TECHNICAL REPORT SMALL/MEDIUM SIZE URBAN AREA ISSUES: METROPOLITAN PLANNING

ABSTRACT

As part of a project funded by the Texas Department of Transportation (TxDOT) to examine methods of improving transportation planning techniques, the need to decrease the burden on the planning staff in smaller urban areas (populations less than 200,000) was addressed. In many cases, these smaller areas may not have the financial or personnel resources to determine growth using the traditional models or methods. An existing technique (the Delphi process) was modified to establish a procedure for allocating projected growth at the zone level. A qualitative measure of each zone's growth potential relative to the other zones in the area was established and used to allocate the projections of population and employment. The Delphi process can provide good results in a short time frame, which provides the benefit of accelerating the overall planning process. The Delphi process is based on an iterative process. A panel of local experts and involved citizens participated in the process to reach a consensus.

A pilot project was conducted in the Longview, Texas, area in the summer of 1992 to examine the ability of the Delphi process to allocate future growth. The pilot project employed a three-tiered process in allocating the areas projected population and employment growth (for the year 2015) to 219 traffic analysis zones. Benefits of the Delphi process include reduced costs to the MPO in both time and money; social, political, and legal advantages of basing the allocations on a panel consensus; and the advantages of involving members of local agencies and committees during the allocation process. Support software and a user's manual are currently under development for TxDOT.

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PREFACE

This is the third in a periodic series of reports issued by the Metropolitan Planning Division, Federal Highway Administration. The three reports in this issue focus on two distinct topics: analysis issues faced in small/medium sized urban areas and cost analysis.

The first report discusses the analysis needs of small and medium size urban areas as they attempt to meet the requirements of ISTEA and the 1990 Clean Air Act Amendments. This report explains the rationale for new technical capabilities and then explains how these new capabilities my be developed. A number of topics are discussed including the following: multimodal demand analysis, land use, social and environmental impacts, time-of-day analysis, and post processing for speeds.

The second report describes the use of the Delphi process in projecting the allocation of growth in urban areas. The report is based on a case study of an application of the process in a small urban area in Texas. This same process could be used in other urban areas, however its application is most appropriate in urban areas with a population of 200,000 or less.

The third report provides assistance to those trying to evaluate transportation alternatives across modes by describing the process for performing a least cost analysis of investment alternatives. The method described is a tool for performing an analysis from a societal point of view using a common measure (i.e. total cost) in an attempt to account for the full cost of each alternative. This methodology is applicable for several different categories of alternatives including both infrastructure development and systems management solutions.

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INTRODUCTION

Many small urban areas do not currently have four-step travel demand models, and may not need to develop full-blown four-step models. A good traffic monitoring program supplemented by manual analysis techniques for demand analysis may be all that is needed, in many cases; or a simple demand modeling computer package, such as QRS II, may be adequate. This paper focuses on those areas which currently have four-step models, or are required to have them because of air quality conformity requirements.

When travel models were first developed in the 1950s, their purpose was to provide a means to evaluate major highway and transit investments and transportation system plans. Only a crude level of accuracy of forecasts was necessary. Today, however, these models are being called upon to evaluate, in addition, demand management policy impacts as well as pollutant emissions impacts. These uses require a finer level of accuracy as well as sensitivity to new variables which were not incorporated into the models of most small and medium sized urban areas which currently have models.

The expansion of the role of travel models has resulted primarily from mandates in the Clean Air Act Amendments (CAAA) of 1990 and the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991. Conformity regulations issued in November 1993 pursuant to the CAAA have spelled out certain "standards" that travel models are required to meet for conformity analyses. Planning and Congestion Management regulations also issued in the Fall of 1993 pursuant to the ISTEA will require many (not all) urban areas to develop enhanced modeling and technical analysis capabilities to address multimodal evaluation issues, as well as issues relating to land use and demand management and evaluation of social, environmental and economic impacts of transportation alternatives.

This paper discusses the issues which impact analysis needs in small and medium sized urban areas and explains the rationale for new technical capabilities. It then discusses how these new capabilities may be developed in small and medium sized urban areas. Urban areas which are designated as nonattainment areas for ozone or carbon monoxide in serious or above categories will need to develop enhanced travel modeling capabilities by January 1, 1995. Transportation Management Areas (TMAs) will also need to develop enhanced capabilities for evaluating congestion management strategies. Urban areas which are not TMAs or serious or above nonattainment areas will also need enhanced analysis capabilities to address multimodal evaluation mandates in the ISTEA.

This paper is organized as follows. First issues stemming from the ISTEA are discussed, along with their implications for travel demand analysis and impact estimation. Next, issues stemming from the conformity rules are discussed along with appropriate responses from small and medium-sized urban areas subject to the rule. The paper concludes with a summary of technical assistance and training available from FHWA to assist urban areas in developing appropriate analysis capabilities.

ISTEA ISSUES

There are no modeling requirements in the ISTEA or its related regulations. However, the many requirements relating to evaluation have implications for the level of sophistication of the travel demand forecasting process, while the requirements for public involvement have implications for the level of transparency of the models to assure that the public can understand how they work. Small and medium sized urban areas may need to enhance the level of sophistication of their analysis procedures to address multimodal evaluation issues, as well as land use, social, environmental, and economic issues which are emphasized in the ISTEA, while at the same time assuring that the new sophisticated procedures remain transparent.

Multimodal Demand Analysis

Multimodal, intermodal and cross-modal evaluation are emphasized throughout the ISTEA. The Act seeks to develop the most "efficient" mix of modal investments compatible with social, environmental and economic goals, and to reduce dependence on single-occupant vehicle (SOV) travel. Thus, measures of transportation system performance and levels of service, hitherto geared primarily towards highway travel in small and medium sized urban areas, will have to reflect all modes.

Does this mean that travel demand models will also have to reflect all modes -- including transit, bicycle and pedestrian, which have usually been excluded from the models? Not necessarily. The answer depends on how significant a role these modes are anticipated to have in future transportation systems. Even if a significant role is anticipated, there will be options relating to how these modes will be incorporated into the four-step process. For example, trip generation could be done by mode; or alternatively, person trips by all modes could be generated, and then split into separate modes in the mode split step.

If person trips are generated during trip generation, possible ways to address this issue are:

1. Use "off-model" software, i.e. software outside the four-step model, such as FHWA's TDM software (1), to obtain changes in base mode shares due to specific pricing or transit strategies. For example, FHWA's TDM software accepts as input trip tables from commercial demand modeling packages, and outputs modified trip tables for input into trip assignment. The TDM model uses a logit-based pivot point procedure.

2. Borrow a mode choice model from a similar urban area and validate it. The NCHRP Report No. 187 update (2) will include "standard" model coefficients for in- vehicle time, out-of-vehicle time and cost which may be used in small and medium size urban areas after validation. However, considerable effort would be needed to develop new transit networks to estimate the time and cost inputs.

3. Use sketch planning procedures. A recent publication of the Washington Metropolitan Council of Governments (3), which will be distributed by FHWA, presents examples of application of off-model software, mode choice modeling, and sketch planning techniques to analyze the travel behavior impacts of various types of multimodal strategies. FHWA is also developing an Advanced Transportation Systems Analysis course to address issues relating to demand analysis for multimodal systems.

Land Use

Consistency between land use and transportation plans is required under the ISTEA. The most sophisticated way to address the issue is to develop and calibrate linked transportation- land use models, such as DRAM/EMPAL, ITLUP, MEPLAN and POLIS. These models forecast the likely location of future employment and population growth based on changes in accessibility as well as other zonal attributes such as available vacant land and zoning. However, significant effort is needed to collect data and calibrate such models, and their predictive abilities are questionable. Therefore, such models would generally be inappropriate for small and medium sized urban areas.

Small and medium sized urban areas may use simpler approaches to address this issue. For example, they may simply compare changes in district-level accessibility indices with growth forecasts, to ensure that districts with relatively large increases in accessibility have been allocated a larger share of future regional residential or employment growth. A fairly simple way to check whether zonal employment growth estimates are reasonable is to run the gravity model for one iteration (instead of the three iterations normally specified), and review the comparison of trips attracted to input trip attractions. For zones with too large an imbalance, the imbalance may indicate that employment projections (and development forecasts) need adjustment.

One issue relating to land use is the contention that if urban areas are to reduce dependence on SOV travel and encourage alternative modes, the key to the successful achievement of such goals will be compatible development patterns. The implication for travel demand models is clear. The model forecasts will need to be sensitive to development patterns such as density, pedestrian and bicycle friendliness, and land use mix. This will pose a challenge to small and medium size urban areas, because except for studies in a few urban areas, such as Portland's LUTRAQ study (4), such models have not been used in the U.S. If major changes in future land use patterns are proposed for evaluation in small and medium sized areas, trip generation rates will need to be reviewed and adjusted, at least to reflect density impacts.

Social Impacts

The ISTEA encourages use of transportation policies to help achieve social goals. A major target group, identified on page 1 of the ISTEA, is the economically disadvantaged. This group has been locked out of access to new jobs which have been primarily created in auto- dependent suburbs in the last two decades. There is a debate as to whether this problem should be addressed simply by providing more transportation services from central parts of urban areas (where the majority of this group live) to the suburbs; or whether transportation and other public policies should be used to encourage shift of job growth to central cities and inner suburbs.

There are implications for travel demand and land use modeling procedures. Models may need to provide measures of accessibility to jobs and other social services for such groups. Historically, the denominator of the gravity model has frequently served as an index of accessibility of individual zones. A 1972 report by FHWA (5) discusses the use of this criterion as an evaluation measure and provides examples.

Analysis procedures may also need to consider the impact of transportation investments on the continuing flight of jobs to the suburbs and further decline of central cities. This will not be easy, since job location patterns depend on many more factors than just transportation. For example, Leinberger (6) suggests that Sears moved its headquarters from downtown Chicago to the outer suburbs to get away from what it perceived as a less productive central city labor force. Such problems cannot be solved solely through transportation policies, but transportation policies and their potential contribution must be included in the comprehensive planning process to address such issues. FHWA has therefore initiated a major research program to demonstrate transportation's role in addressing the issue of access to jobs for the economically disadvantaged, and technical assistance and training related to this issue will follow.

Other social impacts, for example impacts on neighborhood cohesion, aesthetics, sense of place, livability and quality of life are not easily derived from travel model outputs. Qualitative assessments of these impacts is all that may be expected in small and medium sized urban areas.

Environmental Impacts

The ISTEA mandates the assessment of both "direct and indirect" impacts of transportation investments. The issue arises from the increasing concern about the external environmental costs of highways and vehicle use. Many indirect costs such as air, noise, water and land pollution costs, or loss of natural or historical resources, are not borne by vehicle users. Uncertain future impacts, such as climate change, are also a concern.

These issues imply that environmental considerations must be included early in the planning process, before and during development of transportation alternatives; and not "after the lines are drawn on paper" or after transportation solutions are "cast in concrete", simply to consider mitigation of negative impacts of pre-selected alternatives.

To allow the computation of many types of environmental impacts, travel analysis procedures will need to be enhanced to provide more accurate speed estimates. Models used in most small and medium sized urban areas have been calibrated to provide good estimates of traffic volumes, but not vehicle speeds. Accurate speeds are needed to estimate emissions, energy use, and other environmental consequences of alternative transportation plans, programs and projects. FHWA has developed a new course entitled "Estimating the Impacts of Transportation Alternatives " which will provide the tools needed by urban areas to perform "sketch planning" type impact analysis for regional system studies as well as corridor or subzero studies.

Economic Impacts

The ISTEA's theme of "efficiency" is reflected throughout the legislation. (The "E" in ISTEA stands for Efficiency). The concern is that the U.S. cannot maintain competitiveness in an international marketplace if its transportation system is inefficient; therefore inefficiencies such as congestion and inefficient use of limited road space during peak travel periods should be addressed in transportation plans and programs.

Transportation Management Areas (TMAs) as well as smaller urban areas which project congestion in the future due to limitations of available funding to provide additional peak period capacity will need to consider congestion management strategies. This means that they will have to upgrade their analysis procedures (either four-step, off-model or sketch planning procedures) to provide the capability to forecast the impacts of strategies such as congestion pricing, parking pricing, TDM and TSM strategies, and land use strategies designed to make travel more efficient.

FHWA is attempting to develop the types of tools and training programs that will be needed to address these concerns. For example, FHWA's forthcoming course "Advanced Transportation Systems Analysis" will provide training in development of forecasting tools, while the new course "Estimating the Impacts of Transportation Alternatives" will provide the tools which urban areas will need to evaluate the costs, benefits, and economic efficiency impacts of such strategies. Another new FHWA course "Congestion Management for Technical Staff" provides tools to evaluate and monitor the impacts of congestion management strategies.

The ISTEA also calls for evaluation of economic development impacts. Since economic development depends on many factors other than transportation, such impacts will be difficult to estimate at a localized level. Regional economic impact analysis procedures such as input-output models are too complex for most small and medium sized urban areas. Qualitative assessments of the relative differences in economic impacts of alternatives should suffice.

SOV Restrictions

In urban areas which are in non-attainment status for air quality, the ISTEA imposes restrictions on the provision of new highway capacity which may be used by SOVs. Such new capacity may not be built unless it comes from a Congestion Management System, under which a host of management strategies will need to be considered.

This implies that the travel demand analysis procedures in non-attainment areas will need to be capable of evaluating land use, TDM, TSM and pricing strategies. As discussed earlier under "Multimodal Demand Analysis", the four-step process or off-model procedures may be used for such analysis.

CONFORMITY ISSUES

In serious and above nonattainment areas, the conformity rules either require or "encourage" many model features that are not currently employed in the forecasting processes of most small or medium sized urban areas. These features are discussed in the following subsections.

Trip Generation

Sensitivity of trip attraction and production rates to measures of zonal accessibility is "strongly encouraged" by the rules. This issue most likely stems from the contention that congestion will have a dampening effect on trip making -- therefore a "no-build" scenario should have less trips (and emissions) than current models predict, while "build" scenarios should have more.

One "sophisticated" way to achieve sensitivity of household trip production rates to accessibility is to develop regression models based on zonal accessibility for each cell of the trip production cross-classification matrix. Developing such relationships will involve excessive new data collection and model calibration. In small and medium sized urban areas, a simpler approach could be used. For example, trip rates could be developed separately by urban density category or by location (i.e., central city, suburb, and rural fringe) as a surrogate for zonal accessibility. If severe congestion is forecasted, a quantitative assessment of any impact on trip rates may be needed.

Trip Distribution

The conformity rules require travel times used in trip distribution to be consistent with travel times resulting from trip assignment. Congestion, it is believed, will cause trips to be sent to closer destinations. Thus, in a "no-build" scenario, travel distances (and therefore VMT) will be less than in a "build" scenario. Implementing this feature in the forecasting process will pose two main questions:

1. How should congested travel times, which occur mainly during peak periods, be used to distribute daily trips -- the majority of which actually occur in off-peak periods?

2. Travel times output by traffic assignment are not true travel times, but actually "impedances" which are based on speed inputs adjusted during model calibration to obtain a better match of assigned volumes to counts. Should these "impedances" be compared with travel times used in trip distribution? Or would it be more appropriate to first calculate "true" congested travel times based on speed-volume relationships and the assigned vehicle volumes?

Clearly, the questions raised above will need to be resolved before urban areas venture to implement the requirement for travel time consistency between trip distribution inputs and traffic assignment outputs. FHWA is currently undertaking research to develop appropriate techniques.

The conformity rule also requires sensitivity of the trip distribution model to pricing under certain conditions. A simple way to introduce such sensitivity would be to add the time equivalent of tolls and parking charges (with value of time based on some percentage of average wage rates) to the travel time matrix used as input into trip distribution. Note that recalibration of friction factors would be needed, as well as data on average parking costs by zone. In urban areas where parking pricing or road pricing strategies will be considered, the extra effort may be justified.

Mode Split

The conformity rule suggests that mode split models should be sensitive to pricing and transit travel times, where significant transit or pricing strategies are anticipated. In many small and medium sized urban areas, this will pose a problem, since trips are either generated as vehicle trips so that a mode split step is not needed, or person trips generated during trip generation are split by mode in the mode split step using base year percentages, and auto person trips are converted to vehicle trips using base year auto occupancies.

To address this issue, mode split models could be upgraded either based on a mode choice model borrowed from another urban area or from the NCHRP Report No. 187 update (2), or using “off-model “ procedures as discussed earlier under the section "Multimodal Demand Analysis". Of course, person trips will need to be generated during trip generation.

Traffic Assignment

The conformity rule requires that input free flow speeds be based on empirical observations. The contention is that many urban areas use posted speeds as inputs instead of observed free flow speeds. They therefore often underestimate these speeds since speed limits are often exceeded by motorists. Lower speeds will tend to underestimate NOx emissions, and on high speed facilities, HC and CO emissions as well.

Addressing this conformity requirement appears simple. It appears that all that is required is to recode the network speeds to match sampled observed free flow speeds on various facility classes. However, such recoding could result in major shifts in assigned traffic volumes so that they no longer match ground counts. This is because free flow speed inputs are often adjusted by modelers during model calibration simply to get a better match of assigned volumes to ground counts. In other words, free flow speeds used as input in many assignment models are not meant to be accurate speeds but only calibrated "impedance" parameters.

Perhaps a simple way to address this issue is through post-processing of assigned volumes using "accurate" speed-volume relationships to get better speed estimates. Post processing is discussed in a later section.

Time-of-Day (T-0-D) Analysis

The conformity rule requires models to provide peak and off-peak travel demand and travel time estimates. There appear to be three relevant impacts of T-0-D analysis. First, emissions models predict higher emissions at the low and the high ends of the speed range; therefore separate peak and off peak speeds should generate higher modeled emissions than a composite peak/off-peak speed. Second, a "no-build" scenario might show less congestion and emissions if the time-of-day analysis procedure incorporates peak spreading effects. In other words, under a "no-build" scenario for which peak spreading is modeled, estimated peak speeds may not be as low, and high off-peak speeds may be moderated, reducing relative emissions. A third reason for time-of-day analysis arises from the need to adequately model shifts in time of travel that could result from pricing strategies.

Addressing the time-of-day analysis requirement will not be easy, if congestion and pricing influences are to be considered. The range of options is as follows:

1. Continue the current practice in most urban areas of using fixed T-0-D factors by link category which convert daily traffic volumes to peak period or off-peak volumes, with no attempt to dampen peaks to account for higher levels of congestion or new pricing policies. This technique may be appropriate if forecasted increases in congestion are not large.

2. Use the above procedure, but vary factors to account for congestion levels and/or pricing. Account for peak spreading due to congestion using relationships of the distribution of hourly traffic percentages to AADT/C ratios (13). This technique may be appropriate if forecasted increases in congestion are large.

3. Perform time-of-day splits in earlier steps of the four-step process, as is currently done in a few large urban areas. Using observed time-of-day splits from home interview surveys, daily trips may be split into A.M., P.M. and off-peak trips either: (a) prior to trip distribution (i.e. daily trip ends are split); (b) prior to mode choice (i.e. person trip tables are split); or (c) prior to traffic assignment (i.e. vehicle trip tables are split). To validate the assigned volumes, traffic counts by time-of-day are needed. Also, since factors used are developed from base year data, they may not reflect changes in time of travel in the future as a result of congestion. Due to its complexity and its data requirements (both travel survey and count data by time-of- day), this type of procedure is probably not practical in most small and medium sized urban areas.

4. Use the procedures discussed in item 3, but instead of using fixed splits based on base-year survey data, develop procedures to adjust these splits based on congestion levels and peak vs. off-peak monetary costs. Greig Harvey's TRIPS model (7) can accomplish such splits by time-of-day, but it does not include an assignment procedure, and must be used in conjunction with a network model for assignment. The Montgomery County National Park and Planning Commission has also developed some complex procedures to model departure time choice (8). Such procedures are far too difficult for small and medium sized urban areas to implement.

Post Processing for Speeds

The conformity rules require estimates of traffic speeds and delays to be based on estimates of traffic volumes on network links. It appears that the common practice of averaging speeds by functional class will not be acceptable, probably because average speeds tend to be in the middle of the speed range where emission factors are lowest and not usually very sensitive to small differences in speed. This requirement will need to be addressed by post- processing of link traffic volumes after assignment. There are many options to accomplish this.

Perhaps the simplest method to obtain peak and off-peak link speeds is to use relationships of daily traffic volumes over hourly capacity (AADT/C ratios) to speed -- both average daily speed as well as speed by hour of the day. Relationships of AADT/C ratios to average daily speeds have been developed by Margiotta et al for FHWA (9) . The study also generated tables of hourly speeds for ADT/C ratios ranging between 4 and 16 for freeways and arterials, based on a T-0-D distribution of traffic that did not vary with ADT/C (unpublished data, from Margiotta). In a continuing phase of the study, FHWA will develop hourly speed tables based on T-0-D distributions that vary by time of day. This will allow development of weighted average speeds for both peak and off-peak periods.

More sophisticated approaches use Highway Capacity Manual (HCM) procedures with default input parameters (e.g. signal cycle lengths) by functional class. The EPA guidance (10) and Houston Galveston Area Council's procedures (1l) are good examples. An intermediate level of detail uses relationships of V/C ratios to highway level of service (LOS) and LOS to speed from look-up tables (12).

Land Use

The conformity rules require that land use forecasts be consistent with future transportation systems. It is contended that expanded highway systems increase accessibility of undeveloped areas on the fringes of metropolitan areas, promoting sprawl development patterns and greater dependence on automobiles; "no-build" scenarios, with their congestion levels and reduced accessibility to fringe areas, promote more compact development patterns with reduced reliance on automobiles. Such differences in development patterns, it is believed, should be reflected in the land use inputs to the travel demand models for alternative transportation system scenarios. Procedures to determine whether any adjustments may be needed to land use inputs have been discussed earlier under the "Land Use" section relating to ISTEA issues.

FHWA TRAINING COURSES

FHWA is attempting to play a leadership role in addressing the various issues raised by ISTEA and the CAAA. New training courses are being developed, and some are already available. This section provides a description, as of the date of the Conference, of the various courses sponsored by FHWA's National Highway Institute (NHI) to assist urban areas in developing their technical analysis capabilities to address issues stemming from the ISTEA and the CAAA.

Course No. 15259: Congestion Management for Technical Staff Contact: Douglas Laird (202) 366-5972

This three day course provides participants with an in-depth examination of the elements required to successfully develop, implement, and operate a congestion management system (CMS). Subjects will include: modes and networks to monitor, the development of performance measures, establishment of a data collection and performance monitoring plan, identification and evaluation of CMS strategies, linking performance measures to CMS strategies, monitoring strategy effectiveness, relationship to other management systems, and documentation of the CMS. The course is designed for staff responsible for CMS implementation and operation.

15265: Workshop on Transportation-Air Quality Analysis Contact: Jerry Everett (202) 366-4079

This two-day course emphasizes state-of-the-art practices for developing travel-related data for mobile source emissions inventories, analyzing transportation improvement programs and plans for conformity to state implementation plans (SIPs), forecasting and tracking vehicle miles of travel (VMT), and evaluating transportation control measures (TCMs). Additional topics include procedures for analyzing accessibility changes using the four-step travel demand forecasting (TDF) process, emission factor models, and travel demand forecasting and emission factor model interactions. These procedures will be demonstrated through manual workshops. An understanding of the travel demand forecasting process would be helpful for those taking this course.

15257: Estimating the Impacts of Transportation Alternatives (Available Fall 1994) Contact: Patrick DeCorla-Souza (202) 366-4076

This three day course will provide guidance on estimating costs, benefits and impacts for evaluation of highway and mass transit alternatives at the system level, as well as for screening alternatives at the corridor/subarea and project levels. Topics to be covered include estimation of public and private costs; air pollutant emissions and concentrations; energy consumption; safety/security, economic development, equity and other social and environmental impacts; and techniques for cost-benefit and cost-effectiveness analysis. Software for estimating impacts will be introduced through hands-on workshops.

15260: Advanced Travel Demand Forecasting (Available Spring 1995) Contact: Patrick DeCorla-Souza (202) 366-4076

This three-day course will emphasize advanced practices for system level modeling and analysis of travel demand management (TDM) and transportation control measures (TCMs). It will include state-of-the-art procedures for land use forecasting, travel demand modeling using the four-step process, and estimation of TDM/TCM travel impacts. Procedures will be demonstrated through hands-on computer workshops. An understanding of the travel demand forecasting process is a prerequisite for this course.

15263: Intermodal & Public Transportation Management Systems for Technical Staff (Listed as: "Management Systems for Technical Staff" in the NHI Catalog) Contact: Dane Ismart (202) 366-4071

This three-day course covers in detail the technical guidelines and requirements for the State development, establishment, and implementation of the intermodal management system (IMS) and the public transportation facilities and equipment management system (PTMS). Discussion on the relationships and integration with the other management systems, especially the congestion management system, will be included. Emphasis will be on understanding the basis for the IMS and PTMS, performance measures and data needed to assess strategies, and methods to successfully design, implement, and administer the IMS and PTMS.

CONCLUSIONS

Most small and medium sized urban areas will need to enhance their technical analysis capabilities to respond to ISTEA. Serious and above non-attainment areas will need to address specific modeling requirements in the conformity rules. FHWA is responding to these needs by providing technical assistance and training through existing and new NHI courses on Congestion Management, Impact Estimation, Advanced Transportation Systems Analysis, Transportation-Air Quality Analysis and Intermodal and Public Transportation Management Systems.

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GROWTH ALLOCATION BY THE DELPHI PROCESS

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DISCLAIMER

IMPLEMENTATION STATEMENT

The process presented in this report is intended for use by urban areas with populations of 200,000 persons or less. It is designed to be conducted by the MPO or city staff and to require little or no assistance from outside agencies. Software and a user's guide are currently under development as a portion of Project 2-10-9O-1235 funded by the Texas Department of Transportation (TxDOT). The software will run independent of other programs and will be designed with minimal computer hardware requirements.

Introduction

The allocation of future growth is one of the initial and most important steps in developing the input data for trip generation models. The allocation of population and employment growth has a direct impact on travel demand modeling. These zonal allocations also influence future land use plans, future infrastructure improvements, and city zoning ordinances. It is important, therefore, that any method of allocating future growth should reflect the area's growth potential as accurately as possible.

PROPOSED GROWTH ALLOCATION PROCEDURE In an attempt to decrease the burden on the planning staff in smaller urban areas which may not have the financial or personnel resources to allocate growth using traditional models or methods, an existing technique, the Delphi process, was modified to provide a qualitative measure of an area’s potential for growth at the zone level. A qualitative measure of each zone's growth potential was established relative to the other zones in the area and used to allocate projections. The allocation of growth is predicated on the characteristics of zones which give them a greater or lesser potential for growth. Additionally, the Delphi process can provide good results in a short time frame which provides the benefit of accelerating the overall planning process. The Delphi process can be made available to cities and metropolitan planning organizations (MPOs) by the Texas Department of Transportation (TxDOT) in the form of a package consisting of self-contained software and a user's manual.

DELPHI PROCESS -- AN OVERVIEW The Delphi inquiry techniques were originally developed during the mid-to late 1960's by a team of researchers at the RAND Corporation. Their objective was to design a set of techniques which could solicit and collate the opinions of a group of individuals resulting in the most reliable consensus possible. The basic characteristics of these techniques were anonymity of the panel members, statistical observations of the responses given by the panel members, and controlled feedback to the panel. These characteristics are incorporated into an iterative process which permits and encourages the reassessment of previous responses. One of the greatest advantages of the Delphi techniques is that they provide a means of retaining the more desirable features of committee meetings while avoiding some of the characteristic behavioral and administrative problems associated with committees. The decision to use the Delphi process was based on these features and on the flexibility of the process. The Delphi process can be tailored to fit almost any set of circumstances. It has been used in modified forms for many different applications from Sea Grant policy decisions in Michigan in the early 1970's to evaluating future highway projects in New Mexico in 1989. While the primary goal of the process is to achieve a consensus, it can also be used to identify issues which may have conflicting viewpoints and can aid in reaching compromises on those issues.

PILOT PROJECT - LONGVIEW

In order to more thoroughly examine the applicability of the Delphi process to allocating future growth, a pilot project was conducted in the Longview area. The Objective of this pilot project was to allocate the areas projected population and employment growth for the year 2015 to the traffic analysis zone level. There were three basic stages to the pilot project preparation for the Delphi process, administration of the Delphi process, and evaluation of the results. Figure 1 illustrates the flow of the overall Delphi process.

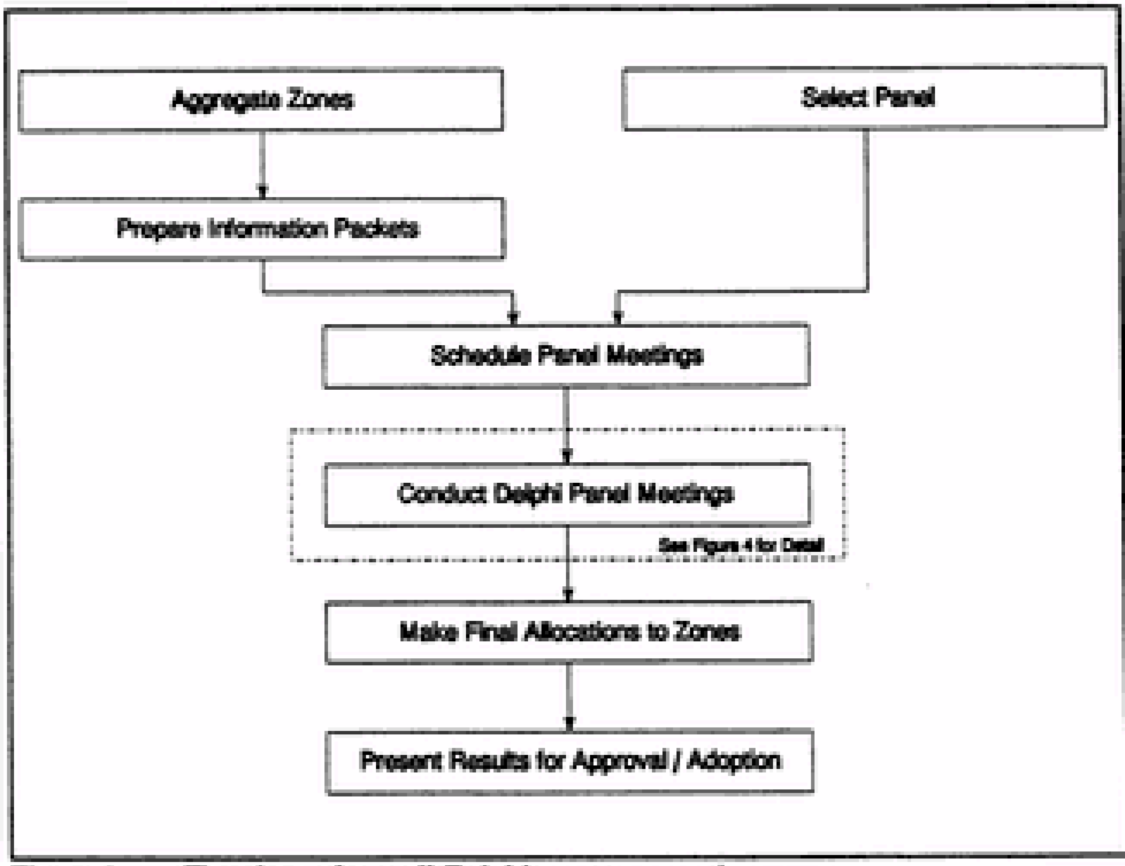

Figure 1. Flowchart of overall Delphi process procedure.

DELPHI PROCESS PREPARATION Preparation for the process can be broken down into four major categories selecting panel members, aggregating traffic analysis zones, preparing information packets, and scheduling meeting times and locations. The preparation for the Delphi process was a joint effort between the Longview city planner and transportation planner (hereafter referred to as the Longview staff) and the Texas Transportation Institute (TIT).

Panel Selection The panel selection was the responsibility of the Longview staff. Recommendations regarding panel size and background were made to the Longview staff. A target panel size of 30 members was established with the desired panel being a multi-disciplinary collection of individuals familiar with the Longview area. The following disciplines were recommended to the Longview staff as a guideline for selecting the panel members:

- Engineers
- Planners
- Elected officials
- School officials

- MPO members
- Real estate brokers
- Bankers
- Employers (basic, retail, and service)
- Developers (commercial and residential)

The Longview staff used several sources in creating a list of potential panelists. Then resulting list was compiled based on recommendations from the director of planning and operation, the city planner, and the transportation planner. Members of the Strategic Planning Economic Development Committee, Planning and Zoning Commission, and the local Economic Development Study Committee were invited to participate on the panel.

A list of citizens who had expressed interest and willingness to serve on these and various other committees, but who had not been selected, was obtained from the Longview public information director. From this list, persons with the recommended backgrounds were contacted and invited to participate on the panel. In addition to these sources, representatives from the local school districts, county commissioners, two former city council members, a water utility employee, and several local builders and engineers were asked to participate. A personal phone call was made to each of the potential panelists by the Longview staff to briefly explain the process and the expected time involved and to invite them to participate. About 40 percent of those contacted declined to serve due to conflicting vacations or family obligations. A letter of confirmation was sent to 28 persons who agreed to participate on the panel. Of the 28 persons who agreed to participate, two did not attend the orientation meeting or any of the allocation meetings. The composition of the panel is shown in Table 1.

Table 1
Occupations of Pilot Project Panel Members

Occupation	Number of Panel Members
Accountant	1
Attorney	1
Banker	1
Building Contractor	2
Chamber of Commerce Member	1
City Official/Administrator	2
County Commissioner	2
Engineer	3
Manager/Administrator (Basic / Service / Retail)	3
Medical Center Administrator	1
Political Appointee	1
Real Estate Broker	2
School Official/Administrator	3
Transportation Services Administrator	1
Utilities Administrator	2
Total	26

Aggregation of Traffic Analysis Zones Although the goal of the growth allocation process is to allocate projected growth to the traffic analysis zones, the number of zones in even a small urban area would be overwhelming for a panel of this nature to deal with. The Longview MPO area (which includes rural areas outside the Longview city limits in addition to the city of Longview) is divided into 219 traffic analysis zones. For this reason the traffic analysis zones were aggregated into allocation districts with the desired number of districts being between five and 10. The quantity and boundaries of the allocation districts were determined by the Longview staff, taking into consideration natural geographic boundaries, traffic analysis zone boundaries, zone population and employment characteristics, and county and city boundaries. A total of six districts were established with the district boundaries corresponding to zone boundaries in almost all cases, the exception being zones which were divided by the county line. It was decided that an intermediate allocation level was required between the district level and the zone level. Following the initial rounds of the Delphi process in which the growth was allocated to the district level (Figure 2), a second level was established. The panel members were asked to examine each of the 219 traffic analysis zones and indicate whether there was or was not a potential for change in that zone. Areas were established based on the same considerations used in creating the district boundaries (Figure 3) and the responses provided by the panel regarding the potential for change. Five of the six districts were divided into six areas, and the remaining district was divided into five areas. This resulted in a total of 35 areas which the panel was asked to consider in the later stages of the process.

Information Provided to Panel In order for the panel members to be able to use the best possible judgment, it was necessary to provide them with as much current and historical information as possible with regard to population, employment, land use, and projected population. The task of compiling this information was greatly facilitated by the fact that most of the information was available on the Geographic Information System (GIS) maintained by Longview. This information was given to the panel at the beginning of the orientation meeting.

Historical Population and Employment Historical population and employment figures were presented to the panel in several formats. A table showing the 1980 census population, 1990 census population, net change, and percentage change for each of the six districts and the total for the MPO area was provided in the information packet. A map was also provided showing the percentage change in each of the six districts to give the panel members a graphical reference for recent growth in the area. In addition to the 1980 and 1990 population figures, historical population from 1900 to 1990 for each decade for Gregg County, Harrison County, and the city of Longview was obtained from the census data in the Texas Almanac and provided in the form of a line graph. Basic, retail, and service employment figures for Gregg County, Harrison County, and the Longview-Marshall Metropolitan Statistical Area (MSA) were obtained from the Texas Employment Commission (TEC) data in the Texas Almanac and presented as line graphs. These figures reflected 1959, 1970, 1980, 1982, 1984, 1986, 1988, and 1990 employment and illustrated the employment growth trends in the area. Maps were also provided for each employment category indicating the locations and concentrations of employment for 1990.

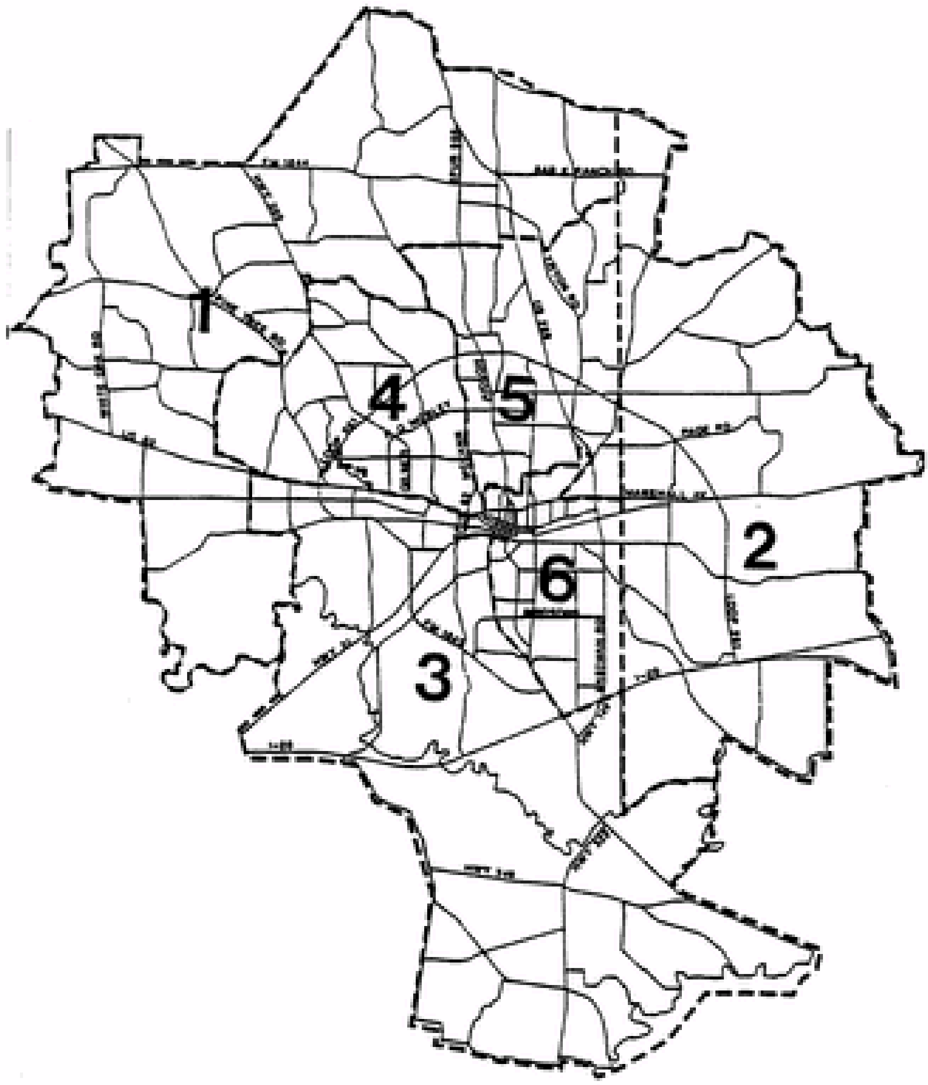

Figure 2. Growth allocation districts for the Longview area MPO.

<u>Base Year Population and Employment</u> Population and employment information for the base year 1990 were compiled by the Longview staff and provided to the panel in tabular form. This table contained population, occupied dwelling units, median household income, undeveloped acreage, and basic, retail and service employment by district. The figures used in this table were consolidated from the detailed traffic analysis zone information used as trip generation variables in the 1990 Longview MPO urban transportation study.

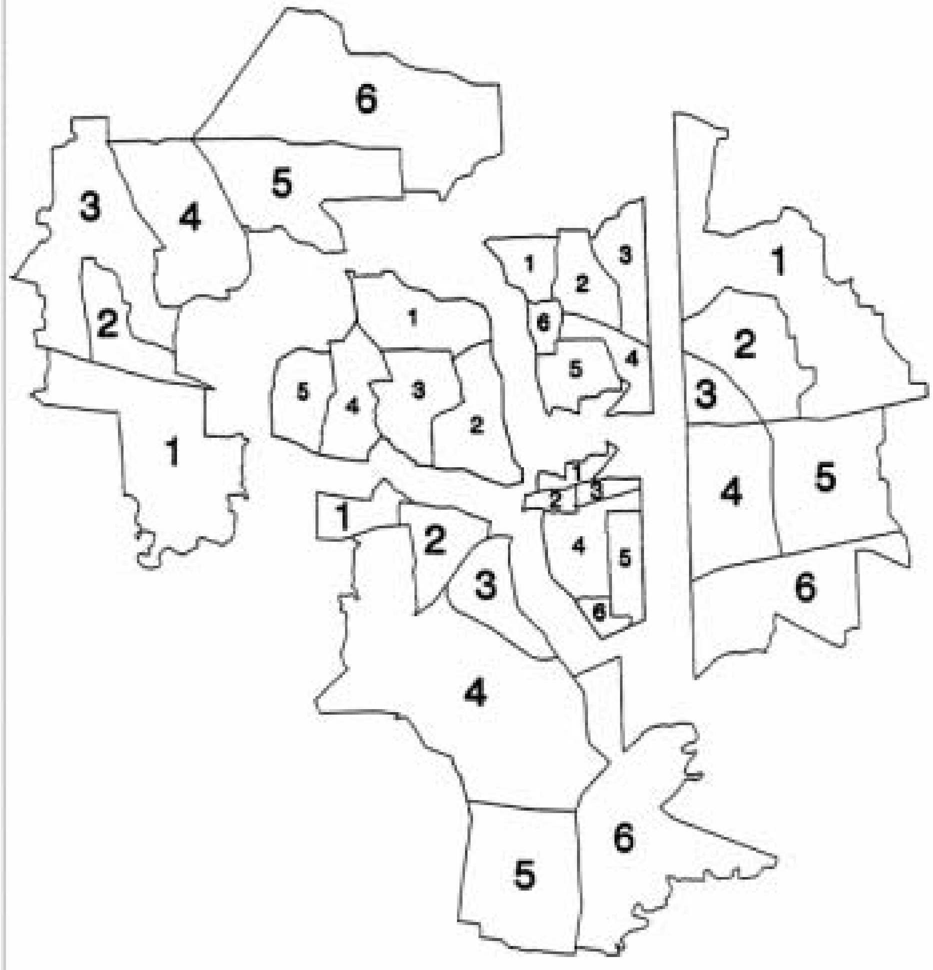

Figure 3. Growth allocation areas within allocation districts (Longview Area MPO).

<u>Projected Population and Employment Growth</u> Although the Longview staff had developed population and employment projections for the year 2015, the projections were not final and had not been formally adopted by the city. Projections for population were developed by the Longview staff using a cohort survival method. Employment projections were then determined using the Longview staff population projection and regional employment projections from the Bureau of Economic Analysis and Woods and Poole. Another set of population and employment projections commissioned by the city and prepared by the consulting firm of Perryman and Associates was also being completed as the process was beginning. The Perryman projections were received the day before the Round 2 meeting. Several members of the panel were aware of the Perryman projections and kept turning the discussion at the meeting to the differences between the Longview projections and the Perryman projections. In order to keep the process moving smoothly, a solution was reached which appeased those few panel members without compromising the integrity of the process. Since the figures for population and employment for the year 2015 had not been formally adopted by the city and MPO, both sets of figures were used. These figures were presented to the Delphi panel as a high estimate (developed by

Perryman and Associates) and a low estimate (developed by the Longview staff) for population and for basic, retail, and service employment. During the course of the Delphi process, the population projections developed by the Longview staff were slightly revised. The allocations made prior to the revisions were updated to reflect the revised projections. The revised projections and allocations were carried forward from that point.

Base Year Land Use and Future Land Use Base year land use, future land use, and related zoning information were included in the information packets in three different tables, and wall maps were available at each meeting for the panel to use as references. One table provided detailed information by district for base year and future land use. Two additional tables provided zoning requirements and zoning classification by district.

Schedule During a preliminary meeting with the Longview staff on May 7, 1992, the decision was made to conduct weekly Delphi panel meetings at 7:00 p.m. on weekdays. An orientation meeting was held on June 4. It had been estimated that six to eight meetings would be necessary to complete the process which would result in the meeting schedule continuing through July. The meeting day varied from week to week due to conflicting meetings of the city council and other committees and a limitation on available meeting locations.

DELPHI PROCESS METHODOLOGY The Delphi process as modified for use with growth allocation consists of an introductory meeting, four to eight meetings where panel members complete questionnaires and exchange information, and an evaluation meeting. Figure 4 illustrates the questionnaire and allocation methodology of the growth allocation process. Beginning with the second round, feedback is provided to the panel regarding the responses and results from the previous round. Panel members are given the opportunity to review the information and revise their responses if they wish. As a consensus is reached at each allocation level the process advances to the next allocation level and the process is repeated. Although the panel members are responsible for establishing a qualitative measure for the growth potential of the districts and areas, they do not directly determine the growth allocations. The growth allocations are made by the agency conducting the Delphi process based on calculations made using the panel responses. In the Longview pilot project, all calculations during the questionnaire portion of the Delphi process (shown inside the dashed area in Figure 4) were completed by TTI. The procedure used for making the allocations are discussed in a later section of this report.

Questionnaire Format During the course of the pilot project, several different questionnaire formats were used. Some of the changes in format were made in order to obtain responses on new information as the process progressed. Other changes were made in an attempt to simplify the questionnaires in response to panel comments on the format of the questionnaires. In making theses changes, great care was taken to ensure that changes were not made between similar rounds in the process which might bias the panel responses. These changes are detailed in the following sections.

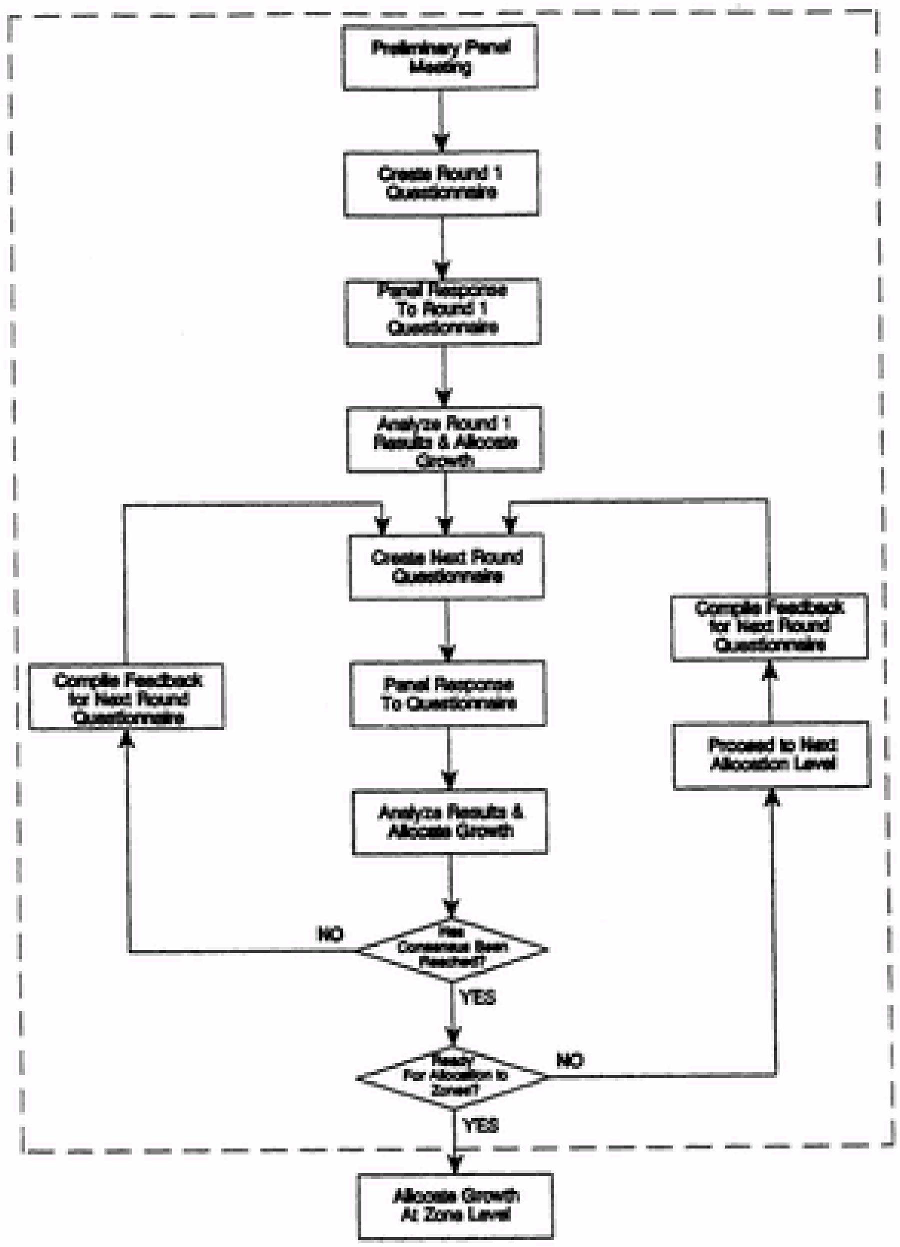

Figure 4. Flowchart of Delphi process methodology.

<u>Orientation Meeting</u> The purpose of the orientation meeting was primarily to acquaint the panel with the Delphi process and to distribute the packets containing the population, employment, and land use information. Therefore, few panel responses were solicited during this meeting. The only information obtained from the panel during this meeting was biographical background information.

<u>Allocation of Growth at the District Level</u> During the first two rounds of the Delphi process, the panel was asked to consider the growth potential of the six districts. Determining the population

and employment growth potential for each of the districts is the first step in allocating the future growth. Panel members were first asked to provide a self-evaluation of their familiarity with the Longview area using the following scale:

1. Unfamiliar
2. Slightly Familiar
3. Generally Familiar
4. Very Familiar
5. Expert or Actively Studying

The same scale was used throughout the questionnaire each time the panel members were asked to evaluate their familiarity with the given issue. The first round questionnaire was divided into four sections: population growth potential, basic employment growth potential, retail employment growth potential, and service employment growth potential. Panel members were first asked to rate the importance of 13 factors which might influence growth in one or all of the districts using the following scale:

1. Little or No Importance
2. Minor Importance
3. Considerable Importance
4. Very Great Importance

The panel members were also asked to rate their familiarity with the factors. The goal of asking the panel members to rate the factors was to gather information on their perceptions of what influences growth and, more importantly, to put the panel members in a frame of mind in which they would consider what factors actually affect the growth potential rather than giving an arbitrary or "gut" response, when rating each district's growth potential. Each section then required the panel member to rate the potential for each type of growth (i.e., population and basic, retail, and service employment) for each of the six districts using the following rating scale:

-1. 10% or Greater Decrease
0. Stable (No Change)
1. 10% Increase
2. 25% Increase
3. 50% or Greater Increase

The panel members were also asked in each section to rate their familiarity with each type of growth in that district and to rank the districts from 1 to 6 with a ranking of 1 being the least likely to grow and 6 being the most likely to grow. The purpose for this ranking to ask for the same basic information regarding growth potential in a different format in order to provide a means of verifying that the panel members were interpreting the questions correctly. Following the questions relating to the potential for growth, the panel members were asked to make a judgment regarding what level of growth activity would occur during each of three projection time periods: 1990 to 2000, 2000 to 2010, and 2010 to 2015. The following scale was used to evaluate the level of activity.

-1. Decrease
0. No Growth
1. Slight Growth
2. Moderate Growth
3. Considerable Growth

The levels of growth during each time period which were calculated from the responses to this question were compared to the actual intermediate projections developed by the Longview staff. Space was also provided on every page for comments. Panel members were provided with space in each section of the questionnaire following the factors which might influence growth and encouraged to provide additional factors. These additional factors and comments were used to stimulate discussion at the next meeting. The Round 2 questionnaire format was essentially the same as the questionnaire used in Round 1. Format changes consisted of the removal of the questions dealing with the factors influencing growth and the district rankings and the addition of the feedback from the Round 1 responses. Feedback was given to each panel member in the form of panel high and low responses, the median and mode of the panel responses, and that panel member's previous responses. Space was provided to allow the panel member to revise the previous response and to make any additional comments. A new section was also added asking the panel members to indicate which traffic analysis zones they felt had no significant potential for change (either positive or negative).

This information was used in conjunction with other characteristics of the zones to establish the area boundaries for allocating growth within each district. Each panel member was also provided with an information packet containing the quantitative allocations and growth distributions over the 25-year time period (1990 to 2015) calculated by TTI using the panel's qualitative responses from Round 1.

Allocation of Growth at the Area Level After two rounds of questionnaires at the district level, a consensus was reached; and the panel was ready to proceed with the area allocations. Based on comments made by some of the panel members at the end of the Round I meeting, and the fact that the time required to complete the Round 1 questionnaire exceeded the time originally estimated, the decision was made to change the format at this level of the process. The format of the questions remained basically the same, but the presentation of the questions was changed. A map of each district showing the area boundaries in that district was placed on a separate page along with the questions pertaining to those areas. A map of the Longview area showing the relative location of each district was also placed on each page. This format provided an immediate visual reference for the panel members without having to use additional maps. The questions regarding the potential for the four types of growth in the areas were worded the same as in previous rounds, and the same rating scale was used. A second section of the Round 3 questionnaire presented the allocation distributions as a percentage of total calculated from the Round 2 responses and asked the panel members to either agree or disagree with the allocation percentages. In cases where panel members disagreed with the percentage for a district, they were asked to indicate whether it should be higher or lower than the value given and to indicate another district which should lose or receive the resulting difference. The Round 4 questionnaire was virtually identical to the Round 3 questionnaire. The only significant difference was the addition of the feedback from the prior round showing the high and low panel responses, the median and mode of the panel responses, and that panel member's previous responses. The panel members were again allowed to compare their previous responses to the panel responses and to make any changes they wished. They were also provided with revised district allocation percentages and asked if they agreed or disagreed. During both Round 3 and Round 4, information packets were provided to the panel members with the questionnaires. These information packets contained the most current revisions of the growth allocation calculations made by TTI based on the panel responses from the prior round.

Allocation of Growth at the Zone Level After reviewing the results of the Round 4 questionnaire, it was apparent that the panel had reached a consensus on the allocations at the area level. The allocation to the traffic analysis zone level was performed by the Longview staff taking into consideration the available land in each area's zones and the future land use plan for the city of Longview. The adjusted results were then aggregated back to the area and district levels, and maps showing the amount of growth at the area level were prepared for each of the four growth categories and for total employment.

Evaluation of the Process by the Panel The Round 5 questionnaire was designed to allow the panel to evaluate the overall process. Panel members were provided with an information packet containing final allocation figures and percentages in tabular form at both the district and zone level. A presentation of the final allocations was also made to the panel using the maps showing the amount of growth for each of the four categories. The panel was asked to evaluate and comment on items such as the effectiveness of the process, the types of questionnaire formats used, the information packets provided to the panel, the meeting format, the meeting schedule, and the final allocations.

Meeting Format The basic format for the Delphi process panel meetings was consistent throughout the entire meeting schedule. In all cases the meetings were intended to be as informal as possible. The meetings were structured to begin with an overview of the goals for that particular meeting followed by an open discussion by the panel. Information pertinent to that round of the process was presented, the information packet for that round was reviewed, and discussion was encouraged. The questionnaire format for that meeting was then outlined, and the remainder of the meeting was devoted to responding to the questionnaire.

Orientation Meeting The first meeting with the panel was the most formal of the meetings. Introductions were made by the Longview staff as well as a presentation to the panel on the transportation planning process and the necessity and difficulties in allocating future growth. An overview of the Delphi process and the panel objectives were then presented by TTI. The Longview staff distributed the information packets and explained the contents of the packets; this was followed by an open discussion. The panel members were informed of the meeting schedule, and the meeting ended with closing comments by the Longview staff.

Growth Allocation Questionnaire Rounds Meeting formats for the growth allocation rounds were essentially the same. An atmosphere of informality was provided in which panel members felt free to ask questions or offer comments at any time and also to move about the meeting room for refreshments or to ask questions on a one-to-one basis of either the Longview or TTI staff. Each meeting began with an explanation of the information packet for that round followed by an open discussion. This was followed by an overview of the current questionnaire and the feedback provided from the previous round results. The panel members were then given as much time as they required to complete the questionnaire.

Evaluation of the Process by the Panel The format for the final panel meeting followed the same pattern as the questionnaire meetings -- presentation and open discussion followed by the completion of the questionnaires. However, after the final allocations were presented, there was considerably more discussion than in prior meetings. The discussion primarily focused on the overall process and the quality of the allocations generated by the panel.

PROCESSING AND EVALUATION OF RESPONSES The following sections detail the steps and decisions involved in processing the questionnaire responses and calculating the growth allocations. Panel responses during each of the questionnaire rounds provided a qualitative measure of relative growth potential. These qualitative responses were then processed by TTI following each round to obtain quantitative values for relative growth potential which were in turn used to allocate the total growth. All calculations and data manipulations were performed by TTI using a series of spreadsheets. Spreadsheets were used to process the pilot project results due to the ease with which format and calculation changes can be made.

Orientation Meeting Due to the nature of the orientation meeting, no calculations were necessary. Processing the responses from this meeting consisted of compiling information provided by the panel members on the biographical background sheets. Each panel member on the list was then randomly assigned a number from 1 to 28. This number was used on all subsequent questionnaires and feedback to insure the anonymity of each panelist.

Allocation of Growth at District Level During the first two rounds of the Delphi process, the questionnaires concentrated on the allocations at the district level. Table 1 shows the allocation of projected population and employment for the year 2015 calculated from the panel responses following each round. Table 2 shows the same allocations as a percentage of the total. Panel responses for Round 1 and Round 2 were in the form of a growth potential rating for each district. The following process was the initial method used to determine the projected growth distribution at the district level following the first round of the Delphi process.

Step 1 The arithmetic mean and median were calculated from the responses given by the panelists. These two values were averaged to reduce the influence of any extreme responses.

Step 2 The population for the base year for each district was then increased or decreased by the percentage obtained in Step 1.

District 6:
Round 1: 16,701 - 16,991 = -290
Round 2: 16,831 - 16,991 = -160
Total:
Round 1: 98,777 - 89,610 = 9,167
Round 2: 99,223 - 89,610 = 9,613

*(Base year district population) * (1 + (% Growth of district)) * Unscaled projected district population*

Round 1: 16,991 * (1 + (-0.01706)) = 16,701
Round 2: 16,991 * (1 + (-0.00941)) = 16,831

Step 3 The calculated populations for each of the districts were summed to obtain an unscaled projected population.

∑ *Unsealed projected district populations = Total calculated population projection*

Round 1: 13,848 + 7,914 + 10,416 + 31,301 + 18,597 +16,701 = 98,777
Round 2: 13,716 + 7,949 + 10,362 + 31,291 + 19,074 + 16,831 = 99,223

Step 4 The net change was calculated between the calculated population projection and the base year population for each of the districts and the total.

Step 5 The net change was calculated between the total projected population and the base year total population.

107,539 - 89,610 = 17,929

Step 6 The net change to reach the calculated population and the net change to reach the projected population were then used to scale the populations for each district using the following calculation:

Round 1:

$$\frac{(\text{Net change of district pop.})}{(\text{Net change of calculated pop.})} * (\text{Net change of projected pop.}) = \text{Scaled change of district pop.}$$

$$\text{Round 1:} \quad \frac{-290}{9{,}967} * 17{,}929 = -567$$

$$\text{Round 2:} \quad \frac{-160}{9{,}613} * 17{,}929 = -298$$

Step 7 The total projected population in each district was calculated by adding the scaled change in district population to the base year district population.

Base year population + Scaled change of district population = Projected district population

Round 1: 16,991 + (-567) = 16,424
Round 2: 16,991 + (-298) = 16,693

Step 8 The percent growth of each district was then calculated using the following equation:

Round 1 and 2:

$$\frac{(\textit{Scaled district population}) - (\textit{Base year district population})}{(\textit{Base year district population})} * 100\% = \%\ \textit{Growth}$$

$$\text{Round 1: } \frac{16{,}424 - 16{,}991}{16{,}991} * 100\% = -3.34\%$$

$$\text{Round 2: } \frac{16{,}693 - 16{,}991}{16{,}991} * 100\% = -1.75\%$$

Following Round 2, the means of the panel responses from the two rounds were compared using a z statistical test to determine if the means were statistically different. The means of the panel responses from the two questionnaires were statistically the same for a confidence level of 99 percent. This statistical result along with the fact that the panel members would still be allowed to make adjustments to their responses for the district growth potential prompted the decision to advance the process to the next level. As a part of the Round 3 and Round 4 questionnaires dealing with growth allocation at the area level, panel members could also agree or disagree with the allocations at the district level derived from Rounds 1 and 2. Where a panel member disagreed with a district allocation, they were asked to indicate whether that district should have a larger or smaller allocation and which other district should be adjusted in the opposite direction. That panel member's previous round responses for the affected districts were adjusted by one rating level in the appropriate direction, the district allocations were recalculated, and the new allocations were carried forward. As the figures presented in Table 2 indicate, some changes were made to most of the district allocations in all categories during Round 3. Following Round 3, the panel agreed with the allocation of basic employment and retail employment, and no further adjustments were made to those district allocations. However, there were still some minor changes made to the population and service employment district allocations. Although adjustments were made during Rounds 3 and 4, these adjustments were relatively minor as indicated by the small changes in percent of total from one round to the next. The largest change in percent of total was only 2.3 percent, and all of the remaining changes were less than 1.5 percent.

Allocation of Growth at Area Level Rounds 3 and 4 of the questionnaire process concentrated on the allocation of growth at the area level. The procedures used in processing the responses for the district allocations from Rounds 1 and 2 were used in processing the responses for area allocation. Calculations were made by TTI using the revised method of converting the responses to an actual allocation, and the means were tested statistically following Round 4 to determine if there had been a significant change between Round 3 and Round 4. When no apparent statistical differences were found between Round 3 and Round 4 responses, the process advanced to the next phase, the allocation of the area growth to the traffic analysis zone level.

Table 2
Comparison of District Allocations Following Each Round of Delphi

POPULATION

District	1990	Estimated 2015 Allocation				
		Round 1	Round 2	Round 3	Round 4	Adjusted
1	14,299	15,076	14,960	17,426	17,480	18,670
2	7,018	8,616	8,755	8,759	9,531	9,642
3	10,177	11,340	10,522	10,523	10,529	10,529
4	25,734	34,077	34,349	31,861	31,966	31,388
5	15,391	20,247	22,260	22,275	22,621	21,897
6	16,991	18,183	16,693	16,691	15,413	15,413

BASIC EMPLOYMENT

District	1990	Estimated 2015 Allocation				
		Round 1	Round 2	Round 3	Round 4	Adjusted
1	1,835	2,090	2,044	1,988	1,988	1,989
2	1,982	2,380	2,572	2,358	2,358	2,357
3	10,813	11,653	11,696	12,093	12,093	12,094
4	978	1,151	1,130	1,056	1,056	1,056
5	942	1,099	1,083	1,032	1,032	1,034
6	3,505	3,658	3,505	3,505	3,505	3,505

RETAIL EMPLOYMENT

District	1990	Estimated 2015 Allocation				
		Round 1	Round 2	Round 3	Round 4	Adjusted
1	621	334	331	654	655	654
2	417	434	445	445	445	446
3	1,224	1,188	1,344	1,344	1,344	1,343
4	3,798	4,459	4,424	4,293	4,293	4,293
5	3,558	4,355	4,217	4,221	4,222	4,222
6	2,433	2,350	2,451	2,453	2,451	2,452

SERVICE EMPLOYMENT

District	1990	Estimated 2015 Allocation				
		Round 1	Round 2	Round 3	Round 4	Adjusted
1	1,408	1,624	1,599	1,625	1,659	1,659
2	311	368	364	374	378	378
3	1,443	1,592	1,503	1,503	1,513	1,512
4	2,838	3,771	3,951	3,921	4,086	4,086
5	3,440	4,632	4,829	5,069	5,096	4,795
6	6,493	7,493	7,235	6,987	6,750	7,049

Allocation of Growth at Zone Level It was felt that the large number of zones in the urban area would be too tedious and overwhelming for the panel to deal with in the context of a meeting atmosphere. Also, it was reasonable to assume that the panel members would not be as familiar with specific zones at that level of detail as with areas and districts on a more general scale. Therefore, allocation of the growth from the area level to the traffic analysis zone level was performed by the Longview staff. Allocations at the area level were distributed to the zones in that area within the constraints of available land, future land use plan, and expected densities. The panel allocations were first considered at the area level. If the growth allocated to that area could be absorbed by the zones in that area, no reductions were made to that area. If the growth allocated to that area could not be absorbed by the zones, surrounding areas were considered to determine if the excess growth could be shifted to those areas. In the event that the growth allocated to the areas in a given district could not be absorbed by the areas in that district, the adjacent areas in the adjacent districts were considered as possible targets for the excess. As shown in Table 4 and Table 5, some minor adjustments were necessary in allocating the growth to the zone level. Excess growth allocated to District 4 and District 5 was shifted to District 1 and District 2. Table 4 shows the comparison of the panel allocations and the adjusted allocations at the district level. The percentage of adjustment ranged from a decrease in District 5 of 3.2 percent to an increase in District 1 of 6.8 percent. The difference in percentage of the total projected population ranged from a reduction in District 5 of 0.7 percent to an increase in District 1 of 1.1 percent. The conclusion can be made that the change in percentage of total at the area level and the district level is a more relevant measure of the impact of the adjustments made to the panel allocations than the actual percent of raw adjustment. This is illustrated by the results provided in Table 5. As indicated by the figures in Table 5, the percentage of adjustment between the panel allocation and the adjusted allocation ranged from a reduction m Area 2 in District 5 of 10.4 percent and an increase in Area 5 in District 1 of 19.3 percent. However, when the change in percentage of total district population is analyzed, the percentage change ranged from a reduction of 2.6 percent in Area 4 of District 4 to an increase of 2.0 percent in Area 1 of District 4. The areas exhibiting the largest positive and negative percentage of adjustment (District 1/Area 5 and District 5/Area 2) resulted in a change in the percentage of total population in those areas of only 1.3 percent and -0.9 percent, respectively. The largest positive and negative effect on the allocations in terms of the change in the percentage of the district total occurred in District 4. This relationship becomes even more apparent when reviewed at the district level. Using District 1 as an example, the adjustment in population allocation results in an increase of 1,190 persons, which is 6.8 percent of the panel allocation of 17,480. However, this is only 1.1 percent of the entire projected population of 107,539 persons for the year 2015. This is a relatively insignificant change in the overall growth allocation. The comparison between the panel allocations and the adjusted allocations for basic and retail employment as given in Table 4, Table 6, and Table 7, provide additional support for using of this technique in the growth allocation process. In distributing the basic and retail employment growth, the panel allocations were completely compatible with the constraints imposed at the district level; no adjustments to the district allocations were needed. At the area level some minor shifts were required within the areas in District 5 for retail employment. These adjustments were not a direct result of excess allocation to these areas but were instead due to the fact that new retail development had already begun in Area 2 and Area 3, and the panel allocations were not sufficiently large enough to reflect this growth.

Table 3
Comparison of District Allocations Following Each Round of Delphi
As Percentage of Total

POPULATION

District	1990	Estimated 2015 Allocation (% of total)				
		Round 1	Round 2	Round 3	Round 4	Adjusted
1	13.7	14.0	13.9	16.2	16.3	17.4
2	7.8	8.0	8.1	8.1	8.9	9.0
3	11.3	10.5	9.8	9.8	9.8	9.8%
4	31.0	31.7	31.9	29.6	29.7	29.2
5	17.2	18.8	20.7	20.7	21.0	20.4
6	19.0	16.9	15.5	15.5	14.3	14.3

BASIC EMPLOYMENT

District	1990	Estimated 2015 Allocation (% of total)				
		Round 1	Round 2	Round 3	Round 4	Adjusted
1	9.5	9.5	9.3	9.0	9.0	9.0
2	10.4	10.8	11.7	10.7	10.7	10.7
3	51.6	52.9	53.1	54.9	54.9	54.9
4	5.3	5.2	5.1	4.8	4.8	4.8
5	4.9	5.0	4.9	4.7	4.7	4.7
6	18.3	16.6	15.9	15.9	15.9	15.9

RETAIL EMPLOYMENT

District	1990	Estimated 2015 Allocation (% of total)				
		Round 1	Round 2	Round 3	Round 4	Adjusted
1	4.2	3.9	4.0	4.9	4.9	4.9
2	3.5	3.3	3.3	3.3	3.3	3.4
3	10.2	8.9	9.3	9.3	9.3	9.3
4	32.1	33.5	33.2	32.3	32.3	32.3
5	29.7	32.7	31.7	31.7	31.7	31.7
6	20.3	17.7	18.4	18.4	18.4	18.4

SERVICE EMPLOYMENT

District	1990	Estimated 2015 Allocation (% of total)				
		Round 1	Round 2	Round 3	Round 4	Adjusted
1	8.7	8.3	8.2	8.3	8.5	8.5
2	1.9	1.9	1.9	1.9	1.9	1.9
3	9.1	8.2	7.7	7.7	7.8	7.8
4	18.0	19.4	20.3	20.1	21.0	21.0
5	21.6	23.8	24.8	26.0	26.2	24.6
6	40.7	38.5	37.1	35.9	34.6	36.2

Table 4
Comparison of District Allocations Before and After Adjustments

District	1990 Population	2015 Panel Allocation	2015 Adjusted Allocation	Adjustment	% Adjustment	1990 % of Total	2015 Panel % of Total	2015 Adjusted % of Total	Diff. in % of Total
1	14,299	17,480	18,670	1,190	6.8	16.0	16.3	17.4	1.1
2	7,018	9,531	9,641	110	1.2	7.8	8.9	9.0	0.1
3	10,177	10,529	10,529	0	0.0	11.4	9.8	9.8	0.0
4	25,734	31,966	31,388	-578	-1.8	28.7	29.7	29.2	-0.5
5	15,391	22,620	21,898	-722	-3.2	17.2	21.0	20.3	-0.7
6	16,991	15,413	15,413	0	0.0	19.0	14.3	14.3	0.0
Total	89,610	107,539	107,539	0	0.0	100.0	100.0	100.0	0.0
Smallest Value					-3.2%	7.8%	8.9%	9.0%	-0.7%
Largest Value					6.8%	28.7%	29.7%	29.2%	1.1%

District	1990 Basic Emp.	2015 Panel Allocation	2015 Adjusted Allocation	Adjustment	% Adjustment	1990 % of Total	2015 Panel % of Total	2015 Adjusted % of Total	Diff. in % of Total
1	1,833	1,989	1,989	0	0.0	9.1	9.0	9.0	0.0
2	1,982	2,357	2,357	0	0.0	9.9	10.7	10.7	0.0
3	10,813	12,094	12,094	0	0.0	53.9	54.9	54.9	0.0
4	978	1,056	1,056	0	0.0	4.9	4.8	4.8	0.0
5	942	1,034	1,034	0	0.0	4.7	4.7	4.7	0.0
6	3,505	3,505	3,505	0	0.0	17.5	15.9	15.9	0.0
Total	20,053	22,035	22,035	0	0.0	100.0	100.0	100.0	0.0
Smallest Value					0.0%	4.7%	4.7%	4.7%	0.0%
Largest Value					0.0%	53.9%	54.9%	54.9%	0.0%

District	1990 Retail Emp.	2015 Panel Allocation	2015 Adjusted Allocation	Adjustment	% Adjustment	1990 % of Total	2015 Panel % of Total	2015 Adjusted % of Total	Diff. in % of Total
1	621	654	654	0	0.0	5.2	4.9	4.9	0.0
2	417	447	447	0	0.0	3.5	3.4	3.4	0.0
3	1,224	1,243	1,243	0	0.0	10.2	9.3	9.3	0.0
4	3,738	4,293	4,293	0	0.0	31.2	32.3	32.3	0.0
5	3,558	4,222	4,222	0	0.0	29.6	31.7	31.7	0.0
6	2,433	2,452	2,452	0	0.0	20.3	18.4	18.4	0.0
Total	11,991	13,311	13,311	0	0.0	100.0	100.0	100.0	0.0
Smallest Value					0.0%	3.5%	3.4%	3.4%	0.0%
Largest Value					0.0%	31.2%	32.3%	32.3%	0.0%

District	1990 Service Emp.	2015 Panel Allocation	2015 Adjusted Allocation	Adjustment	% Adjustment	1990 % of Total	2015 Panel % of Total	2015 Adjusted % of Total	Diff. in % of Total
1	1,327	1,659	1,659	0	0.0	8.4	8.5	8.5	0.0
2	311	378	378	0	0.0	2.0	1.9	1.9	0.0
3	1,443	1,512	1,512	0	0.0	9.1	7.8	7.8	0.0
4	2,838	4,086	4,086	0	0.0	17.9	21.0	21.0	0.0
5	3,440	5,095	4,795	-300	-5.9	21.7	26.1	24.6	-1.5
6	6,493	6,750	7,050	300	4.4	41.0	34.7	36.2	1.5
Total	15,852	19,480	19,480	0	0.0	100.0	100.0	100.0	0.0
Smallest Value					-5.9%	2.0%	1.9%	1.9%	-1.5%
Largest Value					4.4%	41.0%	34.7%	36.2%	1.5%

A similar situation occurred when distributing the area allocations to the zone level for service employment. Due to the concentration of service oriented businesses in District 6 consisting mainly of hospital and medical practices as well as banking and government offices, the growth allocated to this area was increased slightly from the growth allocated by the panel. The adjustment was made by reducing the service employment in District 5 by 300 jobs and allocating those 300 jobs to Area 2 in District 6. This reallocation of 300 jobs amounted to only

1.5 percent of the total service employment projection of 19,480 for the year 2015 in the Longview MPO area. Some minor redistribution was also made among the areas in District 5 and District 4. The results for the service employment allocation are given in Table 4 and Table 8.

Table 7
Comparison of Retail Employment Area Allocations Before and After Adjustments

District	Area	1990 Retail Emp.	2015 Panel Allocation	2015 Adjusted Allocation	Adjustment	% Adjustment	1990 % of Total	2015 Panel % of Total	2015 Adjusted % of Total	Diff. in % of Total
1	1	51	52	52	0	0.0	8.2	8.0	8.0	0.0
	2	119	120	120	0	0.0	19.2	18.3	18.3	0.0
	3	123	125	125	0	0.0	19.8	19.1	19.1	0.0
	4	210	236	236	0	0.0	33.8	36.1	36.1	0.0
	5	56	58	58	0	0.0	9.0	8.9	8.9	0.0
	6	62	63	63	0	0.0	10.0	9.6	9.6	0.0
	Total	621	654	654	0	0.0	100.0	100.0	100.0	0.0
2	1	29	31	31	0	0.0	6.9	6.9	6.9	0.0
	2	53	63	63	0	0.0	12.7	14.1	14.1	0.0
	3	75	89	89	0	0.0	18.0	19.9	19.9	0.0
	4	153	157	157	0	0.0	36.7	35.1	35.1	0.0
	5	49	49	49	0	0.0	11.8	11.0	11.0	0.0
	6	58	58	58	0	0.0	13.9	13.0	13.0	0.0
	Total	417	447	447	0	0.0	100.0	100.0	100.0	0.0
3	1	296	300	300	0	0.0	24.2	24.1	24.1	0.0
	2	353	363	363	0	0.0	28.8	29.2	29.2	0.0
	3	238	242	242	0	0.0	19.5	19.5	19.5	0.0
	4	122	123	123	0	0.0	10.0	9.9	9.9	0.0
	5	25	25	25	0	0.0	2.0	2.0	2.0	0.0
	6	190	190	190	0	0.0	15.5	15.3	15.3	0.0
	Total	1,224	1,243	1,243	0	0.0	100.0	100.0	100.0	0.0
4	1	612	695	695	0	0.0	16.4	16.2	16.2	0.0
	2	1,014	1,182	1,182	0	0.0	27.1	27.5	27.5	0.0
	3	1,654	1,951	1,951	0	0.0	44.3	45.4	45.4	0.0
	4	416	423	423	0	0.0	11.1	9.9	9.9	0.0
	5	42	42	42	0	0.0	1.1	1.0	1.0	0.0
	Total	3,738	4,293	4,293	0	0.0	100.0	100.0	100.0	0.0
5	1	95	101	101	0	0.0	2.7	2.4	2.4	0.0
	2	21	31	406	375	1209.7	0.6	0.7	9.6	8.9
	3	21	23	56	33	143.5	0.6	0.5	1.3	0.8
	4	417	514	514	0	0.0	11.7	12.2	12.2	0.0
	5	881	905	899	-6	-0.7	24.7	21.5	21.3	-0.2
	6	2,123	2,648	2,246	-402	-15.2	59.7	62.7	53.2	-9.5
	Total	3,558	4,222	4,222	0	0.0	100.0	100.0	100.0	0.0
6	1	330	335	335	0	0.0	13.6	13.6	13.6	0.0
	2	939	956	956	0	0.0	38.6	39.0	39.0	0.0
	3	156	159	159	0	0.0	6.4	6.5	6.5	0.0
	4	643	635	635	0	0.0	26.4	25.9	25.9	0.0
	5	91	91	91	0	0.0	3.7	3.7	3.7	0.0
	6	274	276	276	0	0.0	11.3	11.3	11.3	0.0
	Total	2,433	2,452	2,452	0	0.0	100.0	100.0	100.0	0.0
District Total		11,991	13,311	13,311	0					
Smallest Value						-15.2%	0.6%	0.5%	1.0%	-9.5%
Largest Value						1209.7%	59.7%	62.7%	53.2%	8.9%

Evaluation of the Process by the Panel

Following the allocation to the zone level the Delphi process proceeded to the final phase. Although not necessary to the allocation of future growth, the evaluation questionnaire was considered to be an important phase in the pilot project because it allowed the panel members to provide information which may be used to refine and improve the process.

Table 8
Comparison of Service Employment Area Allocations Before and After Adjustments

District	Area	1990 Service Emp.	2015 Panel Allocation	2015 Adjusted Allocation	Adjustment	% Adjustment	1990 % of Total	2015 Panel % of Total	2015 Adjusted % of Total	Diff. in % of Total
1	1	113	122	122	0	0.0	8.5	7.4	7.4	0.0
	2	243	367	367	0	0.0	18.3	22.1	22.1	0.0
	3	111	128	128	0	0.0	8.4	7.7	7.7	0.0
	4	117	221	221	0	0.0	8.8	13.3	13.3	0.0
	5	671	740	740	0	0.0	50.6	44.6	44.6	0.0
	6	72	81	81	0	0.0	5.4	4.9	4.9	0.0
	Total	1,327	1,659	1,659	0	0.0	100.0	100.0	100.0	0.0
2	1	19	19	19	0	0.0	6.1	5.0	5.0	0.0
	2	37	44	44	0	0.0	11.9	11.6	11.6	0.0
	3	30	60	60	0	0.0	9.6	15.9	15.9	0.0
	4	198	228	228	0	0.0	63.7	60.3	60.3	0.0
	5	13	13	13	0	0.0	4.2	3.5	3.5	0.0
	6	14	14	14	0	0.0	4.5	3.7	3.7	0.0
	Total	311	378	378	0	0.0	100.0	100.0	100.0	0.0
3	1	362	381	381	0	0.0	25.1	25.2	25.2	0.0
	2	353	374	374	0	0.0	24.6	24.7	24.7	0.0
	3	364	383	383	0	0.0	25.2	25.3	25.3	0.0
	4	186	188	188	0	0.0	12.9	12.4	12.4	0.0
	5	19	19	19	0	0.0	1.3	1.3	1.3	0.0
	6	157	167	167	0	0.0	10.9	11.1	11.1	0.0
	Total	1,443	1,512	1,512	0	0.0	100.0	100.0	100.0	0.0
4	1	249	368	368	0	0.0	8.8	9.0	9.0	0.0
	2	795	1,300	1,195	-105	-8.1	28.0	31.8	29.3	-2.6
	3	1,071	1,654	1,704	50	3.0	37.7	40.5	41.7	1.2
	4	660	701	756	55	7.8	23.3	17.2	18.5	1.3
	5	63	63	63	0	0.0	2.2	1.5	1.5	0.0
	Total	2,838	4,086	4,086	0	0.0	100.0	100.0	100.0	0.0
5	1	177	305	527	222	72.8	5.7	6.0	11.0	5.0
	2	130	252	231	-21	-8.3	3.8	4.9	4.8	-0.1
	3	36	36	196	160	444.4	1.1	0.7	4.1	3.4
	4	1,341	2,212	1,716	-496	-22.4	39.0	43.4	35.8	-7.6
	5	1,195	1,346	1,359	13	1.0	34.7	26.4	28.3	1.9
	6	541	944	766	-178	-18.9	15.7	18.6	16.0	-2.6
	Total	3,440	5,095	4,795	-300	-5.9	100.0	100.0	100.0	0.0
6	1	805	813	813	0	0.0	12.4	12.0	11.5	-0.5
	2	3,298	3,555	3,855	300	8.4	50.8	52.7	54.7	2.0
	3	124	126	126	0	0.0	1.9	1.9	1.8	-0.1
	4	1,720	1,710	1,710	0	0.0	26.5	25.3	24.3	-1.1
	5	378	377	377	0	0.0	5.8	5.6	5.3	-0.2
	6	168	169	169	0	0.0	2.6	2.5	2.4	-0.1
	Total	6,493	6,750	7,050	300	4.4	100.0	100.0	100.0	0.0
District Total		15,032	19,480	19,480	0					
Smallest Value						-22.4%	1.0%	0.7%	1.3%	-7.6%
Largest Value						444.4%	63.7%	60.3%	60.3%	5.0%

PARTICIPATION RATE Although the participation rate varied from round to round, the overall participation rate was slightly less than the 50 percent originally anticipated. Of the 28 persons who agreed to participate in the process, 12 persons (43 percent) responded to 4 to 5 of the questionnaires, 6 persons (21 percent) responded to 2 to 3 of the questionnaires, and 10 persons (36 percent) responded to 0 to 1 of the questionnaires. These percentages suggest that in order to have responses from 25 to 30 persons during each round, the target size for the panel should be 60 to 70 persons. Based on comments provided by the panel members who returned the evaluation questionnaire, it is possible that some of the eight panel members who did not participate after the first two rounds may have been bewildered by the amount of information provided to them and by the length of the first two meetings. Revisions made to the format of the questionnaires during the later rounds of the process significantly reduced the duration of the meeting. This would likely result in a higher overall participation rate in future applications of the Delphi process. If the assumption is made that 50 percent (four) of these persons would have participated in a total of 4 to 5 rounds of the process, the participation rate increases to 57 percent. This would lower the target size of the initial panel to 45 to 50 persons in order to receive an average of 25 to 30 responses in each round of the process. This is a more practical size for the panel both from the standpoint of seating a panel of qualified individuals and of administering the process.

RESPONSE OF LOCAL GOVERNMENT AND COMMITTEES Following the final meeting of the Delphi panel the results of the growth allocation process were presented to the MPO Technical Committee, the Planning and Zoning Commission, and the MPO Steering Committee. The responses of these groups were important in evaluating the usefulness of the process as a tool for developing allocations which will be accepted by the political bodies involved in the planning process. Reaction to the allocations may also be viewed as an indication of their level of confidence in the growth allocations.

MPO Technical Committee The first group to receive a presentation of the growth allocations was the MPO Technical Committee. This committee is composed of persons whose jobs are related to the planning and implementation of transportation projects and whose expertise lies in transportation and planning. Although they have no formal policy making power, they are responsible for making recommendations to the MPO Steering Committee which does determine policy. One of the members of this committee served as a panel member during the growth allocation process. A presentation of the results was made to the committee by the Longview staff. During the meeting the committee members were very positive toward the process and the results. At one point following the presentation, one of the committee members who is a Longview city official made the suggestion that the allocations be adopted for use in other city and utility planning processes, in addition to the transportation planning process.

Planning and Zoning Commission A second presentation was made to the Longview Planning and Zoning Commission. Although the commission would not be making any formal adoption of the allocations, it was important for this group to accept the allocations since the growth allocations, land use plan, and zoning map are all related. Two members of the commission participated in the Delphi process and were very positive in their responses to other commission members. This gives support to one of the goals of the process: by involving members of various bodies involved in the planning process in the allocation of future growth, there will be support for the allocations later in the approval stages of the planning process. The overall response to the process and the resulting allocations was once again very positive.

MPO Steering Committee The final presentation of the growth allocations was made to the MPO Steering Committee. This group is responsible for setting policies related to transportation in the MPO area and is composed of elected officials from the municipalities included in the

MPO and Longview city officials from upper level management positions, such as the city manager, city planner, and director of public works. One member from this committee served on the Delphi panel. As in the previous presentations, considerable interest in the process and a strong positive reaction from the committee was expressed. Following the presentation by the Longview staff, the committee voted unanimously to adopt the allocations.

ADVANTAGES OF THE DELPHI PROCESS

There are several benefits inherent in the design of the Delphi process. The most important benefits relate to costs to the MPO in both time and money; the social, political, and legal advantages of basing the allocations on a panel consensus; and the political advantages of involving members of local agencies and committees during the allocation process.

Time and Cost Savings - Acceleration of Planning Process

Since the Delphi process is not a computer model, it does not display any of the problems inherent in the models or modeling process. Of the benefits provided by the Delphi process, perhaps the most apparent are the time and financial savings due to its speed and simplicity. When using computer models for growth allocation, the model must be calibrated for use in the specific study area. This calibration process normally requires the services of a consultant for many months to prepare the model for use, followed by the actual modeling for the area, resulting in considerable expense for the local MPO. In contrast, the Delphi process can be conducted by the local staff in a period of two to three months or less, thereby eliminating the expense and time associated with the computer modeling process. Also, the fact that the goal of the Delphi process is to achieve a consensus means that the Delphi process could be considered to be a self-calibrating process. The time savings provided by the Delphi process over a computer model will vary from area to area but will probably save six months to a year or more. In areas where it is desirable to complete the planning process within the period of a political term, the months saved using the Delphi process could mean the difference between approval or rejection of the plan. The previous growth allocations used by the MPO were generated by the Longview staff over a period of three months. Although this is only one month longer than the time required for the Delphi process, it still required considerably more staff hours than the Delphi process. Most of the time spent during the Delphi process is not due to the actual time required to conduct the meetings and process the responses; it is due to the decision to allow one week between meetings and due to scheduling problems which prevent the meetings from being held more frequently. Conceivably, meetings could be scheduled twice per week, and the process could be completed in approximately half the time. However, it is likely that it would be difficult to find persons who would be able or willing to devote their time twice each week to participate on the panel.

PANEL CONSENSUS REGARDING ALLOCATIONS Another advantage of the Delphi process is the reliance on a group consensus to obtain a qualitative measure of the relative growth potential of different areas of the MPO area and to estimate the future growth allocations. While the strength of computer models is their ability to process a large volume of input data and eventually obtain growth allocations, one of the most attractive features of the Delphi process cannot be incorporated into a computer model -- the human factor. The experience, perception, intuition, and judgment of people familiar with more subjective issues in the area such as lifestyles, policy issues, and other factors too numerous to list or even adequately identify, is a benefit which should not be overlooked. The interaction between the panel members and the exchange of ideas allows the panel to reach a much more informed consensus than would be possible for one or two individuals. This results in panel input which is more responsive to local social and political issues. On the legal side of the equation, it is generally much easier to support figures which are the result of citizen input rather than the decisions of two or three members of a local staff if the figures are ever challenged. It is a generally accepted legal tactic that one of the best ways to discredit a project or policy decision is to discredit the numbers on which that project or decision is based. Where community involvement can be shown in establishing the numbers on which policies are based, a stronger foundation is created for projects and decisions resulting from those policies.

INVOLVEMENT OF LOCAL AGENCIES AND COMMITTEES Perhaps one of the strongest advantages of the Delphi process is the opportunity to involve members of local agencies and committees which must at some point adopt or approve the allocations or plan. By inviting these committees and agencies to appoint a committee member to participate as a member of the Delphi panel during the allocation process, a bond is created with that agency or committee. Later in the planning process, when the growth allocation or plan is before that body for approval the participating member will most likely be an advocate of the allocation or the plan since that individual was directly involved in determining the allocations. In fact, the panel member will probably have kept the agency or committee informed of the progress and results throughout the allocation process, and obtaining the approval may be nothing more than a formality. This was indeed the situation in the Longview pilot project. The MPO Technical Committee appointed one member from the committee to participate on the Delphi panel, the Planning and Zoning Commission appointed two members, and the MPO Steering Committee appointed one member to the panel. During the presentation of the final allocations by the Longview staff to these groups, the members who had participated in the Delphi interjected numerous positive remarks, and the responses from the groups were very positive. The MPO Steering Committee voted unanimously to adopt the growth allocations obtained during the Delphi process. In addition to the previously mentioned appointees from local bodies and members of the community who were invited to participate on the panel several other local committees appointed members to the panel. The Strategic Planning Economic Development Committee (formed by the city of Longview to study transportation issues related to economic development) appointed four members of their committee to participate in the Delphi process. Another city sponsored committee, the Southside Economic Development Study Steering Committee, appointed one representative to the Delphi panel who did not participate after the Round 1 meeting. The director of the Chamber of Commerce, who was also formerly the director of planning for Longview, participated in all of the Delphi meetings. Two other members of the Delphi panel although not currently serving on any committees, had formerly served on the city council and as members of the Planning and Zoning Commission.

EVALUATION BY THE PANEL

Results of the panel evaluation indicated an overwhelming positive response to the process. Of the 14 panel members who completed the Round 5 questionnaire, seven had participated in every meeting, five had participated in all but one meeting, and the two remaining panel members had participated in fewer than three of the previous meetings. The 12 panel members who participated in all or most of the meetings felt that the process had been effective in obtaining and conveying their opinions to the city staff and that their participation as citizens on the Delphi panel had been an effective means of communicating information to the city staff. The responses from the two remaining panel members were split on these issues; one gave a positive response agreeing with the rest of the panel and the other gave a negative response indicating that the process and the involvement of citizens was not effective. The response regarding the meeting format was also very positive with all but one of the 14 panel members indicating that they thought the meetings were productive and effective. In evaluating the questionnaire formats, the majority of the panel members felt that the format used in the third and fourth rounds was the better of the two formats. Of all the questions asked in the evaluation, perhaps the most important was whether or not the panel members felt that the allocations calculated using the panel responses were an accurate reflection of the panel's opinions. In answer to this question, the overall response of the panel was that they agreed that the allocations were an accurate reflection of the panel's opinions. Of the eight panel members who completed the evaluation questionnaire, none disagreed with the allocations.

RECOMMENDATIONS

Several important modifications resulted from the pilot project. The most substantial change in the process was implemented during the pilot project. Panel members felt that the Round 1 questionnaire was too lengthy. As a result, the questionnaires for Round 3 and Round 4 were streamlined considerably. A recommendation for future applications of the Delphi process is that the format of the questionnaires should be kept as simple as possible. A second recommended change is to administer a brief questionnaire during the orientation meeting asking the panel members to consider the factors affecting the different types of growth. In addition to reducing the length of the Round 1 questionnaire, this would serve to prime the panel and stimulate the panel to begin thinking about future growth in the area prior to the first round. The open discussion at the beginning of the first round would likely be more productive as a result. The third recommendation resulting from the pilot project is to use a target panel size of 45 to 50 members. This, combined with the changes to shorten the questionnaire format, should result in a better participation rate and, therefore, a larger and more consistent sample size from round to round.

SUMMARY

As with any computer model used to allocate future growth, the only true test of the allocations generated by the Delphi process are the actual growth patterns over time. However, due to the time and financial savings associated with the Delphi process and the speed with which results can be obtained, the Delphi process can be utilized as frequently as needed to update and maintain future growth allocations.

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A LEAST TOTAL COST APPROACH TO COMPARE INFRASTRUCTURE ALTERNATIVES

Why a Least Total Cost Approach?

The new environment for transportation planning in the 1990s presents a challenge to planners and decision makers in evaluating multimodal alternatives. The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 provides new intermodal funding flexibility. Also, ISTEA requires consideration of efficiency, social, economic and environmental factors in the evaluation process. The Act's emphasis on "management" calls for development of procedures that allow comparisons across a variety of alternatives including new services, land use and demand management as well as high capital investment-type solutions. Additionally, the Clean Air Act Amendments (CAAA) of 1990 emphasize vehicular demand management as an important strategy to reduce air pollutant emissions. Future evaluation procedures will thus need to: (a) give adequate consideration to economic efficiency and social and environmental impacts; and (b) be capable of allowing comparisons across modes as well as across a variety of high capital and low capital or management strategies.

In the past, Metropolitan Planning Organizations (MPOs) have usually compared transportation projects using measures of effectiveness which are uniquely applicable to a specific mode. For example, measures of highway project effectiveness commonly used are improvement in highway level of service (LOS) or highway speed, reduction of highway accidents or savings in highway user costs. Transit project effectiveness, on the other hand, is usually measured by transit ridership or public capital and operating costs per new rider. It is likely that Intelligent Vehicle Highway System (IVHS) projects will also use different measures of effectiveness, depending on their modal orientation. If IVHS projects or programs benefiting different modes (e.g. highway solo-driver, highway shared ride or transit) are to be compared with one another or with other types of investment or management strategies, common measures of effectiveness will have to be used i.e. measures applicable across modes, and across supply-enhancing and demand-reducing strategies.

The least total cost approach uses a common measure (i.e. total cost) which is applicable across all types of alternatives. It attempts to account for the full costs of each alternative. The main advantages of this approach are: (1) It allows comparisons of transportation investments across modes; (2) It allows comparisons of major investment alternatives (e.g. new highway or transit capacity) with management alternatives such as new or improved services (e.g. using IVHS technology), pricing strategies, land use strategies and other strategies which moderate travel demand.

The least total cost approach facilitates accounting for costs of competing highway-oriented and transit-oriented IVHS projects in a comparable manner. For example, in current practice, when computing costs for transit alternatives, analysts include vehicle capital and operating costs and costs for garaging the vehicle. On the other hand, analysts computing the costs for highway travel may include the variable portion of vehicle operating costs such as costs for gas and oil, maintenance and tires, but exclude the fixed costs such as vehicle ownership costs and parking or garaging costs at each end of the trip. (Note that, in the long range, vehicle fixed costs and parking fixed costs are avoidable costs i.e. they are not sunk costs to be ignored). For valid comparisons across modes, the **full** avoidable future costs of each alternative will have to be taken into account, not just costs incurred by transportation agencies for capital investment and operation. Public costs incurred by non- transportation public agencies (e.g. police, fire, court systems, etc.), fixed private costs (e.g. auto ownership costs), and external social and environmental costs cannot be ignored. From a societal point of view, it is irrelevant whether costs are borne privately, publicly or socially.

In a least total cost approach, user benefits other than satisfaction of the basic need for access, for example comfort and convenience advantages of a particular modal alternative, need not be excluded. User benefits or "amenities" can be included in the cost totals as negative costs if they are quantifiable and can be converted to monetary terms. Some user benefits and dis-benefits, as well as some external costs and benefits, cannot easily be converted to monetary terms. They may be listed with some measure of their magnitudes for use in trade-off analysis. For example, a break even analysis could be done to determine how much additional benefits from a higher total cost alternative would have to be worth in dollars in order to make decision makers indifferent between the higher cost alternative and the one with the least total cost.

The base to which alternatives are compared in current practice also poses a problem. In current practice, the base used for comparison is usually a future year "do-nothing", or "no- build plus Transportation System Management (TSM)" alternative. Benefits of the alternatives are calculated based on savings with respect to the base. However, the savings estimates will not be real if the base itself could never exist in reality, which is often the case. For example, before the large delays forecasted under base conditions could ever occur, it is probable that travelers would change their travel patterns (either traveling at different times of the day, by different modes, to different destinations, or by different routes); or they may even decide not to make the trip. It is therefore probable that benefits claimed for alternatives by comparing them to the base are inflated to some extent. (Note that travelers do suffer losses in overall utility when they are compelled to shift their travel patterns; however, the increase in travel times modeled under the typical base year scenario probably overestimates their utility losses.)

The least total cost approach as applied in this paper embodies the following major features:

1. A comprehensive accounting is made of the full costs of the current transportation system as well as the future alternatives, to the maximum extent feasible. User benefits or external benefits in excess those for the least total cost alternative are included as negative costs for the remaining alternatives.

2. The **effectiveness** of alternatives is measured using a common measure which describes the chief "deliverable" of an urban transportation system i.e. access. The measure is person trips served, or the ability of alternatives to accommodate the future increment in demand for trips. Where policies to shift person travel demand to telecommuting, walk or bicycle modes are to be evaluated, it is assumed that walk and bicycle trips as well as "eliminated" trips from telecommuting are included in the total of trips accommodated. Each alternative is assumed to be capable of providing for the increment in demand for access, but at

differing incremental cost, reducing the problem to one of finding the least total cost alternative.

3. Incremental costs of alternatives may be calculated relative to a real base, i.e., the existing system and its travel demand, performance and cost.

4. Major investment alternatives oriented to any mode can be compared. Also, they can be compared with alternatives which involve no differences in public investment, but only policy differences (e.g., land use plan and zoning changes, trip reduction ordinances, and parking surcharges).

5. Incremental cost per added trip may be computed by dividing the incremental costs above the current year costs by the increment of trips served above the current year trips. This measure clarifies the true costs of growth.

Applying the Least Cost Approach

The approach is demonstrated in this paper through application to a case study using a simplified microcomputer-based spreadsheet (LOTUS 123). The focus of the case study is on comparison of land use and IVHS strategies. A previous paper presented a case study application of the approach focusing on evaluation of major transportation investments (8) .

Unit costs of travel differ depending primarily on two variables: (1) time of day e.g., peak or off-peak; and (2) type of trip e.g., personal travel for work, personal travel for non-work purposes, or freight travel. These two variables can be used to categorize travel demand into six travel markets. The case study application focuses on the peak period work (person) travel market.

All costs for providing access are included in the evaluation of costs for accommodating future trips, whether or not the tripmaker bears them directly. Costs may be categorized based on whether or not they have market prices. Market-priced costs include dollar costs borne privately by system users and publicly by transportation or other agencies. Market- priced costs may be categorized as private vehicle costs, public transportation system costs, highway facility costs and safety and security costs. Costs which have no market prices include travel time costs, environmental costs, pain and suffering components of accident costs, and other social costs such as community disruption. They may be borne by system users (e.g., travel time costs) or externally (e.g., environmental costs).

Dollar value estimates of many of these costs may be found in the literature, as indicated in Table 1. However, there are other social costs for which it is unlikely that dollar values can be developed -- they will simply have to be listed with estimates of their orders of magnitude for consideration in trade-off evaluation in the decision-making process. Examples of these impacts are: national defense implications for protection of oil sources, community cohesion or disruption, community pride, aesthetics, accessibility of disadvantaged segments of the population, loss of cultural, historic, recreational and natural resources, loss of open space and depletion of non-renewable energy resources.

Cost parameters used in the application example presented in this paper are based on values shown in Table 1, with appropriate adjustments as presented in Table 3 for IVHS alternatives.

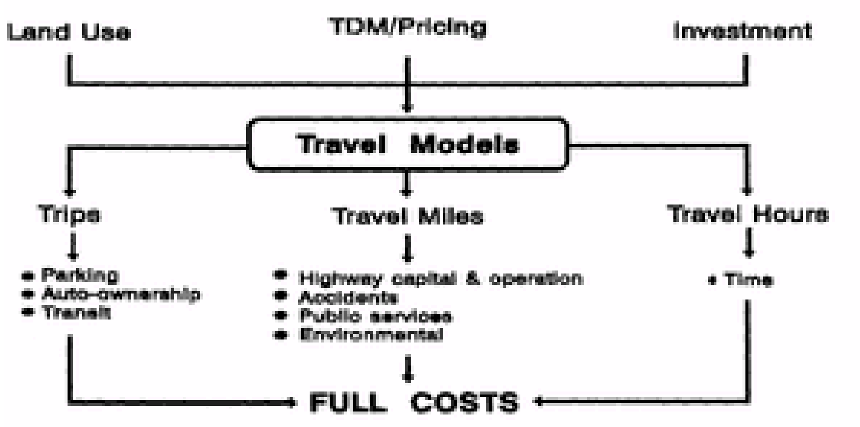
TABLE 1
EXAMPLE UNIT COSTS

Cost Component	Unit Cost	Source
Market-Priced Costs:		
Vehicle		
Operation	7.4 cents/VMT	Ref.1 (less 1 cent fuel tax)
Ownership	$ 3.12/trip	Ref.1 (less acc. insurance)
Parking -- Downtown	$ 3.00/trip	Ref.1 (plus land cost)/2 trips
-- Other	$ 1.00/trip	Ref.1 (plus land cost)/2 trips
Highway		
Oper. & Maint. -- auto	1.8 cents/VMT	Ref.2
-- bus	2.9 cents/VMT	Ref.2, bus/car eqivalency = 1.6
Added capacity -- auto	62 cents/added VMT	Ref.2, Los Angeles Plan data
-- bus	99 cents/added VMT	Ref.2, bus/car eqivalency = 1.6
Public Transportation		
Bus system -- line-haul	$ 3.00/trip	Ref.3, in current dollars
-- feeder	$ 1.50/trip	Ref.3, divided by 2
Subway system	$ 4.25/trip	Ref.3, in current dollars
Safety & Security		
Public services -- auto	1.1 cent/VMT	Ref.4, in current dollars
-- bus	1.1 cent/VMT	Ref.4, in current dollars
-- rail	0.22 cent/VMT	Ref.4, adj. for acc.rate in Ref.1
Accident (market) -- auto	4.2 cents/VMT	Ref.7
-- bus	8.4 cents/VMT	Ref.7
-- rail	1.68 cents/VMT	Ref.7 adj. for acc.rate Ref.1
Costs With No Market Prices		
Travel time	$ 4.50/hour	Estimated
Environmental		
Air pollution	2.4 cents/VMT	Ref.4, in current dollars
Water pollution	0.2 cent/VMT	Ref.12
Noise	0.16 cent/VMT	Ref.4, in current dollars
Solid/chemical waste	0.2 cent/VMT	Ref.5
Oil extraction	1.5 cent/VMT	Ref.5
(Subtotal)	4.46 cents/VMT	
Accidents (non-market) -- auto	7.8 cents/VMT	Ref.7
-- bus	15.6 cents/VMT	Ref.7
-- rail	3.12 cents/VMT	Ref.7

The adjustments account for cost increases due to IVHS technology (both publicly and privately borne) and cost savings from reduced accidents and reduced needs for new highway lanes. More detailed methods for calculation of costs could certainly provide more accurate estimates of costs. **The purpose of the example is simply to demonstrate how the approach may be used in real world situations, and not to provide definitive answers about the cost-effectiveness of the alternatives evaluated.**

The basic process for computation of costs is indicated in Figure 1. The process relies heavily on output from the four-step travel demand modeling process (9) , both for the base year condition as well as for future year alternatives. As Figure I indicates, the outputs from the travel models needed for input into the costing procedures are the following, for each person travel market: (1) person trips by mode (from mode choice); (2) travel miles (from trip assignment) by mode -- person miles of travel (PMT) on transit line-haul and transit access modes, as well as vehicle miles of travel (VMT) on the highway system; and (3) travel minutes (also from trip assignment) by mode. As Figure I indicates, the travel measures output from the travel models are input into cost models which provide unit cost parameters for the various cost components. Unit costs may be costs per trip, per PMT, per VMT or per minute of travel time, as indicated in Table 1.

FIGURE 1
FULL COST ACCOUNTING
TRAVEL INPUTS



The case study urban area was Washington, DC. A previous study (10) provided model output data. In cases where needed travel parameters were not available from the study report, national averages from the Nationwide Personal Transportation Study (NPTS) were used (l1) . The Washington, DC study involved analysis of the systemwide travel and transportation system impacts of two alternative urban development patterns for the year 2010. The first alternative (BAL) promoted a closer balance between housing and employment growth, both regionwide and within individual "employment growth" subareas within the region. The second alternative (CONC) maintained regionwide balance between housing and employment as in the first alternative, but concentrated employment in areas with good transit service and significant levels of transit use at the job end of the work trip. The study also provided a base model run for 1995. To demonstrate the application of the least total cost approach with IVHS alternatives, two new alternatives were developed by the author. Both built upon the concentrated (CONC) alternative. The first alternative, IVHS(S), assumed use of only supply-enhancing IVHS technologies such as technologies which smooth the flow of highway traffic, provide priority to transit vehicles, provide real- time information to highway and transit users, provide new services e.g. single-trip carpooling, and enhance highway and transit safety. The second alternative, IVHS(D), added to IVHS(S) by managing demand through pricing mechanisms for peak use of highways.

The travel data and results of the cost analysis are presented in Table 2. A comparison of total costs which were calculated by the spreadsheet suggests that the concentrated (CONC) alternative has lower total costs than the balanced alternative (BAL). **Based on the liberal use of cost and travel demand assumptions for IVHS** by the author, the IVHS(S) scenario could save about $400,000 daily in aggregate mobility costs relative to the concentrated (CONC) scenario. For the IVHS(D) scenario, the savings would be about $5.7 million daily. Public agency costs (for highways and for public transportation deficits assuming a 40 % farebox recovery rate) would be about $244,000 lower daily under IVHS(S) and $3.4 million lower daily under IVHS(D). As indicated earlier, the cost totals include only those cost items included in Table 1, and exclude some non-monetizable environmental and social costs. Many of these costs are primarily related to auto travel. Since the IVHS(D) scenario involves much less auto travel than the other scenarios, additional savings in non- monetizable environmental and social costs may be expected.

Table 2 also indicates that, while providing mobility currently costs about $5.90 per work trip (including all cost items listed in Table 1), the cost per new trip added by 2010 will be significantly higher under all future alternatives except for IVHS(D). Average cost per added trip amounts to $10.35 under the balanced scenario, $10.03 under the concentrated scenario and $9.54 under the IVHS(S) scenario, but only $3.00 under the IVHS(D) scenario.

Note that Table 2 includes a line item for "negative costs". These are the additional user benefits for the BAL, CONC and IVHS(S) alternatives relative to the IVHS(D) alternative, reflecting primarily the consumer surplus enjoyed by single occupant vehicle (SOV) drivers who are tolled off by the IVHS(D) alternative. This consumer surplus is calculated by multiplying the number of SOV drivers tolled off by half the tolls they would have had to pay. The IVHS(D) alternative is assumed to cause shifts of SOV drivers to other modes only, since work trips are not very likely to shift out of the peak periods during which tolls apply due to limited flexibility of work start and end times. (Note that there may be some debate as to whether the consumer surplus losses suffered by tolled off SOV drivers have already been accounted for through the higher travel times on the HOV and transit modes which are included in the "positive" cost totals. The excess travel time costs incurred by SOV drivers who shift modes may need to be subtracted if their consumer surplus losses are included as negative costs. The spreadsheet has not been set up to do these calculations at this time.

TABLE 2
COSTS FOR WEEKDAY PEAK PERIOD WORK TRAVEL

		1995 BASE	2010 BAL	2010 CONC	2010 IVHS(S)	2010 IVHS(D)
Peak period travel data (millions per day)						
Trips:	SOV trips	1.3748	1.9308	1.8749	1.8749	0.8583
	Carpool person trips	0.9904	1.1483	1.1751	1.1751	2.0916
	Transit person trips	0.4599	0.5563	0.5855	0.5855	0.6855
	Total person trips	2.8251	3.6354	3.6355	3.6355	3.6354
	Total vehicle trips	1.825	2.453	2.409	2.409	1.809
VMT:	Total (incl.bus and transit access)	19.329	25.931	25.498	25.498	19.333
Time:	Total (incl. walk and wait time)	69.7967	88.4880	89.1946	86.2673	91.6269
Peak period travel costs (dollars per day)						
Market costs:	Auto ($M)	6.883	13.408	12.964	12.956	6.738
	Transit ($M)	2.106	2.560	2.697	2.696	3.166
	Total ($M)	8.989	15.968	15.662	15.651	9.904
Non-mkt costs:	Time ($M)	5.235	6.637	6.690	6.470	6.872
	Environmental ($M)	0.862	1.157	1.137	1.137	0.862
	Accident (pain) ($M)	1.514	2.031	1.997	1.831	1.392
Total costs:	Total +ve costs ($M)	16.600	25.791	25.486	25.090	19.030
	Negative costs ($M)		-0.804	-0.762	-0.762	0.000
	Net total costs		24.987	24.724	24.328	19.030
	Avg. net cost per trip	5.876	6.873	6.800	6.692	5.235
	Incr. cost per added trip		10.349	10.025	9.536	2.999
Transp. agency:	Total costs ($M)	1.817	6.350	6.171	5.927	2.761
	Incr. cost per added trip		5.594	5.373	5.071	1.164

LEAST COST CONCLUSIONS

This paper has explained the theory in support of a least total cost approach to compare transportation investment alternatives across modes, and to compare significant changes in management and land use policies. The approach is based on assessing the relative economic efficiency of alternatives by determining which alternative involves the least total cost for providing access for various travel markets. The approach has been demonstrated through application of a simplified analysis technique using a LOTUS 123 spreadsheet. Results from the analysis have been presented for demonstration purposes only. The application of the approach to the case study suggests that the approach can be a useful tool for comparison of multimodal investment, IVHS, management and land use policy alternatives.

TABLE 3

UNIT COST CHANGES FOR IVHS

Cost Component	Unit Cost	Rationale
Market-Priced Costs:		
Vehicle		
Operation	8.4 cents/VMT	1 cent added for veh. gadgetry
Ownership	$ 3.22/trip	10 cents added to veh. cost
Highway		
Oper. & Maint. -- auto	2.3 cents/VMT	0.5 cent added for oper
-- bus	3.4 cents/VMT	0.5 cent added for oper
Added capacity -- auto	56 cents/added VMT	6 cents reduced for efficiency
-- bus	90 cents/added VMT	9 cents reduced for efficiency
Safety & Security		
Accident (market) -- auto	3.2 cents/VMT	1 cent reduced for acc. savings
-- bus	6.4 cents/VMT	1 cent reduced for acc. savings
-- rail	1.68 cents/VMT	No change

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