useful input to the forecasting project and t he types of information gained from those studies. These studies can be costly, and their cost often precludes their use for most forecast efforts.

These data do not all have to available at the beginning of the project, but most of them must be available by the time the forecasting effort begins in earnest.

Future Growth Estimates

The third crucial data input to a forecast is some measure of the future. This estimate of the "future" can take many forms. It can be predicted levels of population and employment, or it can be the expectation that growth will continue in the same manner as it has in the past. It is also important to estimate how the envisioned future will happen. For example, will the anticipated changes occur constantly over time? Will the changes occur slowly at first and then accelerate? Will the changes occur rapidly in the beginning and then slow down?

As with the data required for input to the forecasting process, the estimates needed for predicting future year traffic vary, depending on the forecasting technique. You should have a good idea about the data available as a result of acquainting yourself with the project area (see Chapter 3). Use this information and the instructions in the following section to select a forecasting process. Pick a forecasting process for which the necessary data are available, and then collect those data so that the forecasting process can be completed.

Regardless of the format of the forecasting process selected, it is important that you collect any "official" estimates of future growth that have been developed by impacted jurisdictions and agencies. Urban areas with a population of greater than 50,000 people have a designated agency (usually the MPO) which maintains one or more datasets with the "expected" future conditions. It is important that you obtain and examine this estimate as part of the data collection process. Unless further examination shows this data to be unreasonable, this data should serve as your starting point for the future year forecast. The use of "official" estimates maintains credibility and consistency in the planning and design process. When "official" estimates are obviously unreasonable, collect the necessary data to improve on those estimates, and document the changes you made to those estimates and the reasons you made those changes. In this manner, your reasoning can be reviewed by outside persons and agencies tracking the development of the project. If differences of opinion arise through this analysis, it is then a simple matter of discussing whether your clearly defined assumptions are appropriate or should be changed. (While this may be a heated argument, it is at least a *focused* heated argument.)

MAKE A PRELIMINARY SELECTION OF THE FORECASTING TECHNIQUE TO BE USED

A variety of factors enter into the selection of a traffic forecasting technique for a specific project. The required forecast elements (i.e., the "answers" needed) and data available are the most important of these factors, because the forecast technique must be capable of producing the desired results, and no forecast can be made without the necessary input data. Once the available data have been determined, you should consider the other factors involved in this process. These other factors are as follows:

- the available budget,
- the available time frame,
- your knowledge of the alternative techniques (i.e., experience using specific techniques or computer programs),
- the importance of the project to political leaders and other decision makers, and
- the tools and equipment available to perform the forecast (e.g., access to computers and specific software).

Available Budget and Time Frame

The available budget and time frame control whether complicated modeling or "quick and dirty" forecasts must be performed. The larger the budget and the longer the time frame, the more complex and intricate the forecasting procedure can be. In addition, larger budgets and longer time frames allow you to perform special studies that yield additional insight into the traffic patterns of the study area.

For example, if a freeway is to be constructed, the size and importance of the project should dictate the need for a careful examination of potential traffic. In this case, a comparably large budget should be available for forecasting work, and the time frame involved should be fairly long. Thus, you will be able to use sophisticated computer models such as UTPS or EMME II to examine the impacts of a wide range of factors, including alternative routes, different population and employment growth rates, and different roadway ramp configurations.

Use of these more sophisticated models is often required for large projects so that Department engineers can answer questions the EIS process develops or affected local jurisdictions ask. If these models are to be used, expect to spend fairly large quantities of money and staff time on collecting reliable, accurate input data and validating the model outputs against present traffic conditions to ensure that the models are working correctly before you make the forecast itself.

When time and/or budget are very small, the forecast is likely to consist of an extrapolation of historic traffic volumes. This type of estimate is commonly used on small pavement jobs in rural areas. For these projects, you may calculate a historic trend line of volume against time and then project it to the future year desired. This "straight-line projection" is then adjusted to account for any specific changes (e.g., a proposed new factory) that would not have been anticipated by the trend analysis.

Knowledge of the Forecaster

Your knowledge plays an important role in choosing between forecasting alternatives. In many cases, more than one technique could be successfully used to perform a forecast. In these cases, the appropriate technique is the one with which you are the most familiar and the most comfortable. For small projects that require a fast turn around, it may be better to use a forecast methodology that is not "perfectly" suited to a job, if you are familiar with that process and unfamiliar with the alternatives.

In addition, lack of experience with, or knowledge of, a particular forecasting technique should often remove that technique from consideration when good alternatives exist. This is particularly true for the complex computer models. These models can easily be misused, and when they are misused, they produce misleading results. Gaining familiarity with complex models takes time, and their complexity often makes them difficult to use and interpret. Thus, if time is not available, you should avoid unfamiliar techniques in favor of tools that can be used more effectively until you have the opportunity to learn the more powerful models. When your skills are not sufficient to use a model that you believe is necessary for a specific job, request help from the TDO and/or obtain help performing the forecast from someone with more experience with that technique.

Available Equipment

As with knowledge of specific forecasting techniques, this criterion is used mostly to rule out specific techniques that cannot be used for a specific reason. For example, the EMME II planning model requires access to a specific series of computers and should not be selected unless you have adequate access to, and resources on, one of these machines. A list of the equipment required for each of the forecasting tools is shown in Table 4-5.

Importance of the Project

The importance of the project plays a lesser role in the selection of a forecasting technique. This is mainly a good criterion for helping you decide between two otherwise equally suitable techniques. Essentially, this consideration means that for important, high profile projects, you should (if possible) select a technique that is sensitive to factors that are important to the persons reviewing or commenting on the project. For example, in an urban area, the forecast technique may need to be sensitive to

- mode choice,
- alternative routes,
- availability of transit, or
- some other factor.

A sophisticated planning model capable of examining these issues may thus be desired, even if other factors indicate that such a complex model may not be totally necessary. Similarly, it may be to your advantage to select a technique that project reviewers are familiar with, so that the review process can spend more energy on reviewing the results and less energy on reviewing the process used.

TABLE 4-5

EQUIPMENT REQUIRED FOR EACH FORECASTING TECHNIQUE

Forecast Technique	Equipment
QRS II	80286 or 80386 based MS-DOS compatible microcomputer, Mouse Printer (plotter is helpful)
SPF	80286 or 80386 based MS-DOS compatible microcomputer, Mouse Printer (plotter is helpful)
MicroTRIPS	80286 or 80386 based MS-DOS compatible microcomputer, Mouse Printer (plotter is helpful)
TModel2	80286 or 80386 based MS-DOS compatible microcomputer, Mouse Printer (plotter is helpful)
EMME II	DEC VAX mini-computer, Unix compatible minicomputer, and 80386 and 80486 based computers High resolution graphics display Printer and Plotter Mouse
UTPS	IBM Mainframe High volume output printer
Spreadsheet Calculator	80286 or 80386 based MS-DOS compatible microcomputer Mouse Printer (plotter is helpful)
CINCH	80286 or 80386 based MS-DOS compatible microcomputer, Printer (plotter is helpful)
Highway Emulator	80286 or 80386 based MS-DOS compatible microcomputer Printer (plotter is helpful)

TABLE 4-6

APPLICABILITY OF FORECASTING TECHNIQUES

Forecast Technique	Appropriate Area Size for Study	Urban/Rural	Time Frame For Use
QRS II	Small areas 10-50 streets	Urban/Rural	Week or more
SPF	Small areas 10-50 streets	Urban/Rural	Week or more
MicroTRIPS	Small to medium areas 50-100 streets	Urban	Month or more
TModel2	Small to medium areas 50-100 streets	Urban	Month or more
EMME II	Medium to large areas 50-200 streets	Urban	Month or more
UTPS	Large areas 50-500 streets	Urban	Month or more
Spreadsheet Calculator	Individual roads Small projects	Rural	Hours or Days
CINCH	Small networks 2-10 streets	Rural/Small Urban	Days
Highway Emulator	Small to Medium large Networks 5-1000 streets	Urban/Rural	Days or greater depending on network size

SELECT THE FORECASTING TECHNIQUES

If you are unclear about which technique you should use for performing a forecast Table 4-6 can provide some insight into which models are most appropriate for each type of analysis and the available time frame. In addition, Volume 2 of this guide includes a step-by-step decision making process to help you choose a forecasting technique when you need help with that selection.

COLLECT THE INPUT INFORMATION

Having selected the forecasting techniques to be used for the project, gather any data not already collected and examine it for completeness and reasonability (i.e., Do the volumes estimated by the local agencies match the traffic counts made by the Department? Does the MPO dataset for 1990 show a development that was never built?).

If you have questions about the data collected, or if you were told that some data exist, but are unable to obtain it, you may have to either arrange to generate those data (i.e., arrange for traffic counts, or special surveys) or change the selected forecasting technique to reflect the data actually obtained.

REVISE THE SELECTION OF TECHNIQUE(S) AS NECESSARY

If the data required to use a specific forecasting technique are not available, return to the technique selection criteria and select the appropriate tools on the basis of the revised input information. You may also need to pursue this same step if the model results produced with a selected forecasting technique do not appear to be reasonable or are not sufficiently sensitive to the necessary inputs.

CHAPTER 5

PERFORMING THE FORECAST

This chapter introduces the steps that you must follow to perform a traffic forecast. More specific details are given in Volume 2 of this Guide. Figure 5-1 illustrates those portions of the forecasting process covered.

The procedures for actually performing a forecast will vary with the tools you select to do that analysis. Because these steps vary so much, this chapter will only briefly discuss two basic categories of forecasts, simple trend analyses and four-step modeling approaches. Trend analyses are done both manually or with Lotus 1-2-3 spreadsheet templates.

The four-step modeling process uses one of the four-step computer models supported by the Department. The specific modeling steps required vary, depending on the model selected. This chapter will only outline the basic process you must follow. (Specific instructions for the individual models can be found in the User's Guides for the respective models.)

TREND ANALYSES

The specific steps to be followed in this forecasting process are as follows:

- determine the year for which the baseline traffic estimate is made,
- determine the initial traffic conditions,
- define the length of the design period and the forecast year,
- calculate the growth patterns you will be applying,
- determine any mitigating circumstances,
- forecast the traffic levels,
- adjust the forecast traffic on the basis of the mitigating circumstances,
- review the results,
- test the sensitivity of the forecast,

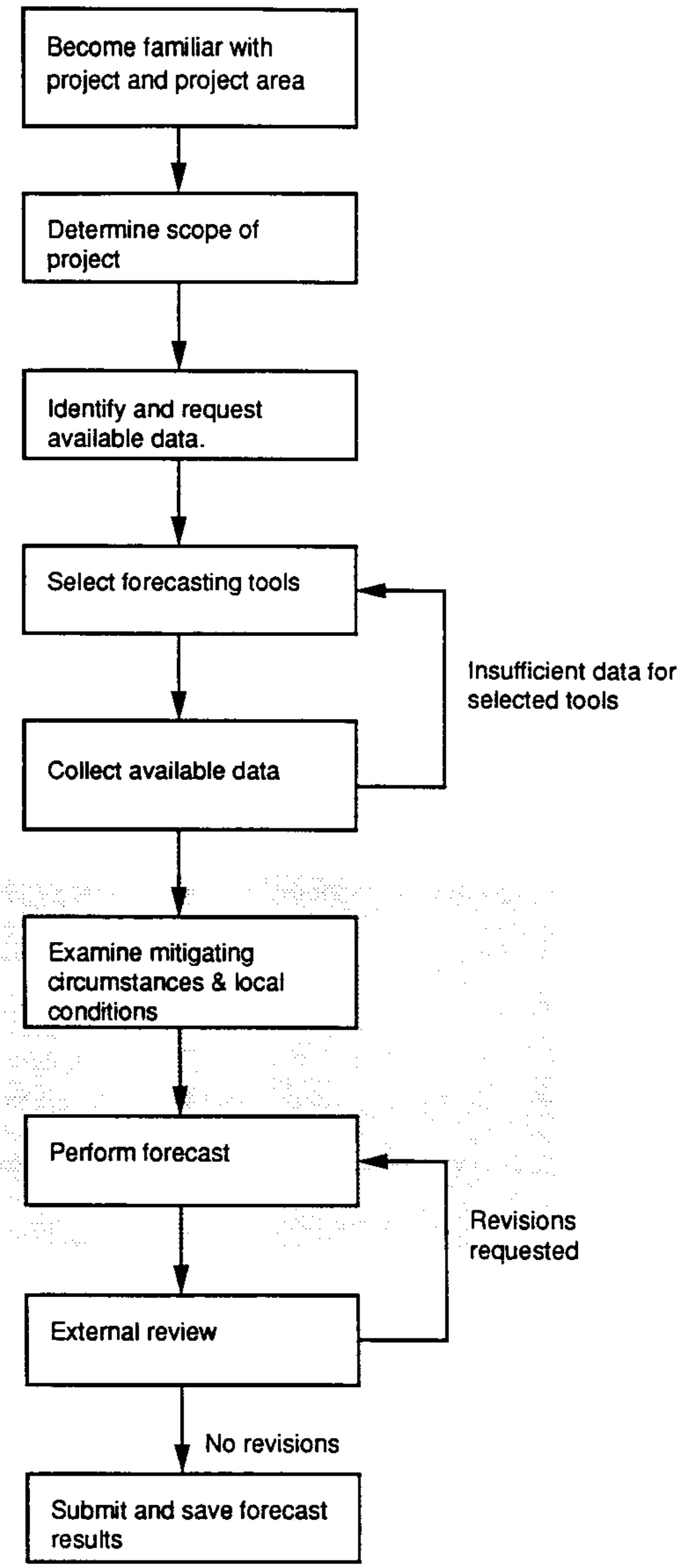

Figure 5-1. Forecasting Process

- adjust the mitigating circumstance assumptions that have been used,
- revise the forecast, and
- estimate the design traffic data.

These steps are described in detail in Volume 2. Worksheets 1 through 3 are used to keep track of the results of these steps and to document the assumptions and results of the forecast efforts.

Determine Base Year For Traffic

This is the year in which the roadway will be opened for traffic after the project has been completed. It will either be the current year or a year in the near future.

Determine The Initial Traffic Conditions

Determine the base year traffic volumes for the project facility from the current year traffic volumes obtained from the TRIPS files or from special traffic counts performed to provide these data. If the project is not scheduled to be opened to traffic for more than one year, treat the baseline as this year and add the number of years left until the project opens to the design period.

Define The Length Of The Design Period And Forecast Year

Determine the length of the forecast period and the actual forecast year. For overlays, the forecast period is usually ten years, and most projects forecast with this methodology will be overlay jobs. However, other forecast periods may be required, and information about these different design periods should be provided to you as part of the forecast request, or you should obtain them as part of the scoping process (See Chapter 3).

Calculate Historic Growth Patterns

In this step, you must determine the growth rate that will be used in the analysis. A variety of methods for doing this are available. Some of these methods are described in Volume 2 of this guide.

Worksheet 1. Summary Traffic Information

SR#	________	Beginning Milepost	________	Ending Milepost	________
Forecaster's Name:	________				
Base Year	________	Forecast Year	________	Duration	________

BASE YEAR CONDITIONS

Automobile Volume =	________	Other 2-Tire, 4-Axle Veh. =	________	Other Vehicles (Specify type and vehicle):	________
Buses =	________	4-Axle Single Trailer	________		
2-Axle, 6-Tire SU	________	5-Axle Single Trailer	________	5-Axle Multi-Trailer	________
3-Axle Single Units	________	6+ Axle Single Trailer	________	6-Axle Multi-Trailer	________
4+ Axle Single Units	________			7+ Axle Multi-Trailer	________
Total Single Units	________	**Total Single Trailers**	________	**Total Multi-Trailers**	________
AADT =	________	Percent Trucks (Daily) =	________	K =	________
		Percent Trucks (Pk. Hr.) = T =	________	D =	________

FORECAST YEAR CONDITIONS

Automobile Volume =	________	Other 2-Tire, 4-Axle Veh. =	________	Other Vehicles (Specify type and vehicle):	________
Buses =	________	4-Axle Single Trailer	________		
2-Axle, 6-Tire SU	________	5-Axle Single Trailer	________	5-Axle Multi-Trailer	________
3-Axle Single Units	________	6+ Axle Single Trailer	________	6-Axle Multi-Trailer	________
4+ Axle Single Units	________			7+ Axle Multi-Trailer	________
Total Single Units	________	**Total Single Trailers**	________	**Total Multi-Trailers**	________
AADT =	________	Percent Trucks (Daily) =	________	K =	________
		Percent Trucks (Pk. Hr.) = T =	________	D =	________

WORKSHEET 2

ESALs BY PROJECT YEAR

Current Year: ____________ Design Year: ____________

Project Opens: ____________ Design Period: ____________

Actual Forecast Duration: ____________

Year										
Forecast Volumes (AWDT)										
Forecast Truck Volumes (AWDT)										
Forecast ESALs (Annual, in 000)										
Cumulative Project ESALs (Annual, in 000)										
Year (continued)										
Forecast Volumes (AWDT)										
Forecast Truck Volumes (AWDT)										
Forecast ESALs (000) (Annual, in 000)										
Cumulative Project ESALs (Annual, in 000)										

DESIGN ESAL ____________

WORKSHEET 3
ASSUMPTIONS USED IN THE FORECAST

Project SR ____________________ Forecasters Initials __________

Date Forecast Completed ____________

Major road system improvements included in the forecast

Special economic growth included in the forecast

Sources for land use, population and current year traffic estimates used in the forecast

Mitigating circumstances and growth rates assumed in the forecast

Determine The Mitigating Circumstances

Mitigating circumstances are expected changes that may cause the forecast traffic volumes to be different than historical trends indicate. These are the various factors you have explored as part of "becoming familiar with the project" in Chapter 3. They include the construction of new recreational, manufacturing, or industrial facilities along the highway, or along highways that intersect the project highway. These changes can also include the closing of these facilities, or even changes to the highway network itself (such as the opening of parallel roads or the abandonment of a rail line spur).

Forecast Traffic Levels

Using the historic growth rate calculated above, use the tools you selected earlier to calculate the base traffic forecasts for the project. A set of Lotus spreadsheets are included in Volume 2 of this guide to assist with this calculation. This forecast represents the amount of traffic expected without the "mitigating circumstances" you determined in the previous step.

Adjust The Forecast Traffic On The Basis Of The Mitigating Circumstances

Apply the changes you expect from the "mitigating circumstances" to the preliminary traffic volume estimates. The Lotus spreadsheets discussed above can also be used to make these additions. Note that these adjustments can occur at any point in the forecast period.

By adding in the mitigating circumstances, you have now created the initial set of forecast estimates for this project.

Review The Results

The forecast estimates produced above must be reviewed before they are provided to the design engineers. This review must include both a check for "reasonableness" and a check for sensitivity.

If this is a pavement overlay project, one review should examine the forecast with respect to data from the pavement performance monitoring system (PMS). This review should be performed by the Materials Lab (or whoever else is performing the axle load calculation). The PMS tracks a pavement's condition and deterioration over time. If a pavement has deteriorated more quickly than it should have (i.e., the pavement has not reached its design life, in years), it is important for you and the pavement design engineer to look particularly carefully at truck volumes on that facility. If the truck volumes used for the last pavement design are available, compare those estimates with the current truck volume estimates. If they are the same, or nearly the same, you should consider increasing the estimated truck volumes. Essentially, you are using the unusually high rate of deterioration shown in the PMS as an additional mitigating circumstance. While many factors could cause premature pavement deterioration, under-estimated truck volumes and under-estimated truck weights are particularly common causes.

A review that should be performed for all projects is an examination of the Level of Development (LOD) category implied by a forecast. LOD impacts the design standards for a roadway, and you should not take lightly the shifting of a road from one LOD category to another. If a forecast does cause a change in a road's LOD categories, you should discuss this result with the project design engineer and examine whether small changes in the forecast alter this new LOD rating. Essentially, you want to know whether small errors in the forecast will cause you to incorrectly predict the proper LOD category for that road.

If small changes in the forecast assumptions cause changes in the future LOD category for a road, the uncertainties of the forecasting process may warrant a closer examination of the forecast estimate and the inputs used to make that estimate. In particular, you may also want to consider other factors, such as the availability of funds for increasing the size of that road, the public reaction to a change in the LOD designation for that road, and the desires of local jurisdictions to have that road change LOD categories.

In addition to the PMS and LOD reviews described above, you should also examine other aspects of the forecast's impact on the project. More about these reviews is explained in Volume 2 of this guide. Any specific concerns that develop as a result of these reviews should be noted on the Worksheets and investigated carefully.

Adjust Mitigating Circumstance Assumptions

If the sensitivity analysis and review of the project point out errors or areas of concern, adjust the assumptions and mitigating circumstances used in the initial forecast estimate. These adjustments can be made to the expected changes in total traffic volumes or the expected changes in particular vehicle types. They can occur over the length of the project or be restricted to one-year events. Make sure that you note any additions or deletions you make to your assumptions on the Worksheets.

Revise The Forecast

Using the revised mitigating circumstance assumptions, revise the initial daily traffic forecasts for the project. Review these revised results in the same manner you reviewed the initial forecasts. Continue the review/revision process until you are satisfied with the results, and then record the tests you made, the reasons you made those tests, a brief explanation of the results of those tests, and the final assumptions used in the actual project forecasts.

Estimate Design Traffic Data

In many cases, you must refine traffic forecasts to include design hour volumes, truck percentages and directional splits. A discussion on how to estimate these values is included in Volume 2 of this guide.

FOUR-STEP MODELING PROCESS

This procedure is to be followed when you select any of the four-step computer models. The basic steps involved in the modeling chain are similar for most of the models. Additional information on these models can be found in Volume 2 of this guide and in the User's Manuals for the computer software.

The primary differences among these models are in the specific input formats used for the data; the complexity of the input data; the complexity of the modeling sequence; the specific factors the models are sensitive to, and the manner in which information is input, manipulated, and extracted from the models. However, the basic steps you perform when using the models are the same. These steps include the following:

- determine the year for which the baseline traffic estimate is made,
- determine the initial traffic volumes,
- define the length of the design period and the forecast year,
- format the data for input to the base year model runs,
- calibrate the model,
- format the input data to be used for estimating future year predictions,
- apply the model to provide future year estimates,
- review the results,
- perform sensitivity analyses,
- revise the forecast (re-apply the model),
- refine the model estimates,
- determine the shape of the expected growth curve, and
- develop intermediate volume estimates as needed.

These steps are described in more detail below and in Volume 2 of this guide. As with the more simple trend analyses, use Worksheets 1 through 3 to keep track of the assumptions you make in the modeling process and the results that you obtain.

Determine The Base Year For Traffic

Determine the base year for the traffic forecast. This is the year in which the roadway will be opened for traffic after the project has been completed. This will either be the current year or a year in the near future.

Determine the Initial Traffic Conditions

Determine the initial traffic conditions within the project. These values should be either the current year traffic volumes obtained from the TRIPS files (or from special traffic counts) or these same values adjusted slightly to account for growth in the next year or two, if the project will not be opened until then. (This short-term growth should be a linear growth and can be estimated using the estimates stored in TRIPS or on the basis of conversations with District or local agency personnel.)

Define The Length Of The Design Period And Forecast Year

Define the length of the forecast period and the year for which the forecast is made. For new pavements, this is usually 20 or 30 years. For overlays, the forecast period is usually ten years. If a forecast period other than this is required, you should be informed of the desired time period in the forecast request or during the scoping process (See Chapter 3).

Format Data For Input To The Model

It is now time to begin working with the computer models. The first step in this process is to transform the data obtained in Chapters 3 and 4 into the format required by each model. (Specific model inputs are described in each model's User's Guide and summarized in Appendix D.) Data formatting usually requires the following steps:

- creating a highway network (link/node representation) in the appropriate model structure,
- developing the zone structure to be used by the model,
- aggregating the land use and population information obtained in Chapters 3 and 4 into the zone structure developed, and

- obtaining any mode split models that are required by the modeling chain (some models use them, some do not).

Create The Highway Network

All four-step models except SPF use a link/node highway network. In many cases an existing network can be obtained from one of the sources listed earlier in Table 4-1. If not, the network must be obtained from maps and translated into the appropriate link/node format for the selected model.

When you create (or obtain) a link/node highway network, it is important that you tailor the network to the project being performed. It is very important to compare the highway network given to you with the actual configuration of the street system. Networks can easily become out-of-date. They may include roads that were planned but never built. They may include "dummy" links that were added as part of another analysis and not removed. They may include links that represent a combination of several roads. For every analysis, you should review the network after coding has been completed to ensure that the modeled network contains all of the links that you desire, that you understand and want all of the links present in the network, and that no errors in the network are present as a result of the coding process.

Finally, when you create or review a network it is important that you check to ensure that the network contains the necessary provisions for examining all project proposals. This means that not only does the project street system need to be well represented in the network, but the network must be able to add new links or facility changes that need to be modeled as part of the forecasting alternatives.

For the more complex models (EMME II and UTPS), you must also often develop and code a transit network.

Develop The Zone Structure

The zone structure is developed in tandem with the highway network. In most all cases, you will inherit an existing zone structure (census tracts or an existing model's

Traffic Analysis Zones (TAZ)) from previous studies. You must refine these zone systems to fit your needs. Refinement entails aggregating zones where the existing zones provide more detail than you need, and splitting zones into finer geographic areas where you want to "window" and require a greater level of precision. Pay particular attention to the size of zones near your project and the number, location and potential impact of the zonal connectors that link those zones to the link/node highway network. These connections tend to overload the roads they join, and this overloading can seriously impact the accuracy of the traffic conditions predicted for your project.

Aggregate Zonal Data

Once the zone system has been established, you must transform the available data into the appropriate data entry format. This may mean the aggregation of some information and the disaggregation of others. Take care when you perform this task to ensure that the character of each zone is accurately reflected by the data for that geographic area. (In other words, make sure the aggregation/disaggregation process does not lead to modeling problems such as all trips to or from a zone using the same highway, when in reality they would use four different roads that are included in the network.)

Obtain Mode Split Models

With the more sophisticated modeling packages (EMME II and UTPS) a mode split model must be run as part of the modeling chain. The less complex models usually assume a mode split and auto occupancy rate and are not sensitive to transit characteristics or mode shifts caused by economic factors. The more complex programs apply mode split models developed as part of large survey efforts and other large studies.

When you have questions about using a particular mode split model, contact someone within the Headquarters staff assigned to assist with forecasting, and discuss the options that are available to you. Taking a little more time and making valid decisions when selecting mode split models will always provide you with a better end product than continuing without direction.

Calibrate The Model

Run the selected model through its modeling chain using the base year inputs you have just finished coding. Compare the traffic volumes output from the model with the traffic data that you entered or collected earlier in the forecasting process. Also compare the traffic volumes output from the model with existing volumes on other important roads in the network. Data on the actual traffic volumes on other roads in the network can be obtained from TRIPS, the jurisdictions responsible for those roads and a variety of other sources.

The model volumes on major roads and roads near your project should be within about 10 percent of the measured street volumes for the model to be considered calibrated.

In general, if the model outputs do not match the existing traffic predictions, then you must make some type of adjustment to the network, zonal information, and/or model parameters to calibrate the model. This topic is discussed more heavily in Volume 2, but should also be included in your training in the use and interpretation of four-step models.

Format The Data For Future Year Predictions

After the model has been calibrated, you are ready to convert the future estimates of land use, population, and highway changes into the appropriate modeling format. Take care to use the same modeling conditions (except for planned network changes) in the forecast year that you used in the final calibration run.

Apply The Model For Future Years

After you have coded the input data, apply the models for the future year conditions. The different four-step models require different levels of effort to work through the modeling chain. UTPS can require as many as 14 separate program runs to complete all phases of trip generation, trip distribution, mode split, and assignment. Other models, such as SPF, require only two or three steps from data entry to model output. Specific directions for each model are given in each model's User Guide.

Review The Results

After the initial forecast model runs have been completed, you must examine the model outputs for reasonableness. Problems apparent from the review can be investigated through revisions in the input data and the modeling assumptions. Investigation of the model output also provides you with the information necessary to answer questions about the model runs raised by the outside review process (see Chapter 6).

Perform Sensitivity Analyses

An important aspect of the computerized modeling efforts is testing the sensitivity of the model to changing input assumptions. The more complex the modeling sequence is, the more carefully you should test the input assumptions. The objective of the sensitivity analysis is to give you insight into what factors have the greatest impact on the model's output. For example, if doubling the downtown parking rates halves the model's estimates of the traffic volumes heading downtown, you may want to reexamine the rates you have predicted for the future year forecast before accepting the model's initial output as "accurate."

Even for models that are not complex, it is a good idea to make minor alterations to the basic modeling inputs to determine whether the accuracy of these inputs have a significant impact on the model outputs. If you have used input assumptions that differ from those used in other studies, apply those other assumptions and examine the changes that occur in the model output. Knowledge gained from this comparison will allow you to better defend your assumptions and will give you answers to questions that are likely to be raised during the review process.

Finally, remember that most of the model inputs are forecasts themselves and are likely to contain their own errors. Therefore, it is important to determine the possible impact on the output that potential errors in the input will have.

If the model you are using is sensitive to the changes you make, discuss the implications of this sensitivity with other professionals involved in the project. Come to an agreement on how the sensitivity should be handled (average the estimates, accept one as the "correct" answer, or have the design engineers take into account the potential variability in the traffic as part of their design.) Again, remember that a forecast is an estimate and is never "correct." Your job is to produce the most likely estimate from the available information. Designs are based on the best available information, and knowledge of a model's sensitivity is one part of developing that information.

Revise The Forecast (Reapply The Model)

If concerns are found as a result of the review process or the sensitivity analyses, you should carefully construct a series of model runs that provide answers to the questions you identified. If necessary, create a final, "official" forecast using a revised set of inputs based on the insight you have gained from the review and sensitivity analyses.

Refine The Model Estimates

Four-step model output is generally not complete by itself. Four-step models usually require aggregated network descriptions (that is, all roads are not incorporated in the network because of space limitations) and deal only with passenger cars and transit vehicles. In many cases, you must refine model inputs to include estimates of truck traffic and additional detail on turning movements and other micro-scale traffic characteristics. These steps are defined more completely in Volume 2 of this guide.

Determine The Shape Of The Expected Growth Curve

In some cases (especially pavement design), it is necessary to know the expected yearly vehicle volumes for each vehicle class to estimate the total number of vehicles passing a section of road during the design life of that pavement. To make this calculation you must estimate the rate at which the forecast growth will occur. (You currently have the end points of this curve from the modeling process.)

You may reapply the selected four-step model for each year of the forecast if the input data are available, but usually they are not. Population and employment estimates are usually available only for five- or ten-year increments (i.e., 1990, 1995, 2000, etc.). Converting these to yearly figures and then re-running the modeling chain is slow and costly.

As a result, a series of Lotus 1-2-3 spreadsheets have been developed to help you estimate the intermediate years of traffic data. The spreadsheets are based on the base year and forecast year volume and truck estimates and a prediction about the shape of the growth curve. The spreadsheets allow for growth that occurs in a linear fashion, exponential fashion, or in either sharply increasing or decreasing factorial rates.

Develop Intermediate Traffic Estimates

The spreadsheets require as input the beginning and ending volumes (by vehicle classification) and the shape of the curve desired. They output the annual and average daily volume totals for each vehicle class, as well as the ESALs for each class and the total design ESAL for the project life.

CHAPTER 6

REVIEWS AND PRESENTATION OF THE FORECAST

This chapter describes the ways that a forecast should be reviewed before it is used as design information by the Department. It also describes how the forecast should be presented to the requesting party and stored in the project and TDO files.

The reviews that should be performed for all traffic forecasts include the following:

- reviews within the forecasting office,
- reviews within the Department but outside of the office that creates the forecast, and
- reviews outside of the WSDOT.

Reviews within the forecasting office (reasonableness checks, sensitivity analysis, and review of basic assumptions) have already been discussed in Chapter 5. The two remaining categories are described below.

WSDOT REVIEWS

The primary reviews that need to be performed within the Department are consistency checks and examinations of the assumptions used in the forecasting process. Specifically, the Department needs to review the following information:

- base year truck and total volume estimates for the project,
- forecast year truck and total volume estimates for the project,
- the growth assumptions (rate of growth) implied by the forecast, and
- the mitigating circumstances included as part of the forecast,

Each of these reviews are discussed below.

Base Year Truck and Total Volume Estimates

The reviewer should examine these values in light of their understanding of the current traffic conditions. Do the estimates used as the basis for the forecast make sense when compared to your understanding of the existing traffic conditions? If they don't, are the current estimates based on actual recent traffic counts, or extrapolated from older counts? If the counts do not seem to reflect what you feel are current conditions, discuss these differences with the individual making the forecast.

Under extreme circumstances, it may be necessary to schedule counts to confirm or revise the base year traffic estimate. The cost of a short duration count is very small in relation to the cost of any project which requires placement of pavement, however, the delay caused by having to schedule and perform such a count often makes requesting new counts impractical except for those cases where the accuracy of the traffic estimates (i.e., their importance in the design work being performed) warrants the additional delay to the design process.

In the end, the forecaster is responsible for his/her own work, but approval of the volume estimates should also be obtained from the district supervisor of traffic forecasting or the Transportation Data Office in Olympia. The forecaster should be sensitive to the review comments received. In addition to these reviews, the design engineer has the option of applying a reliability factor to the volume estimates as part of both the pavement and geometric design procedures.

Forecast Year Truck and Total Volume

The reviewer should examine the forecast results in a preliminary fashion to quickly understand the impact of those estimates. Do the new estimates mean additional lanes of highway construction are required? Do they indicate the need for a change in the scope of work for the project? Do the forecast numbers indicate a change in the pattern of traffic using the road (i.e., an increase of loss of some seasonal or other traffic pattern?)

Have these impacts been accounted for in the design process? Are changes in the project design required by as a result of the forecast traffic? Is the design of the project subject to change if the forecast traffic volumes are marginally different? (For example, is the project barely over the dividing line between level of development categories or is it well within the bounds of one specific category?)

If relatively small changes in the forecast traffic estimates will have major effects on the project design, the reviewer should sit down with the forecasting person, and discuss the nature of these design changes, and the assumptions made in the forecast. From this meeting should come a consensus about the assumptions that should be used in the forecast, and that these assumptions are consistent with the assumptions being used by the remainder of the Department for that location.

Growth Assumptions Used and Mitigating Circumstances

When reviewing growth assumptions, the primary area of concern is that the forecast reflect the expected conditions for that geographic area. Are the growth estimates consistent with those used by other agencies? If not, are the reasons for using different growth estimates valid and well documented? Is the shape of the growth curve realistic? (That is, is growth constant in this area? Accelerating? Declining?) Can the developments forecast actually be built in the time frame assumed? What are the chances that they will be built faster?)

EXTERNAL REVIEWS

External reviews of the project should take place, whenever the project impacts another agency or jurisdiction. The intent of the external review is to share information about the project and diffuse any potential disagreements about the assumptions used in an analysis. In particular, the external review should allow the external agency to voice concerns over specific assumptions used by the Department which do not coincide with assumptions made by that agency. (For example the agency might assume that a new county road is not being built and the Department might assume that road will be built. The existence of that road may have a significant impact on the traffic volumes forecast for the project.)

In some cases, the Department may want to make different assumptions than used by the local agency. If this is the case, the Department needs to be able to explain (and defend) the use of those assumptions in place of other alternatives. Providing for external review brings the important parts of the forecast to light, and allows a straight forward discussion of the issues, before significant design work begins. This allows potential differences to be straightened out before early in the design process, and should produce a smoother, more timely design.

PRESENTATION OF THE FINAL FORECASTING RESULTS

The final forecast results should be submitted to the requesting office on Worksheets 1, 2 and 3. These estimates should be accompanied by a hand-drawn flow map (or maps) of the roads included in the forecast, listing the appropriate daily and design hour volumes and turning movement estimates. These estimates should be included in the project design documentation, and stored for later review. A copy of each of these documents should also be maintained at the Transportation Data Office.

A brief transmittal letter should accompany the Worksheets and traffic sketches. The transmittal letter should highlight any concerns the forecaster has, and summarize the forecast results. If external review of the forecast provided dissenting opinions to the forecast estimates and revisions were not made to the forecast as a result of these disagreements, information describing the reasons behind the dispute, the reasons why the assumptions used in forecast were selected, and the reasons why the objections of the external agency were not accepted or agreed with should also be included in the transmittal letter. This letter should also be included in the permanent design record.

APPENDIX A

DICTIONARY OF TERMS AND ACRONYMS

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DICTIONARY OF TERMS AND ACRONYMS

3R	Rehabilitation, Reconstruction and Restoration. This is both a category of funding and a level of development category.
3S2	A type of truck. This truck consists of a standard three axle tractor and a two axle semi-trailer.
AADT	Average Annual Daily Traffic The daily average of total traffic volume, including both weekdays and weekends for the stated year.
AAP	Arterial Analysis Package. A microcomputer modeling package used for analyzing traffic signal timing options. It gives the user the option to test signal timing plans using both TRANSYT-7 and PASSER.
ADT	Average Daily Traffic. The daily average of total traffic volume during a stated period. When not specified, the period is usually assumed to be one year and ADT is equivalent to AADT.
Average Annual Daily Traffic (AADT)	The daily average of total traffic volume, including both weekdays and weekends for the stated year.
Average Daily Traffic (ADT)	The daily average of total traffic volume during a stated period. When not specified, the period is usually assumed to be one year and ADT is equivalent to AADT.
Centroid	A computer modeling term. It denotes the "center" of a geographic region (a zone). In traffic demand modeling, all trips are assumed to start at the centroid of a zone.
Cordon Line	A screen line drawn completely around a portion of a city. A cordon line is used to measure traffic entering into an area from all directions. (A screenline only measures traffic from one direction.)
D	Directional split. The percentage split of total traffic volume into a specific direction. (Hourly estimate)
DDHV	Directional Design Hour Volume. The design hour volume occurring in the peak direction of a facility.

Design Hour Volume (DHV)	The hourly traffic volume used for design calculations. Usually the 30th highest hour of traffic in the design year. For heavy recreational routes, it may be between the 50th and 200th highest hour of traffic, depending on the size of the road, and the size of the recreational movement. (Small roads with very heavy recreational movements may use the 200th hour.).
DHV	Design Hour Volume. The hourly traffic volume used for design calculations. Usually the 30th highest hour of traffic in the design year. For heavy recreational routes, it may be between the 50th and 200th highest hour of traffic, depending on the size of the road, and the size of the recreational movement. (Small roads with very heavy recreational movements may use the 200th hour.).
Directional Design Hour Volume (DDHV)	The design hour volume occurring in the peak direction of a facility.
Directional Split (D)	The percentage of traffic occurring in the peak direction during the design hour.
DOE	The State Department of Ecology
Double Unit	A truck classification. A double unit is any vehicle consisting of two separate sections traveling together. This can include a truck pulling a trailer or a tractor pulling a semi-trailer.
EMME II	A computerized four step planning model. One of the most complex of the four-step models. It has significantly better than average capabilities for graphic input and output of transportation data. (Pronounced "em - me 2.")
Equivalent Standard Axle Load (ESAL)	A unit measure of pavement damage caused by vehicle axles. One ESAL is equal to the damage caused by an 18,000 pound single axle (18 kips).
ESAL	Equivalent Standard Axle Load. A unit measure of pavement damage caused by vehicle axles. One ESAL is equal to the damage caused by an 18,000 pound single axle (18 kips).
External Trips	Trips which have at least one of their trips ends outside of the geographic bounds of the study area.
FHWA	The Federal Highway Administration
Four-step Models	Any model which uses the classic four step planning process of trip generation, trip distribution, mode split and assignment.

Friction Factors — A computer modeling term. Friction factors are used in trip distribution as a means of helping distribute trips between zones where they originate and zones where they arrive.

G — Growth Factor. The annual rate of growth for traffic on a facility. Usually expressed as a percentage of existing traffic.

Growth Factor (G) — The annual rate of growth for traffic on a facility. Usually expressed as a percentage of existing traffic.

HCS — The Highway Capacity Manual Software. A document (and software) developed by FHWA containing a variety of algorithms for estimating the capacity of roads and intersections and the performance of those facilities under specific traffic loadings.

Highway Capacity Manual Software — A document (and software) developed by FHWA containing a variety of algorithms for estimating the capacity of roads and intersections and the performance of those facilities under specific traffic loadings.

K Factors — A computer modeling term. K factors are used in trip distribution to help model unusual deviations in how people travel. For example, the presence of a river which must be crossed reduces the number of travelers that would be expected to cross between two areas on each side of the river, if that river was not present.

K — Design hour percentage. The design hour volume expressed as a percentage of the average annual daily traffic.

Level of Development (LOD) — A term used to define the design standards that are applicable to a specific roads. Level of development categories are based primarily on road usage, as defined by Interstate/non-interstate designation, volume of traffic, and the percentage of trucks in that traffic.

Level of Service (LOS) — A term used to define the level of congestion and delay on a road. Level of service A represents free flow, uncongested conditions. Level of Service F means heavy delays in stop and go conditions. Ratings in between (B through E) represent increasing levels of congestion and delay.

Link — A computer modeling term. A link is the representation of a transportation facility between two discreet points.

LOD — Level of Development. A term used to define the design standards that are applicable to a specific roads. Level of development categories are based primarily on road usage, as defined by Interstate/non-interstate designation, volume of traffic, and the percentage of trucks in that traffic.

LOS — Level of Service. A term used to define the level of congestion and delay on a road. Level of service A represents free flow, uncongested conditions. Level of Service F means heavy delays in stop and go conditions. Ratings in between (B through E) represent increasing levels of congestion and delay.

McTRANS — The Center for Microcomputers in Transportation. The national center which distributes and supports much of the transportation software available in this country. McTRANS is located at the University of Florida.(904) 392-0378.

Mode Split — A computer modeling term. This is the third step in the four-step computer modeling sequence. In this step, the model determines the distribution of trip makers using different modes of travel. That is, how many will drive cars, how many will carpool and how many will take mass transit or other mode.

Modeling Chain — Any group of computer programs or subprograms that must be run in sequence to perform an analysis.

Multi-Unit — A truck classification. A multi-unit is any vehicle consisting of more than two separate sections traveling together. This usually means a tractor pulling a semi-trailer and an additional trailer. Also called a "double bottom" or a "Train."

Network — In general terms, the transportation facilities available within a study area. In computerized modeling, the electronic representation of the available transportation facilities.

Node — A computer modeling term. A node is a point of interest on an electronic network. It is usually represents some physical aspect of the facility such as the intersection of two roads, or where a road changes directions. It also applies to transit networks.)

Origin - Destination Study (O/D Study) — A study consisting of questionnaires which determine where travelers begin and end their trips. This information is used to help calibrate computer models and to get an idea of where facilities need to be improved to help travelers get from one location to another.

Overlay	The addition of new pavement on top of an existing road service. A typical maintenance action to extend the life of a road and improve the road surface.
Path	A computer modeling term. It represents the set of links used to travel between two points, usually zones, in the network.
Peak Hour	The highest hour of traffic volume that occurs during a day, week or month. The peak hour is not synonymous with the design hour.
Peak Hour Percentage (K)	The design hour volume expressed as a percentage of annual average daily traffic
Peak Period	Those times of the day experiencing the highest traffic volumes. In large urban areas, the peak periods usually are assumed to be 6:00 to 9:00 AM and 3:30 to 6:30 PM.
QRS II	A computerized four step planning model. Built with a special emphasis on graphic input of information.
Screenline	A line drawn on a map, at which traffic or transit patronage volumes are measured. A screenline is usually used to measure the total volume (on parallel roads) flowing past or into some portion of a city. (See cordon line)
Single Unit	A truck or bus which is not pulling a detachable unit.
SMSA	Standard Metropolitan Statistical Area. A census term used to define a group of cities treated as a contiguous metropolitan area in census documents.
Sub-area Focusing	A computer modeling technique where the detail of a small geographic area of major importance within the study area is described in greater detail than the other parts of the geographic area included in the modeling effort.
T	Truck Factor or Truck Percentage. The percentage of trucks in the design hour. Sometimes this is also used to represent the average percentage of trucks throughout the day, although this usage is incorrect.
TAZ	Traffic analysis zone. A small geographic area used in modeling an urban area.

TDO — The Transportation Data Office. The WSDOT headquarters office that has responsibility for collecting most traffic planning and reporting data for the state highway system. This office also performs the review of (and assists in the development of) traffic forecasts made by District personnel.

Through Trips — Trips that have both their origin and destination external to a study area, but pass through the study area.

Traffic Assignment — A computer modeling term. This is the last step in the modeling process. It consists of estimating how many vehicles will use each section of roadway in your network.

Traffic Generator — A location which produces traffic. It usually represents a factory, store or other activity center or combination of activity centers (i.e., many stores) to which people drive vehicles in order to partake in that activity.

TRANSYT-7 — A computer model used to develop signal timing plans. It is most commonly used to design plans in complex coordinated networks.

Train — While this term usually means a railroad train, in traffic terminology it also is synonymous with "multi-unit vehicles" (that is, vehicles with three or more detachable units. For example, tractor, semi-trailer, trailer.).

Travel Time — The time required by a traveler to go from one location to another.

Trip Distribution — A computer modeling term. This is the second step in the four-step modeling sequence. In this step, the modeling process determines the pattern of trips in the region being studied. It estimates how many trips starting in each zone travel to every other zone in the study area.

Trip Generation — A computer modeling term. This is the first step in the four-step modeling sequence. In this step, the modeling process determines how many trips of each type (home to work, home to school, etc.) are produced and attracted within each zone.

Trip Table — A table showing the number of trips moving from every zone to every other zone in a study area.

TRIPS — The Transportation Information and Planning Support System. A database system maintained by WSDOT. It contains roadway and traffic information collected by the WSDOT.

Truck Percentage (T) The percentage of trucks in the design hour. Sometimes this is also used to represent the average percentage of trucks throughout the day, although this usage is incorrect.

UTPS The Urban Transportation Planning System. The USDOT/FHWA developed and supported four-step planning model. Currently used by most large cities. It is the most capable of the four-step models, but also is the most complex to operate.

Window A computer modeling technique where the detail of a small geographic area of major importance within the study area is described in greater detail than the other parts of the geographic area included in the modeling effort. The term "window" is also used to refer to the small, detailed geographic area itself.

Zone A geographic region. A zone is used to collect and compress highly disaggregate geographic information (such as population, or economic activity) into a manageable single value or distribution of values.

Zone Centroid A computer modeling term. It denotes the "center" of a zone's geographic area In traffic demand modeling, all trips are assumed to start at the centroid of a zone.

APPENDIX B

TRAINING AND THE AVAILABILITY OF HELP

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TRAINING AND THE AVAILABILITY OF HELP

This appendix provides information on various training courses that are offered to WSDOT staff. It also lists information on where to obtain help when you have difficulties when performing a forecast.

TRAINING

As part of learning the process of forecasting, it is a good idea to become familiar with the tools for performing forecasting and the design and planning functions which use forecast data. Learning more about the tools used for forecasting will allow you to perform more thorough forecasts, while performing those forecasts more quickly. Learning more about the design and planning functions which use forecast data will give you a better understanding of the importance of the various parts of the forecasting effort and allow you to concentrate more effectively on those aspects of the forecast which have the greatest impact on the design being made.

Training is available to help you learn these procedures through the ongoing WSDOT staff development process. WSDOT provides training classes taught by a variety of institutions, including WSDOT itself, short courses taught by University of Washington faculty, and courses taught by national organizations which are brought to the Northwest by WSDOT or other agencies.

While the classes being taught at any one time vary and the actual course names and contents change over time, the following list of classes provides a reasonable summary of classes that would benefit someone working in traffic forecasting.

Class Title	Taught By	Class Number
DP - Lotus 1-2-3, Beginning	DOT	RJ
DP - Lotus 1-2-3, Intermediate	DOT	BD
DP - Lotus 1-2-3, Advanced	DOT	RL

Class Title	Taught By	Class Number
Traffic and Traffic Planning Orientation	DOT	N.A.
TRIPS System - Data & Services	DOT	ZG
Highway Capacity Manual	DOT	3C
Design - Design of Pavement Structures	DOT	108
Design - Geometric Design for 2R/3R Prog.	DOT	112
TRAF - Traffic Operations	DOT	124
Statistics for Transportation Engineers	DOT	121
Urban Travel Demand Forecasting	UW	N.A.
Arterial Analysis Package	NHI	13319
Pavement Design	NHI	13111
Traffic Management Strategies	NHI	13345
Site Impact Traffic Evaluation	NHI	15253
Simplified Microcomputer Planning Methods	NHI	15230
Introduction to Travel Demand Forecasting	NHI	15254

There is also a possibility that a course will be developed specifically to address traffic forecasting using this notebook as the course text. To learn more about what courses will be offered in the near future, contact the Staff Development Office at (206) 753-7135, or SCAN 234-7135.

AVAILABILITY OF HELP

WSDOT has many resources available to persons performing traffic forecasting. If you experience difficulties performing a forecast, you should initially seek help from those in your office familiar with the project and/or the forecasting technique that you are using. If this help is insufficient or unavailable, contact the following offices within WSDOT for assistance.

Transportation Data Office

Computer modeling assistance	SCAN 234-3210
General office number,	SCAN 234-2172
TRIPS assistance	SCAN 234-6156
Other traffic data availability questions	SCAN 234-6234
Review of / assistance with modeling assumptions	SCAN 234-3210

Materials Laboratory

General office number	SCAN 234-7103
Estimates of loads due to trucks	SCAN 234-7083

Headquarter's Planning Office

General office number	SCAN 234-3231
Assistance with planning models	SCAN 234-7490

Information and Planning Center (MIS Support)

Computer support	SCAN 234-2133

APPENDIX C

DESCRIPTIONS OF MODELS COMMONLY USED IN TRAFFIC FORECASTING

APPENDIX C

DESCRIPTIONS OF MODELS COMMONLY USED IN TRAFFIC FORECASTING

This appendix provides brief descriptions of several computer models commonly used as part of the traffic forecasting process. The Department actively supports many computer packages, both by providing training courses for those packages and by designating individuals as technical experts who can provide assistance in working with specific programs. All software described in this section are available for microcomputers (although some are also available through the Department's mainframe).

The descriptions are intended to provide you with a better understanding of the needs and capabilities of these models. Five of the models which are often used directly in the forecasting process are reviewed in more detail. The other models mentioned in this appendix are also very useful, but they usually play a more peripheral role in the forecasting process.

The detailed reviews presented later are intended to help you select the appropriate model for the forecasting needs you have. These reviews should not be viewed as a substitute for the user's manuals for the various software packages. The reviews do not contain complete user instructions and are not sufficiently detailed to act as stand alone documents. The reviews cover the following five models:

- QRS II (The Quick Response System, version II),
- CINCH,
- SPF (Simplified Project Forecasting),
- THE (The Highway Emulator), and
- TMODEL2.

In addition, a brief summary of the USDOT Urban Transportation Planning System (UTPS) is provided.

Available computer software can be divided into categories on the basis of the primary emphasis of the program. The categories most appropriate to traffic forecasting are

- four-step planning models,
- traffic flow and evaluation models, and
- miscellaneous spreadsheets and computational aids.

Four-step Planning Models

Four-step planning models (i.e., those that perform trip generation, distribution, mode split and assignment) are at the high end of the traffic modeling process. That is, these models are complex and time consuming. They require a reasonable amount of user training to be accessible, but they perform a type of analysis that is often impossible to perform by hand. These models are best for examining expected growth in traffic levels based on predicted growth in population and economic variables. Traffic estimates produced by these models are usually assigned to "high level" representations of the actual street network (i.e., these networks often do not include all of the streets that actually exist, and the networks do not accurately model factors such as signal timing or turning movements), and these estimates must usually be refined before they can be used for design computations.

In general, the four-step planning models start with inputs in the form of zonal (socio-economic) and highway network information and produce estimates of traffic volumes. These relationships are fairly complex and inexact, and the model outputs must be carefully reviewed to ensure "reasonable" results. Four-step models are generally useful for larger projects and planning studies, particularly projects that occur in urban areas.

Among the four-step planning models the Department supports are

- QRS II,
- TModel 2
- MicroTRIPS,
- EMME II, and
- UTPS.

These models are listed in increasing order of their complexity and capabilities. QRS II is the simplest of the models but also has the fewest capabilities. EMME II and UTPS are the most complex and have the greatest capabilities. UTPS contains more complete transit modeling capabilities than EMME II, but EMME II allows graphical input (not possible with UTPS) and has considerably better graphics output than UTPS.

Within this guide, four-step planning models are differentiated primarily by the amount of effort required to operate each model, the number of default parameters each model provides (or allows to be over-written), and the detail each model allows when it electronically represents the city and highway being analyzed. In general, the more capable the four-step model is, the more difficult it is to use, and the more time it requires to operate.

Traffic Flow and Evaluation Models

The second category of microcomputer models are the traffic models. These models are concerned with specific roadway operations. They generally use a more sophisticated and precise model of the study area's highways than the four-step models do, but they usually cover a much smaller geographic area.

Models within the "traffic" category are differentiated from each other by the specific task each was designed to perform. While all four-step models perform the basic functions of trip generation, distribution, mode split and assignment, the traffic models tend to fulfill very different technical and functional needs.

The traffic models whose use the Department encourages are listed below.

- The Highway Emulator (THE) is a new model that combines the capabilities of the four-step models with the basic data requirements of the traffic models. It can create origin/destination tables from ground counts and then examine the impacts of roadway changes on the trips made using that O/D table.

- FREQ — This is a freeway simulation model used to examine the impacts of forecast traffic volumes on alternative freeway configurations.
- FRESIM — This is a detailed microscopic simulation model for analyzing the operation of freeway sections. It is more of an analysis tool than a forecast tool.
- NETSIM — This is a detailed microscopic simulation model for analyzing the operation of arterial signal networks. Like FRESIM, it is more of an analysis tool than a forecast tool. Recent work by FHWA has provided NETSIM with a graphic simulation component that can be useful in studying signal operation.
- HCS — The Highway Capacity Manual Software automates the analyses included in the 1985 upgrade to the Highway Capacity Manual.
- SOAP 84 — This is a program for designing isolated intersection signal timing plans for both actuated and semi-actuated controllers.
- TRANSYT-7F — This is a program for developing optimized traffic signal control plans for networked traffic signal systems.
- AAP — AAP is a modeling package that includes the TRANSYT-7F and PASSER II modeling programs. It is designed to allow the user to develop one database but use either or both of the modeling packages to examine alternative signal timing algorithms.
- PASSER III — This program is designed to assist in the development for signal timing plans for diamond interchanges.

Not all of the models listed above are used as part of the "forecasting" process (that is, the actual prediction of future traffic volumes). They are, however, part of the analysis process that parallels and impacts the forecasting effort and are often part of the design effort that includes the forecast volumes. Therefore, they are discussed in this guide to encourage their use and to help those in charge of forecasting future traffic levels investigate the "reasonableness" of specific traffic estimates and become aware of how those estimates will be used when they have been completed.

Other Models and Computational Aids

A number of the techniques used to develop forecasts require the application of reasonably simple mathematical procedures or the solving of various equations. As part of this project, several of these procedures and formulae have been converted into Lotus 1-2-3 spreadsheets. These spreadsheets are available through the Transportation Data Office. The capabilities and operation of these worksheets are described in Appendix A of this guide.

In addition to computer models, a number of other forecasting techniques exist. Most of these techniques were formalized prior to the advent of microcomputers, but they are still very valuable resources for obtaining initial forecasting assumptions, performing simple analyses, and learning about the factors which impact forecasts. Foremost among these resources are the NCHRP reports 187 (Quick Response Urban Travel Estimation Techniques and Transferable Parameters) and 255 (Highway Traffic Data For Urbanized Area Project Planning and Design), which are available in the WSDOT library.

DETAILED MODEL DESCRIPTIONS

The Quick Response System (QRS) Model

Quick Response System II (QRS II) is a set of computerized procedures for forecasting impacts of urban developments on highway traffic and for forecasting impacts of highway projects on travel patterns. It can also do complete transit ridership forecasts. Depending on the level of detail with which the network is described, QRS II can perform sketch planning or rigorous analysis. QRS II requires that the user draw the network with a program called General Network Editor (GNE). All data are entered through GNE.

Input Data Requirements

The following data are required if the user wants to develop project level traffic volumes, although the user may also input locally defined parameters at each step.

Table C-1. Input Data Requirements

- Map of study area including zone structure and highway links
- Zonal average income or average auto ownership
- Zonal retail and non-retail employment
- Zonal dwelling units
- Zone x - y coordinates
- Zone location type (CBD, center city, suburb);
- Percentage of travel on arterials within a zone
- Minimum travel time paths between zones

Output Generated By The Model

QRS II produces numerous reports and output files, which are listed below.

Table C-2. Output Data

- All assigned traffic volumes
- Shortest highway path from one origin to all destinations
- Transit loads
- Highway volumes and transit loads tabulated for specifically requested links
- Turning movements for specifically requested intersections
- Transfer volumes for requested transfer points
- Ridership levels for all transit routes
- Number of vehicle trips that go to, come from, or stay within every zone

Steps To Be Followed To Use The Model

The following steps may be used to complete a traffic simulation with QRS. More steps may be required, but these are the minimum number of steps.

Table C-3. Application Steps

1.	Establish base maps; trace zone boundaries; establish zone numbers
2.	Describe Highway link structure
3.	Develop zone data
4.	Calculate trip production and attractions
5.	Distribute trips using the gravity model
6.	Assign trips

The Cinch Model

The CINCH model will perform intersection capacity analysis and turning movement estimation. If the user chooses to perform an intersection capacity analysis, the model first performs volume and saturation flow rate adjustments for the specific geometric, traffic, and signalization conditions. It then provides a capacity analysis and indicates the level of service based on average delay per vehicle for the intersection and each approach.

This menu-controlled software is the equivalent of the intersection capacity analysis methods for signalized and unsignalized intersections described in the 1985 Highway Capacity Manual (HCM) and Circular 212. Data may be entered interactively at the keyboard or from files. The latter method alleviates the use of the forms supplied in the 1985 HCM. The model is iterative and allows quick revisions and changes to signal timing plans to provide rapid evaluation of alternatives.

The CINCH model will also estimate turning movements for three- and four-legged intersections according to the methods outlined in TRR #795, "Estimation of Turning Flows from Automatic Counts." The computer software acts as a "seed" program. It takes old turning movement data and new approach counts and rebalances the turning movements. The data for estimating turning movements must be entered manually.

Input Data Requirements

Intersection Capacity Analysis

The following chart lists the input data required to use CINCH for intersection capacity analysis. Remember that these data can be entered interactively at the keyboard and then stored in a file, or they can be retrieved from a file.

Three types of data (volume, geometric, and signal) are required.

Table C-4. Input Data for Intersection Capacity Analysis

Volume Data	Geometric Data	Signal Data
Left, right and through volumes by approach in vph	The location (CBD or non-CBD)	Number of phases
Number of buses stopping by approach	Number and average width (in feet) by approach for through/general purpose and exclusive left turns	Movements allowed by the phase
Number of pedestrians crossing by approach	Curb-to-curb distance (in feet) that pedestrians have to cross by approach	Green time by phase in seconds
Peak hour factor by approach	Grade (in %) by approach	Yellow and red clear times (change interval) by phase in seconds
Percentage of heavy vehicles by approach	Presence of parking or pedestrian actuation buttons	
Number of parking moves by approach		
Arrival type by approach		

Turning Movement Estimation Input

Three types of turning movement estimation may be performed:

- four-legged intersection- existing turns and future ins and outs known,
- three-legged intersection — existing turns and future ins and outs known, and
- three- or four-legged intersection — only ins and outs known.

Table C-5. Input Data for Turning Movement Estimation

Four-legged intersection	Three-legged intersection	Three- or four-legged intersection
• existing turns • future ins and outs	• existing turns • future ins and outs	• only ins and outs known

Output Generated By The Model

Intersection Capacity Analysis

While the format of the output data is similar to the ten worksheets at the end of Chapter 9 in the 1985 HCM, some exceptions are listed on page 23 of the user's manual. The first five charts summarize the output of the intersection capacity analysis program and the next lists the relatively simple output from the turning movement estimation program.

Table C-6 — Output Data from Intersection Capacity Analysis

Input Summary — all the required information on which subsequent computations are based	• Geometric conditions • Traffic conditions • Signalization conditions
Volume Adjustment	• Adjustment of movement volumes to reflect peak flow rates • Determination of lane groups for analysis • Adjustment for lane distribution
Saturation Flow Rate Adjustment	• Adjusted saturation flow rate to account for prevailing conditions that are not ideal
Capacity Analysis	• Flow ratio for each lane group • Capacity of each lane group • V/c ratio of each lane group • Critical v/c ratio for the overall intersection
Level-of-Service	• Average stopped-time delay per vehicle for each lane group, approach, and intersection • Level-of-service for each lane group, approach, and intersection • Average queue and 95th percentile queue for each lane group

Turning Movement Estimation Output

The turning movement estimation program simply provides estimates of the number of left and right turns, through movements, and exiting vehicles for each approach.

Steps To Be Followed To Use The Model

Because the program is menu-controlled and interactive, it is very simple to use, and repeating the steps here is unnecessary.

The Simplified Project Forecasting (SPF) Model

Simplified project forecasting serves as a quick alternative to the traditional four-step travel simulation forecasting process. The traffic forecasts provided for the design year are link specific and similar to the four-step process, except that SPF does not require large amounts of data and time.

To provide a forecast, SPF develops a growth factor for traffic on specific links as a function of growth in trips between any two zones in the area. The growth in trips is estimated with the gravity model, while the percentage total trips between zones using a specific link is estimated with a usage factor.

Input Data Required

The input data should give a representation of travel at the zonal level.

Table C-7. Input Data Requirements

- Productions and attractions (or surrogates) by zone for both base year and forecast year
- Zone centroid coordinates
- Endpoint coordinates of project being analyzed
- Population of urban area
- Functional class of highway containing project

Output Generated By SPF

The default destination for the program output is the terminal screen, but output may also be directed to the printer or to a user-named disk file.

Table C-8. Output from SPF

- Base year and future year predictions and attractions by zone with associated growth rates
- Growth and weighting factors at project level for six trip types

•	Overall traffic growth rate

Steps To Be Followed To Use The Model

The model comprises six modules, which may be selected from the main menu and executed sequentially.

Table C-9. Application Steps

1.	Establish project zonal system (24 districts).
2.	Compute productions and attractions (or, for example, population and employment) for each district.
3.	Determine zonal movements that will use or affect the project location (usage factors).
4.	Determine travel time and friction factors for each district movement.
5.	Apply growth factor equations to determine future growth.

The Highway Emulator Model

The Highway Emulator (THE) is a microcomputer-based highway traffic simulation model developed to model individual communities, corridors, sections of counties, or to analyze small sections of major cities. Based on trip generation equations from the Transportation Research Board report #187, the model can generate estimates of productions and attractions for three types of trips in each zone (home based work, home based non-work, and non-home based) and for external trips at the cordon line. After a preliminary assignment of these trip tables to a highway network, THE uses the initial trip table, a gravity model, and a "representative set of network traffic counts" (measured, actual counts) to adjust the trip table incrementally until it produces traffic volumes consistent with those observed counts.

THE comprises 11 separate programs in addition to a menu program that allows the user to move between the programs. Each of these programs may be run independently if the required data are accessible.

Input Data Requirements

The following two programs in THE require input from the user. Output from these models is used in later stages by the model. For instance, the assignment program uses the information from the network program to assign traffic volumes to particular links.

Table C-10. Input Data Required by THE Model

Network Coding	Node numbers at each end of the link Length of the link in miles Free flow speed on the link Whether link is one or two way Any additional impedances Hourly capacity for each link direction Traffic volume for each direction if THE will be used for calibration
Trip generation phase	External traffic zones Internal traffic zones The number of households by income range for each internal traffic zones The retail and non-retail employment for each internal traffic zone External zone cordon line volume

Output Generated By The Model

The information used to generate the output is stored in a traffic volume file. The output can be reported in two ways: as roadway segment volume information (speeds, capacities, assigned volumes, etc.) or as intersection turning movement information.

Table C-11. Output from The Highway Emulator

Summary page	• name of network file used • trip table used • number of traffic zones • hours for which the trip table applies • vehicle miles traveled for entire system • vehicle hours traveled for entire system
Report #1 Output	• information concerning the total volume of traffic assigned to each link by direction
Report #2 Output	• volume, speed, and capacity information

Steps To Be Followed To Use The Model

The following steps should be followed to develop a trip origin/destination table. If only traffic count information is used, then

1. Identify the area to be modeled and balanced.
2. Define a coded network.
3. Key the network attribute data and volumes into THE model.
4. Use the trip table program to create a trip table with a uniform value in every cell.
5. Run the trip table estimation program to develop a calibrated trip table.
6. Output the calibrated trip table.
7. Output traffic volumes from the assignment of a calibrated table

THE can also be used for site analysis by showing the change in traffic volume as a result of development.

1. Define the area to be modeled and the AM peak hour traffic counts.
2. Code the highway network.
3. Input data to THE.
4. Create a trip table matrix of uniform values.
5. Use the trip table estimation program to estimate the trip origin destination table.
6. Print out the calibrated trip table.

7. Perform a traffic assignment.

8. Print out the traffic assignment

9. Edit the trip table to include trips to and from the development site.

10. Perform a traffic assignment.

11. Print out the traffic assignment

TMODEL2

TMODEL2 is a microcomputer version of a classic 4-step planning model. It uses a convenient menu driven structure and contains batch processing options to speed up processing for users familiar with the program. The model was designed with the PCs graphics capabilities in mind, and is a good choice for medium large modeling efforts.

TMODEL2 provides a reasonable level of flexibility in the analysis process by providing both defaults for most modeling parameters and the option to change those defaults where such information is available. TMODEL2 follows the classic modeling procedure of network and zone construction, trip generation, trip distribution, mode split and assignment. The model does give the option of using either pre- or post-distribution mode split procedures, and provides some flexibility for the user to define the mode split model to be used. However, the model does set limits on the form these models can take.

TMODEL2 is primarily designed to model automobile traffic. It can be used to generate transit networks, but it is not intended as a transit analysis tool, and does not contain the techniques necessary to evaluate transit operations.

The model does have a number of utilities which allow for manipulation of trip tables, and zonal and network attributes. These utilities allow graphic review and manipulation of data files where appropriate. However, X/Y coordinate information must be included in the databases to be used if the graphics portions of TMODEL2 are to be used.

Input data Requirements

The following data are required if the user wants to use the model in its intended fashion.

Table C-12. Input Data Required by TModel2

Network Data	Consecutive Zone and Node numbers Length of the link in hundredths of miles Free flow speed on the link One-way capacity Optional area types and facility types, extra impedances Intersection capacity, turning movement restrictions and penalties
Zonal Data	Population and employment data for up to 10 land use categories Trip generation rates

Output Generated by the Model

TMODEL2 produces a variety of outputs, including link volumes, estimated speeds and volume/capacity ratios. This information can be viewed in either graphic or tabular formats. Output can be directed to the computer screen, standard printers, or to multi-pen plotters. The model also has the ability to output specialized analyzes such as selected link or selected zone statistics, and turning movement analyses.

The Urban Transportation Planning System (UTPS)

The Urban Transportation Planning System was developed by the U.S. Department of Transportation between the late 1960s and the early 1980s. It is a mainframe computer package that runs only on IBM 370 and compatible computer systems.

UTPS is the most complete and flexible of the available four-step modeling packages. However, it is old, runs on a limited number of computers, and is the least "user friendly" of the models currently available. UTPS can explicitly model both automobiles and up to eight additional modes of travel.

The user can adjust almost all parameters used in the model and perform a wide variety of data manipulations with utility programs supplied with the transportation modeling software. The documentation supplied with the model is very complete, but it is quite voluminous, requiring ten megabytes of computer disk space, or roughly one entire drawer of a standard file cabinet if printed on paper.

Input Data Requirements

UTPS requires a large quantity of information. It can handle any number of socio-economic variables attributable to zones; complete traffic networks, including turn penalties, toll facilities, and HOV facilities; as well as complete descriptions of transit networks, including walk movements, park and rides, transit lines for a variety of modes, transit fares, transfer parameters, and other transit inputs.

The greatest advantage of UTPS is that the modeler has control over the vast majority of data items and processing procedures used to estimate forecasted traffic levels. The disadvantage of UTPS is that the forecaster must often also supply many parameters that are unimportant to the forecaster, whereas these values are provided as defaults in other modeling packages. Secondary disadvantages to the new user are the lack of a menu driven system for implementing UTPS runs and the amount of training required to operate the mainframe computers that maintain the system.

Output Generated By The Model

UTPS produces a wide variety of output reports. However, with the exception of large traffic flow maps produced on a mainframe plotter, it lacks graphical output capabilities. Most UTPS reports are tabular reports that provide almost all the information desired by a traffic forecaster, including traffic volumes, v/c ratios, air pollution estimates, travel times between specified points, trip interchange matrices, and various selected link statistics. However, the tabular format used to print this information tends to be cumbersome to read and often contains a large number of data not desired by the user. These data must be skipped over to get the desired figures.

Steps To Be Followed To Use The Model

The steps involved in running UTPS are too involved to discuss here. UTPS contains over 20 specific programs to perform the wide variety of tasks built into the package. The specific set of programs required to progress from network development through the four-step process varies depending on the complexity of analysis performed and the types of output information are desired. A typical flowchart of a UTPS process is shown in Figure C-1.

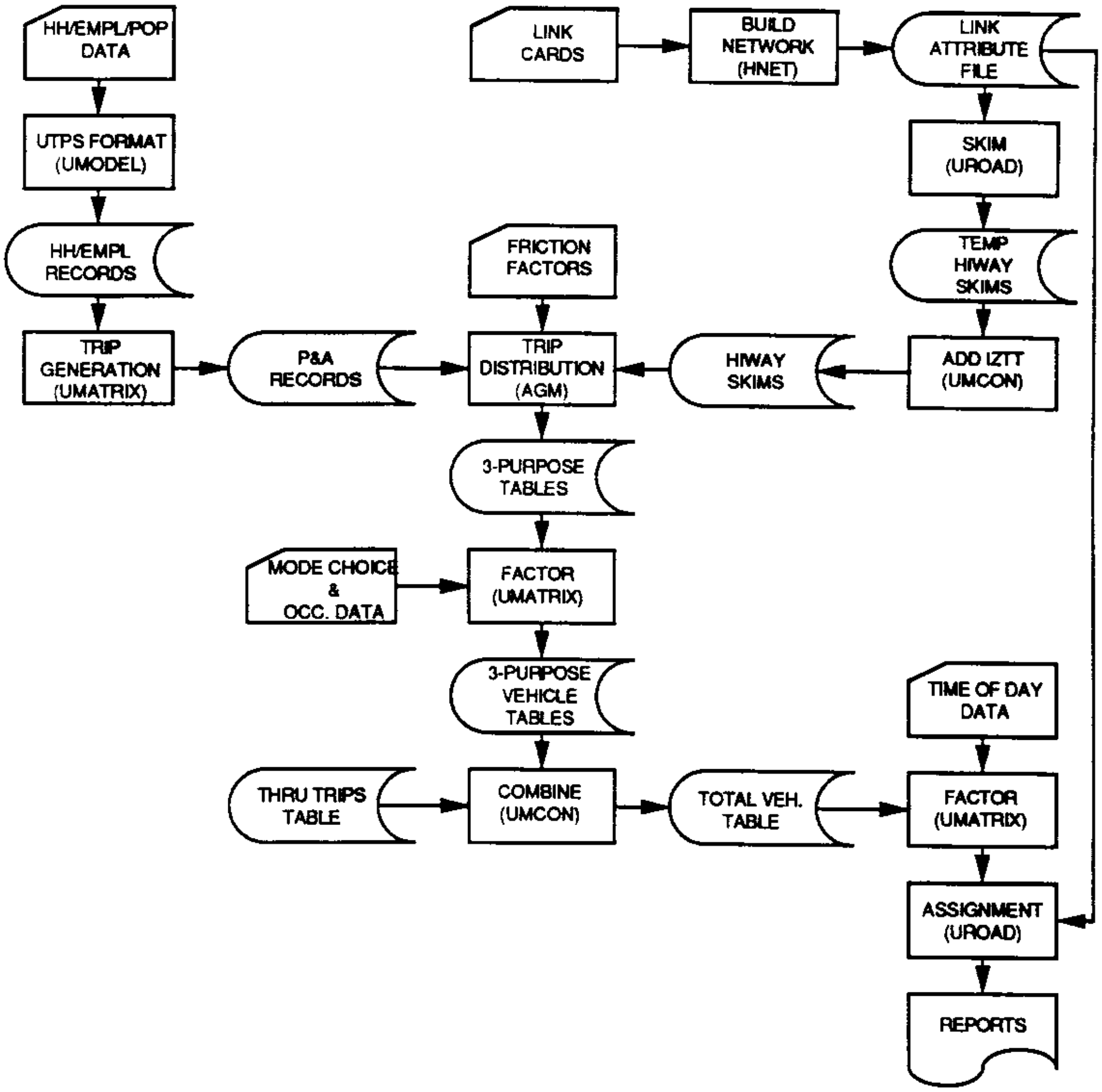

Figure C-1. Typical UTPS Modeling Sequence

APPENDIX D

DATA REQUIREMENTS AND SOURCES

TABLE D-1

DATA AVAILABLE FOR USE IN FORECASTING

Type of Data	Location(s)	Use For Data
Short Duration Traffic Volume Counts	TRIPS database Transportation Data Office Annual Traffic Report New data collection	Estimate current traffic volumes Review historical trends
Permanent Traffic Recorders	TRIPS database Annual Traffic Report	Examine seasonal changes Review historical trends
Vehicle Classification Counts	TRIPS database Transportation Data Office Annual Traffic Report New data collection	Estimate current traffic volumes Review historical trends
Truck Weight Surveys	TRIPS database Transportation Data Office	Examine pavement loading aspects of trucks using the project facilities.
Origin / Destination Surveys	Transportation Data Office MPOs	Input to model calibration process Examine impact of new roads on specific movements made by target areas of population and industry.
Turning Movement Counts	TRIPS database Transportation Data Office	Intersection analysis
Population Estimates	MPOs WSDOT Planning Office Transportation Data Office Census Bureau Local counties and cities OFM	Input to planning models Estimates of predicted growth and growth rates Estimating trip generation
Employment Estimates	MPOs WSDOT Planning Office Local counties and cities Employment Security Labor and Industries	Input to planning models Estimates of predicted growth and growth rates Estimating trip generation
Industrial / Agricultural Activity Estimates	County Offices Reebie Ass. Trans. Consultants Woods & Poole Economics, Inc. WSU (Casavant)	Input to planning models Estimates of predicted growth and growth rates Estimating trip generation
Transit / HOV Information	MPOs Local Transit authorities Transportation Planning Office	Estimating mode split Examining the impact of HOV incentives
Statewide Growth Esitmates	TRIPS database Transportation Data Office OFM	Background (through) traffic growth estimates for rural roads

TABLE D-2

INPUT DATA NEEDED FOR FORECAST TECHNIQUES

Forecast Technique	Population / Employment Data	Traffic Estimates	Other Data
QRS II	Base year & forecast year estimates of average income or auto ownership, retail and non-retail employment and dwelling units by zone	None, except for calibration and comparison against base year estimates.	Map of the study area and/or coordinates of nodes in the transportation system. Min. travel times between zones. Percent travel on arterials within zones.
SPF	Production and Attraction estimates by zone Pop. of urban area.	None, except for calibration and comparison against base year estimates.	Endpoint coordinates of project being analyzed.
MicroTRIPS	Base year & forecast year estimates of pop. and emp. by zone	None, except for calibration and comparison against base year estimates.	Highway network file or highway description (distances, number of lanes, etc.)
TModel2	Base year & forecast year estimates of pop. and emp. by zone	None, except for calibration and comparison against base year estimates.	Highway network file or highway description (distances, number of lanes, etc.)
EMME II	Base year & forecast year estimates by zone	None, except for calibration and comparison against base year estimates.	Highway network file or highway description (distances, number of lanes, etc.)
UTPS	Base year & forecast year estimates by zone	None, except for calibration and comparison against base year estimates.	Highway network file or highway description (distances, number of lanes, etc.) Trip generation rate equations Mode split model.
Spreadsheet Calculator	None, except for general consideration	Base year AADT Estimates Base year truck volumes by vehicle class	Estimated growth rate Type of growth expected (straight line, compound, etc.) Truck volumes
CINCH	None, except for general consideration	Base year hourly volumes Base year turning movements Number of Buses Percentage of heavy vehicles	Pedestrian Movements Signal Timing Plans Parking Movements Geometric Data
Highway Emulator	Number of Households By Income Range By Zone Rtail and Non-retail Employment By Zone	Base year hourly volumes Cordon line volumes	Link Distances and Speeds Hourly Capacity Any Additional Impedances