State
Transportation
Policy
Initiative

A New Strategic Urban Transportation Planning Process

Center for Urban Transportation Research

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CUTR

Center for
Urban Transportation Research
University of South Florida

June 1995

Preface

Recent legislation and fiscal trends in Florida and nationwide have created a unique combination of constraints and opportunities, providing an impetus for examining the way Florida conducts transportation planning. In response to these challenges, the Florida Legislature and the Governor's Office directed the Center for Urban Transportation Research (CUTR) to undertake the State Transportation Policy Initiative (STPI). The purpose of this multi-phase study is to reevaluate the way transportation infrastructure and services are planned and developed at the state and local levels in Florida and to formulate options for implementing requirements of the 1991 Intermodal Surface Transportation Efficiency Act.

Efforts undertaken as part of STPI include:

- a comprehensive review of local and regional planning in Florida in the context of State growth management requirements and federal legislation
- an evaluation of the impact of community design on transportation needs
- a review of the literature on the transportation costs of urban sprawl
- an evaluation of comprehensive transportation planning for state purposes
- an examination of the relationship between air quality and transportation planning, as practiced in Florida
- an evaluation of trends and forecasts of Florida's population and transportation characteristics
- a study of transit, transportation demand management, level of service, and concurrency issues and of congestion management and urban mobility planning
- preparation of a state land use map by Florida's Regional Planning Councils
- a study of statewide transportation needs and funding
- recommendations for a new strategic planning process for Florida that recognizes uncertainty
- a review of the extent to which local land development regulations complement comprehensive plans
- a study of sustainable community design and transportation.

This report is one of a series produced as part of the State Transportation Policy Initiative.

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Special thanks to the staffs of local governments, metropolitan planning organizations, regional planning councils, and the many other agencies and individuals who participated in this research.

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Chapter 1

Introduction: A World of Change and Uncertainty

Background

As observed 20 years ago by Marvin Manheim, "We live in a world of rapid change."[1] Along with the world of rapid change, we might note a world of uncertainty; not only is change occurring, but it is occurring in ways that we cannot anticipate. Manheim identified three dimensions of change that are relevant to transportation systems: change in demand, change in technology, and change in values. Neumann and Pecknold similarly have noted that "...change is endemic in the society in which we live," and that "...changes in values, demand for service, and the influence of transportation on these changes cannot be predicted with certainty."[2] In addition to the factors noted by Manheim, they cited the uncertainty in future availability of resources to address transportation problems. Others, for example Pickrell[3] and Wachs,[4] cited uncertainty in estimating costs of major transportation facilities.

Demand

Demand for transportation is a result of a myriad of social and economic factors. Population levels, demographic characteristics, relative wealth, land use, labor force participation, and availability and price of transportation service are but a few of the factors influencing the demand for transportation. Each of these, in turn, is the result of many complex interactions. For example, population levels are influenced by birth and mortality rates, immigration and migration, and family structure. In turn, each of these is influenced by numerous causal factors. As any one of these characteristics undergoes change, the demand for transportation can change as a result. Can it be any surprise that forecasts of future transportation demand are highly uncertain?

Technology

Transportation technology changes over time and in ways that are difficult–if not impossible–to predict. The widespread adoption over the past several decades of the private automobile as the dominant mode of personal transportation has had profound and unanticipated effects on the structure of our country. The flexibility afforded by the private auto has allowed people to trade time for reduced housing costs and has permitted the move to the suburbs of residences, followed by retail businesses, and, more recently, by jobs.

The current interest in intelligent transportation systems (ITS) has raised hopes for roadways of the future in which the motorist will relax behind the wheel as his vehicle speeds along to a distant destination. If these hopes turn into realities, another massive change in transportation behavior will occur. Recent advances in electronic toll collection and in advanced motorist information systems are already influencing travel characteristics.

Roadbed improvements over the last 20 years have allowed the Amtrak Northeast Corridor passenger rail service to compete effectively with other intercity transportation alternatives. The widespread entry of commuter airlines onto the scene has brought the benefits of air transportation to many markets that were previously too small for commercial air service.

Who can say what the long range impact of the information superhighway will be? The future may see many more Americans working out of home offices, tied to the organization by electronic mail and a fax modem.

These are but a few examples of changes in transportation and related technology. Each of these has had (or could have) dramatic impacts on patterns of activity and behavior.

Costs

Costs of constructing and operating transportation systems are similarly difficult to predict, as they are influenced by costs of labor, fuel, and raw materials. In turn, these costs are affected by union agreements, the international situation, and other factors. Perhaps the most dramatic recent example is the ill-fated Denver International Airport. It is anticipated that the project, when finally completed, will cost $4.2 billion, compared to the $1.7 billion anticipated when approved by voters four years earlier.[5]

Resource Availability

The ability to implement transportation projects is obviously dependent on the financial resources available. In turn, these depend on the state of the economy, fuel tax revenues, license and tag fees, impact fees, and airport landing fees. Resource availability is also influenced by the priority placed on transportation compared to other social objectives. Not only do these factors change, but they change unpredictably. It is often difficult for state-level revenue forecasts to estimate three to six months ahead. Trying to estimate years into the future is even more difficult.

Values

Values are one of the most interesting and difficult dimensions of change. The fact that values change over time means that the optimal solution of today may not be the optimal solution of next year. For example, the increased value placed by society on environmental quality has dramatically altered the decisionmaking process for major transportation investments. Thirty years ago, building major freeways through low income neighborhoods was seen as an effective means of "slum clearance." Today, we are much more sensitive to the social disruption caused by major projects and go to great lengths to minimize the need for relocations.

In the past decade, we have seen increased awareness of the transportation needs of the transportation disadvantaged, those who by virtue of physical, mental, or economic condition are unable to utilize traditional forms of transportation. Society has recognized as an important priority that people with disabilities should be provided with mobility.

Over time, we can expect values to continue to change in response to many factors. The relative importance placed on economic development and environmental preservation may be influenced by the unemployment rate or the health of the economy. The value placed on energy conservation will be influenced by the level of stability in the Middle East.

Research Objective

Although we do live in a world of change and uncertainty, as noted by Neumann and Pecknold, "public policy and investment decisions can strongly influence the patterns of change...."[6] In spite of the uncertainty of future events, we need to plan for that uncertain future. DeSalvo, citing Seeley, defined planning as "a formal or ordered process in which men seek by forethought to affect action so as to bring about more desired states than it is anticipated would otherwise occur."[7] This definition serves as a useful reminder that our society does have preferences that are worth pursuing, in contrast to "letting things happen." This reaffirmation is important, in that we can recognize the full range of uncertainties and inabilities to forecast, and yet desire to move toward the attainment of certain goals.

Indeed, that is the objective of this research: to recognize uncertainty, yet not be paralyzed by it; to move proactively toward the attainment of valued societal objectives, yet to be prepared for the changes we cannot predict. This report examines the urban transportation planning process, identifies shortcomings (particularly those related to decisionmaking and uncertainty), and proposes principles and procedures for improving the process.

Overview of Report

This report consists of five chapters. The introductory Chapter 1 provides a background to the research and an overview of the report. Chapter 2 presents an overview of the urban transportation planning process. It includes a summary of federal legislative requirements, as well as the technical methods commonly applied. Particular attention is given to underlying, but often unrecognized, assumptions. The process is presented as a deterministic one, which is predicated on the ability to forecast social and economic variables long periods into the future to produce a master plan.

Chapter 3 presents the reality that change cannot be predicted with certainty. It begins with a discussion of the limitations of models in general, and the models employed in the urban transportation planning process in particular. It deals with errors in specification, calibration, and input forecasts. Because we as individuals often fail to translate our observations into logical conclusions, it also reviews common errors in individual perceptions that affect our understanding of decisionmaking. Examples of social and political bias are then presented. It is demonstrated that in many cases these biases have led to gross misrepresentations of uncertainties and have resulted in incorrect decisions.

Chapter 4 examines strategies that have been proposed to deal with uncertainty in the planning of large scale public systems. These include strategic planning, various incremental approaches, risk-avoidance and insurance measures, and several others. The challenge presented in this chapter is adopting those methods that have potential for the practice of transportation planning.

Finally, Chapter 5 draws from all previous work to identify practices that can be incorporated into the transportation planning decisionmaking process to make it more strategic, dynamic, and flexible in responding to future uncertainties.

Chapter 2

Overview of the Urban Transportation Planning Process

This chapter reviews the current transportation planning process and new requirements for metropolitan transportation planning under the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). It begins with an overview of new state planning requirements and their relationship to the metropolitan planning process and concludes with a description of the traditional urban transportation planning process modeling methods for determining future transportation needs.

State Transportation Planning

ISTEA provides the first federal mandate for statewide transportation planning–a process modeled after that for metropolitan planning organizations.[8] Under the provisions of ISTEA, state departments of transportation must prepare a statewide transportation plan that considers a range of transportation options designed to meet the transportation needs of the state for a period of at least 20 years. The state must also develop a statewide transportation improvement program. State long range plans and transportation improvement programs must be consistent and coordinated with each other and with metropolitan transportation plans and improvements programs.

States must address 23 factors in the statewide transportation planning process, including the effect of transportation decisions on land use and land development, and acquisition and preservation of rights-of-way for future transportation corridors. The 1993 session of the Florida legislature passed a Florida Intermodal Surface Transportation Efficiency Act designed to bring Florida into conformance with federal ISTEA. Florida ISTEA strengthens some of the federal ISTEA, and adds two requirements (Table 1).

States must also address the long range needs of the state transportation system and pursue innovative financing, such as value capture pricing, tolls, and congestion pricing, in addressing those needs. New transportation management systems must be developed to assist with needs determination and to improve management and operation of existing facilities. ISTEA calls for greater public participation in the transportation planning and programming process at both the state and regional levels.

Although the ISTEA mandates for statewide transportation planning clearly intend to promote a strategic approach to transportation decisionmaking, they do not explicitly acknowledge the role of uncertainty in the planning process.

With the enactment of ISTEA, a shift in transportation decision authority has occurred in metropolitan areas of 200,000 persons or more, as greater authority for setting transportation investment priorities has been given to Metropolitan Planning Organizations (MPOs). Although ISTEA calls for greater regional responsibility, state Departments of Transportation will still have considerable authority.

Additional or enhanced requirements of Florida ISTEA include:

- consistency of the plan, to the maximum extent feasible, with comprehensive regional policy plans, MPO plans, and approved local government comprehensive plans so as to contribute to the management of orderly and coordinated community development;

- a seaport or airport master plan, which has been incorporated into an approved local government comprehensive plan, and the linkage of transportation modes described in such a plan which are needed to provide for the movement of goods and passengers between the seaport or airport and the other transportation facilities;
- joint use of transportation corridors and major transportation facilities for alternate transportation and community uses.

State transportation officials will continue to control state matching funds and are ultimately responsible for developing and implementing state projects. Urban projects on the National Highway System or pursuant to the bridge and Interstate maintenance programs remain under their purview. The state is required to review and certify MPOs in metropolitan areas of more than 200,000 persons (now called Transportation Management Areas), for conformance with ISTEA's planning and programming requirements once every three years. If the MPO is not certified, the state can withhold all or a portion of their apportionment under the Act.

Table 1
FACTORS REQUIRED BY ISTEA TO BE ADDRESSED BY THE STATE

1. The results of the ISTEA management systems.
2. Any federal, State, or local energy goals, objectives, programs or requirements.
3. Strategies for incorporating bicycle transportation facilities and pedestrian walkways in projects where appropriate throughout the State.
4. International border crossings, access to ports, airports, intermodal transportation facilities, major freight distribution routes, national parks, recreation and scenic areas, monuments and historic sites, and military installations.
5. The transportation needs of nonmetropolitan areas through a process that includes consultation with local elected officials with jurisdiction over transportation.
6. Any metropolitan area plan.
7. Connectivity between metropolitan areas within the State and with any metropolitan areas in other States.
8. Recreational travel and tourism.
9. Any State plan developed pursuant to the Federal Water Pollution Control Act.
10. Transportation system management and investment strategies designed to make the most efficient use of existing transportation facilities.
11. The overall social, economic, energy, and environmental effects of transportation decisions.
12. Methods to reduce traffic congestion and prevent it from developing in areas where it does not yet occur, including methods which reduce motor vehicle travel, particularly single-occupant motor vehicle travel.
13. Methods to expand and enhance transit services and to increase the use of such services.
14. The effect of transportation decision on land use and land development, including the need for consistency between transportation decisionmaking and the provisions of all applicable short-range and long-range land use and development plans.
15. The transportation needs identified through use of management systems required by ISTEA.
16. Where appropriate, the use of innovative mechanisms for financing projects, including value capture pricing, tolls, congestion pricing.
17. Preservation of rights-of-way for future transportation project construction, including identification of unused rights-of-way that may be needed for future corridors, and identification of those corridors for which action is most needed to prevent destruction or loss.
18. The state transportation system's long-range needs.
19. Methods to enhance the efficient movement of commercial motor vehicles.
20. Life-cycle costs in the design and engineering of bridges,tunnels, or pavement strategies.
21. Coordination of metropolitan transportation plans and programs with the statewide transportation plans and programs.
22. Investment strategies to improve adjoining State and local roads that support rural economic growth and tourism development, federal resource management, and multipurpose land management practices.
23. The concerns of Indian tribal governments having jurisdiction over lands within the boundaries of the state.

State Transportation Improvement Program (STIP)

The Statewide Transportation Improvement Program required by ISTEA must have at least a three-year horizon and reflect projects identified by MPOs, as well as projects of rural or statewide significance. For nonattainment areas, the STIP must conform to the State Implementation Plan (SIP) for carrying out the requirements of the Clean Air Act Amendments of 1990.

Projects included in the STIP are to be selected as follows:

- Projects undertaken with federal or state funding in areas of less than 50,000 population are to be selected by the State in cooperation with the affected local officials. Projects undertaken in areas on the National Highway System or pursuant to the bridge and interstate maintenance programs are to be selected in consultation with affected local officials.
- Projects undertaken with federal or State funding in areas with a population between 50,000 and 200,000, will be selected by the state, in cooperation with the MPO, in conformance with the Transportation Improvement Program for the area.
- Projects carried out within the boundaries of the transportation management area, for areas over 200,000 population with federal or state participation will be selected by the MPO, in consultation with the state, in conformance with the Transportation Improvement Program.
- Projects undertaken within the boundaries of a TMA on the National Highway System or pursuant to bridge and interstate maintenance programs will be selected by the state in cooperation with the MPO.

The Florida Transportation Plan

Florida is fortunate in that FDOT has been carrying out many of ISTEA's requirements already. Notwithstanding, the 1993 Legislative session passed a Florida ISTEA that brings Florida into conformance with Federal ISTEA. The Florida Transportation Plan (FTP) is the statewide comprehensive transportation plan developed by FDOT. The plan historically has served as the transportation portion of the state comprehensive plan and has consisted of the following elements: systematic planning process, transportation policies and guidelines, transportation modes, transportation designation and coordination, performance monitoring, and five-year program and resource plan.

The Florida Transportation Plan was updated in 1994 to better conform to the new legislative requirements of Florida ISTEA and the ELMS-III Act, which calls for the plan to serve as one of the guiding documents for a new growth management portion of the state comprehensive plan. An extensive program of public involvement activities is being undertaken as part of the development of the Florida 2020 Transportation Plan.

In a companion document to the 2020 Florida Transportation Plan, FDOT has presented a series of 25 "snapshots" describing major demographic and transportation conditions and trends for the State of Florida. Snapshot #1 is titled "If Only Foresight Could be 2020," and it states:

> It's tough to tell the future. Analyzing historical and current trends to forecast conditions 20 or more years into the future has been compared to throwing darts at a moving board under a strobe light. The dynamic nature of social, economic, and political activities in the United State and Florida creates too many uncertainties for foolproof forecasting.[9]

In spite of this recognition, our methods and practices for dealing with uncertainty are to largely ignore its implications in the planning of our future transportation facilities.

Metropolitan Transportation Planning

MPOs are responsible for carrying out long range transportation planning and setting transportation programming priorities for metropolitan areas. MPOs were created in 1975 to carry out the urban transportation planning mandates of the Federal Highway Administration and the Urban Mass Transportation Administration (now the Federal Transit Administration). MPOs were to be established in all urbanized areas of 50,000 population or more and were to work in cooperation with the state DOT and transit operators. The transportation planning process was to be continuing, cooperative, and comprehensive (the "3-C process"), and MPOs were to provide a forum for cooperative decisionmaking by principal elected officials of general purpose local government.

ISTEA retains much of the flavor of the 1975 Joint Planning Regulation, but the new planning requirements include a much stronger intermodal emphasis, allow greater flexibility in the application of federal funds, and call for greater recognition of the needs of commercial transportation and the efficient movement of freight.

ISTEA requires consideration of 15 interrelated factors (see Table 2) by MPOs in preparing the long range transportation plan, which is required to cover a period of at least 20 years. Long range plans must address the effect of transportation policy decisions on land use and development. The plans are required to include strategies that lead to the development of an integrated intermodal transportation system. The plan is to be reviewed and updated at least triennially in nonattainment and maintenance areas and at least every five years in attainment areas to confirm its validity and its consistency with current and forecasted transportation and land use conditions and to extend the forecast period. (In this requirement, there is at least an acknowledgment of uncertainty in the forecasting process).

Table 2
FACTORS REQUIRED BY ISTEA TO BE CONSIDERED BY MPOs

1. Preservation of existing transportation facilities and, where practical, ways to meet transportation needs by using existing transportation facilities more efficiently.
2. The consistency of transportation planning with applicable federal, State, and local energy conservation programs, goals, and objectives.
3. The need to relieve congestion and prevent congestion from occurring where it does not yet occur.
4. The likely effect of transportation policy decisions on land use and development and the consistency of transportation plans and programs with the provisions of all applicable short- and long-term land use and development plans.
5. The programming of expenditures on transportation enhancement activities.
6. The effects of all transportation projects to be undertaken in the metropolitan area, without regard to whether such projects are publicly funded.
7. International border crossings and access to ports, airports, intermodal transportation facilities, major freight distribution routes, national parks, recreation areas, monuments and historic sites, and military installations.
8. The need for connectivity of roads within the metropolitan area with roads outside the metropolitan area.
9. The transportation needs identified through use of the management systems required by ISTEA.
10. Preservation of rights-of-way for construction of future transportation projects, including identification of unused rights-of-way which may be needed fro future transportation corridors and identification of those corridors for which action is most needed to prevent destruction or loss.
11. Methods to enhance the efficient movement of freight.
12. The use of life-cycle costs in the design and engineering of bridges, tunnels, or pavement.
13. The overall social, economic, energy, and environmental effects of transportation decisions.
14. Methods to expand and enhance transit services and to increase the use of such services.
15. Capital investment that would result in increased security in transit systems.

MPOs are responsible for creating and annually updating a Transportation Improvement Program (TIP) that consists of improvements recommended from the long range transportation plan. In Florida, the TIP must be consistent, to the maximum extent feasible, with local government comprehensive plans in the region. Projects in the TIP that have advanced to the design stage of preliminary engineering can be removed or rescheduled only in subsequent TIPs by the joint action of the MPO and FDOT.

Each TIP is developed in cooperation with the state and affected public transportation operators and must include the following:

- a priority list of projects and project phases to be funded with state or federal funds;
- a list of projects for funding under the Federal Transit Act;
- a financial plan that shows how the TIP will be carried out;
- grouping of projects and project phases of similar urgency into appropriate staging periods;
- examples of projects which further the long range plan and indication of how the TIP relates to the long-range plan;
- any inconsistencies of projects or project phases with local government comprehensive plans; and
- indications of how improvements are consistent with seaport and airport master plans and public transit development plans.

On the local level in Florida, the Transportation Element of local government comprehensive plans must consider the adopted level of service standards and improvements, expansions and new facilities planned in the FDOT Five-Year Work Program and the MPO plans (9J-5.007). Goals and objectives of each plan must coordinate with the MPO plans, any public transportation authority, any appropriate resource planning and management plan, and FDOT's Five-Year Work Program.

The Urban Transportation Planning Technical Process

The urban transportation planning process, which is sometimes known as the systems planning process, uses a series of sequential models to describe the interactions between land use, the transportation system, and travel characteristics. There are several proprietary software packages that execute the basic modules of the urban transportation planning process, including TRANPLAN, MINUTP, EMME, and others. The State of Florida has standardized this process through its widely-distributed TRANPLAN-derivative FSUTMS models. The sequential transportation planning models are summarized in Table 3.

The process begins by dividing the planning area into traffic analysis zones (TAZs) and estimating various socio-economic activity measures, such as population and employment, for each zone. The number of zones can vary from 50 for a small urbanized area to over a thousand zones for a large metropolitan area. For example, Hillsborough County is divided into approximately 800 traffic analysis zones.

Population forecasts for a metropolitan area are generally produced by an officially recognized forecasting organization; in Florida, this is the Bureau of Economic and Business Research (BEBR) at the University of Florida. The methods used by BEBR generally assume the continuation of past trends for the state, and for metropolitan areas. Forecasts are based on an average of the most recent 5-year, 10-year, and 15-year trends. Employment forecasts are normally locally generated, and are frequently based on historical trends in labor force participation rate, which are applied to the population forecasts. These regional totals of basic socio-economic variables are then allocated to each of the TAZs in the study area.

Based on demographic and economic characteristics, the trip generation model estimates the number of trips produced or attracted by each zone. Generally this is done for a 24-hour period. Typically, the dependent variable, trip ends, is related to some causal factor, such as population, dwelling units, auto ownership, employment, school enrollment, or combinations of variables such as these.

Based on productions and attractions in each zone and assumed performance characteristics of the transportation system, the trip distribution model estimates the number of trips from each zone to all other zones. The trip distribution model used in most applications is the gravity model, which operates as a share model by splitting all trips produced in a given zone to all other zones, in direct proportion to the number of trip attractions in each zone, and in inverse proportion to the time and cost of getting from one zone to another.

Table 3
THE SEQUENTIAL URBAN TRANSPORTATION PLANNING PROCESS

Land Use	Location and intensity of development
Trip Generation	How many trips are made?
Trip Distribution	... to where?
Modal Split	... by what means?
Assignment	... by what path?

Modal split involves the division of trips between each pair of zones into modal alternatives—primarily the proportion traveling by automobile versus the share traveling by public transportation. The mode split model can differentiate between different forms of public transportation, such as commuter rail, express bus, local bus, etc. The mode split model compares various service characteristics between each pair of zones and divides interzonal trips into competing travel modes, based on their comparative performance characteristics. Service characteristics that are compared might include out-of-pocket cost, travel time, waiting time, and similar performance factors.

The traffic assignment model compares the difficulty (usually measured in travel time or cost) in traveling by various routes between each pair of zones, and specifies the particular transportation links utilized between each set of zones and the total number of trips on each link. There are numerous assignment algorithms, ranging from all-or-nothing (in which all trips are assigned to the minimum impedance path), to various multipath and capacity restrained algorithms. The models are normally applied on a 24-hour basis, with various "rules of thumb" applied to translate to peak period directional volumes. By examining the total network loadings of the traffic assignment process, traffic demand can be compared with the traffic-carrying capacity of each link.

These models are first applied to a base case year, for which input variables are known with some certainty. For the base conditions, the model outputs are compared to historical traffic counts for that same time period. By comparing model output with known traffic counts, adjustments can be made to various submodels until the output accurately reflects ground traffic counts. This process is known as calibration and validation. In many cases, the adjustments that are made to force the model to replicate historical traffic counts result in unrealistic descriptions of the network. A specific example can be found in a model validation effort for Lee County, Florida, from which the following excerpts are taken:

> ...Time penalties are used in modeling to represent an aversion to using a particular roadway or link within the network which the model would not otherwise recognize.[10]

> ...the model causes [too many] trips to be attracted to an expressway due to the free

> flow characteristics and the relatively high speeds. For this reason, expressway speeds are usually lowered in most modeling efforts to an unrealistic speed. However, lowering the speeds usually has the effect of discouraging longer trips which should be travelling on the expressway. Therefore, a time penalty was used on the I-75 on-ramps to discourage the short trips...[11]
>
> ...The 1987 traffic counts are showing many of the two-lane roads in Lee County are carrying more traffic than the two-lane capacities would allow.... For the model to replicate these conditions, the capacity restraint on the two-lane roads needed to be removed. Therefore, the capacities on selected two-lane roads were increased by 25 percent...[12]

In effect, what each of these statements is saying is that the network description is changed, not based on the actual condition of the network but merely to force the output of the model to match the desired output.

After models have been calibrated using base year data, they are applied with forecast year input data (land use and transportation system characteristics) with the assumption that basic relationships between socio-economic conditions and trip making will not change over the forecast period. The quality of model results is dependent, among other things, upon the reasonableness of the socio-economic activity measures and land use assumptions forecast in the future year.

The degree of accuracy originally intended and built into the basic assumptions of the models was ± 1 lane of traffic. Further, it was originally intended that corridors be looked at wherever possible. The *use* of the models has frequently gone well beyond this.

The transportation planning process described above is used by MPOs in Florida and across the nation. It utilizes a methodology that originated in the early 1960s and has changed only modestly in the last 30 years. Virtually all MPOs apply this sequence of models based on economic and land use characteristics forecasted for the study area in some future year—generally 20 years into the future. A long range transportation plan is produced, based on that forecasted future land use scenario. The plan is then staged, so that early implementation projects are timed for consistency with the long range plan.

Land Use/Transportation Relationships

Interrelationships between transportation and land use are well known to transportation and land use planners. Important trade-offs exist between regional mobility and land access, and access management is an important tool in preserving the mobility function of our highway system. Land use decisions affect transportation demand and that transportation investments are a major factor in location decisions.

On a regional basis, transportation facilities are determinants of the shape and character of urban form. Circumferential highways constructed around major cities have demonstrated the role of transportation infrastructure in shaping urban areas. The quintessential American land use, the suburban shopping mall, is always located on a highly accessible site, frequently at the interchange of a limited access highway with a major arterial.

The State of Florida has recognized this important interaction and is making great strides in promoting integrated land use and transportation planning. Florida has recognized that planning for land use, transportation, and other infrastructure must be integrated to achieve the State's growth management objectives.

The difficulty confronting transportation and land use planners is how to incorporate this integrated philosophy into technical practice. The interactions between transportation and land use are rarely acknowledged in analytical procedures. Most often land use is taken as an exogenous variable to be input into the complex urban transportation planning models, and a great deal of effort is spent testing and calibrating the models to assure that the replication of current conditions is acceptable. The model is then applied to alternative transportation networks to test the effectiveness of each network in meeting anticipated demands of the land use scenario. The fundamental impact of the transportation system on the placement of land use activity is largely ignored.

This process may be adequate when only marginal changes are made in the transportation system, but is not appropriate in the context of comprehensive systems planning. It overlooks a very important fact—the specification of future land use and economic activities (the input variables) are highly dependent on an assumed future transportation network (the ultimate output). When future land use plans are developed they are based on some anticipation of the future transportation network. This assumption is not necessarily explicit—indeed, it rarely is. Our standard approach recognizes that land use influences transportation. However, in the transportation planning process, transportation facilities are implicitly assumed to have no impact on land use.

One problem with using a fixed land use scenario can be the underestimation of traffic volumes on major new highway facilities. Even though a proposed new highway would dramatically alter the transportation system, opening up vast areas for development, this fact of economic development is typically ignored in the transportation planning process. An excellent example of this potential problem is the North Suncoast Parkway, a new limited access highway traversing several counties on Florida's West Coast.

Another example is the case of one Florida coastal city, where several recent studies have tested the feasibility of a new water crossing. Traffic was assigned from a fixed set of land use assumptions onto alternative transportation networks. Because the alternative networks included major differences in a proposed new water crossing, the probable land use characteristics under each transportation network would vary substantially. Nonetheless, the process redistributed and reassigned traffic from the same land use scenario, regardless of whether the new water crossing was part of the test network. This methodological shortcoming may account for the common experience of new or improved transportation facilities reaching their 20-year design capacity within a few years of opening.

The Larger Context

An underlying premise of the urban transportation planning process is that the future can forecasted with some reasonable degree of accuracy. The typical process is to develop 20-year forecasts of key independent variables for each of the traffic analysis zones of a metropolitan area. Depending on the size and characteristics of a region, these may range from 50 to over 1,000 traffic analysis zones.

Based on the 20-year socioeconomic forecasts, disaggregated to a zonal basis, the models produce forecasted traffic volumes on each link of the transportation network. Planners then attempt to devise a master plan that, in some metric, represents an optimal solution to the forecasted condition.

Subsequent planning activities, particularly the preparation of the Transportation Improvement Program, focus on staging projects in such a way that they lead to the completion of the master plan. Following the adoption of a long range plan developed in the systems planning process, more detailed studies are undertaken on individual projects selected from the long range plan. Individual projects are typically the subject of a project development and environmental study, which examines the range of environmental, engineering, social and economic impacts of proposed actions.

Chapter 3

The Reality: Change Cannot Be Predicted with Certainty

The urban transportation planning process assumes we can forecast 20 years into the future. We apply complicated models, fail to acknowledge the core assumptions, and present results in a way that implies deterministic certainty. We then develop a master plan intended to optimally serve the forecasted future conditions. The reality is that the models are not very precise, the inputs to the models are fraught with uncertainty, and the predicted results are almost sure not to occur.

Sources of Error in Transportation Planning Models

Lowe and Richards identify three sources of error in transportation planning models: specification error, calibration error and error in exogenous inputs. Specification error simply recognizes that with the complexity of human behavior, it would be unlikely that the models would include all relevant factors. Calibration error recognizes that the estimated coefficients are based on sample values, which introduces additional error. Finally, they note difficulty of forecasting exogenous variables at the national level, let alone at the traffic zone level. They emphasize that the error associated with these forms of error are likely to be substantial.[13]

Specification Error

Computer-based transportation planning models were initially created in the 1950s and 1960s for application to long range regional transportation planning problems. Over the years, a number of refinements have been made. The assumptions built into the models are reasonable, but imprecise, characterizations of reality.

Some underlying assumptions of transportation planning models are that:

- trip generation is related to land use characteristics;
- trip linkages between zones are directly related to the levels of activity in those zones;
- trip linkages between zones are inversely related to the difficulty of getting between zones; and
- trips between zones generally take the shortest time path.

Each of these assumptions, as generalized statements, are well-tested and defensible. Yet travel behavior is extremely complex and the combination of these factors, as described by mathematical relationships, explains only a portion of real world travel behavior.

Calibration Error

Because of the specification errors, transportation planning models are calibrated to real world conditions by applying adjustment factors to base case conditions to force the models to replicate real world travel conditions. Frequently, factors take the form of time adjustments applied to particular links to correct heuristically for modeled traffic assignments different than observed ground counts. Alternatively, travel speeds specified in the model may be increased if the model is under assigning traffic to a particular link. The result is often a traffic volume assignment that has been forced to correspond with ground counts, but a network description that fails to reflect the condition of the facility. Furthermore, these adjustments often lack any theoretical basis.

An important test of the models is base year traffic assignment results. To what extent do traffic assignments from the models reflect known traffic volumes, based on known land use activities? Even after the application of heuristic adjustment factors, results are often imprecise. In one study evaluated by the author, comparisons of actual traffic on selected links with that calibrated and validated by local government staff revealed the following discrepancies (actual vs. model): 23,600 vs. 32,400; 21,900 vs. 32,000; 26,200 vs. 18,200; and 21,200 vs. 13,900.[14] These comparisons are for a base year condition in which there was complete knowledge of land use and traffic conditions. Although these results are generally within ± 1 lane in each direction, it is difficult to argue that the models give accurate forecasts of future conditions when traffic assignments for known conditions reflect major errors, even after adjustment.

These examples are by no means isolated. The calibration standards generally used for these models accept high levels of error. Standards used in Florida call for assigned vehicle miles traveled (VMT) and vehicle hours traveled (VHT) to be within 5 percent of actual counts on an areawide basis. While a five percent standard seems very precise, it can easily be met on an areawide basis while having enormous variability on individual links.

Volume-to-count ratios on screenlines, used to compare estimated with actual traffic volumes, are required to be within 10 percent for screenlines greater than 50,000 vehicles per day, and within 20 percent for screenlines less than 50,000 vehicles per day. Similarly, a comparison of traffic crossing a screenline can indicate a high level of precision, while volumes on individual links cut by the screenline can have high degrees of error. A percent root mean square error in the 35 to 50 percent range is considered acceptable, and error ranges as high as 29 percent on individual freeway links and 56 percent on two-lane arterials are acceptable for calibration purposes.

Given the lack of precision in duplicating known conditions, how much confidence should we have in model outputs for uncertain future conditions? Complexity should not be confused with precision. Lee states that large scale urban models strive for too much inclusiveness.[15] Modelers believe the more complexity that is modeled, the better the model. Lee states that most models require too much information, produce too much irrelevant information, and shed too little light on strategic choices. Similarly, De Neufville argues that to use resources most effectively, we might emphasize simpler models, since they are cheaper and apparently no less accurate than complex statistical formulations.[16]

Morgan and Henrion note that most of the best policy models are small, simple, easy to understand. They go on to question the motives for complex models, noting that "The development of large and complex models by agency management is not always inadvertent. Such models can be used to 'snow' people with complexity.[17]

Error in Exogenous Inputs

Limitations in the precision of the transportation planning models pale in comparison to the uncertainty of input assumptions. How precise can we be in forecasting social and economic factors 20 years into the future?

Look ahead 20 years into the future and think about what the United States will be like. Specifically, think about what the population and employment of the United States will be 20 years from now. While you are thinking about this, don't forget to account for the following factors:

- Will there be a major war or numerous "police actions"?
- Will there be major recessions in the next 20 years?

- Will the petroleum exporting nations reduce the production of crude oil?
- Will there be changes to U.S. immigration policy?
- Will there be changes in human fertility or death rates?
- What will be the impacts of NAFTA?
- With all these factors in mind, estimate the population and employment of the U.S. 20 years into the future.

Now think about what Florida's share will be, 20 years in the future. While contemplating this, don't forget to account for the following factors:

- Will Castro fall from power in Cuba? If he does, how will it impact Florida?
- Will the social and political situation in Haiti stabilize?
- Will Florida retain its popularity as a retirement destination? Or will recent trends continue, as increasing numbers of retirees are settling in Georgia and the Carolinas?
- Will high profile crimes against tourists or other factors slow the growth in Florida tourism? Or will Florida's attractions continue to see increases in tourism?
- Will there be other natural disasters like Hurricane Andrew?
- Will Florida experience major development moratoria?
- Will a statewide high speed rail system be constructed?
- Will Florida exhaust its water supplies?

Now that you have addressed all these factors and are confident with your estimates of Florida's population and employment 20 years from now, think about what Hillsborough County's share will be, 20 years from now. Don't forget to account for factors such as:

- What will be the worldwide demand for phosphate?
- Will the Tampa Interstate be rebuilt?
- Will the Florida Aquarium be a commercial success?
- Will Disney build a new animal oriented theme park in Orlando? If so, will it adversely effect Busch Gardens?
- Will the cruise port business continue to expand?
- Will the downtown arena be built?
- Will there be any major corporate relocations to Hillsborough County?

Now take these national, state and county estimates and allocate the Hillsborough County share across 800 traffic analysis zones. By the way, don't forget to consider:

- the amount of developable vacant land in each zone,
- the accessibility of each zone,
- zoning regulations,
- the available capacity on the roadways serving each zone,
- the share of future commercial development in the Tampa CBD, the Westshore area, and the I-75 Corridor.

Seems like a pretty hopeless exercise, doesn't it? Yet, this is exactly what we do, with deterministic certainty every time we prepare a long range plan for an urbanized area. As noted by Spielberg, it is one thing to recognize that shifts in basic conditions are occurring, but it is quite another to know how to deal with the uncertainty in projections that these changes introduce. As he notes, we can deal with the unknown; it is the unknown unknowns that give us trouble.[18]

Evidence of the massive uncertainty in the forecasting of land use, economic activity, and transportation demand can easily be found by reviewing local media reports. In the recent past, the *Tampa Tribune* has featured a number of articles demonstrating these uncertainties:

- A September 1, 1991, article discusses the massive changes that have challenged the growth of Tampa International Airport, including such unpredictable events as various airline bankruptcies and major investments in competing airports in Sarasota, Fort Myers, and Orlando.
- An October 20, 1992, article "County planners to recommend reducing population estimate," notes that Hillsborough County population forecasts for the year 2015 are now expected to be 166,000 fewer than had earlier been officially forecasted for the year 2010.
- A May 21, 1993 article citing "Florida's finances looking better", which quotes the director of the Florida Legislature's economic research unit as saying, "The problem with our forecasting technique is that we are always wrong."
- An August 22, 1993, article chronicles "County charts change of course [as] planners are revising the county's development plan to reflect a slowing of the growth rate of the 1980s."
- A December 18, 1994, article, "Hillsborough growth slower than expected," notes that almost two years ago, the Planning Commission took a lot of heat for recommending the County adopt lower growth estimates. As it has turned out, even the low projections were optimistic.

Instead of recognizing this uncertainty, we continue to plan for an optimal response to a set of forecasts that will almost certainly not materialize. We develop plans as if we could take a rifle shot 20 years into the future and predict with certainty the precise magnitude and distribution of activities within a region. The reality is quite different—more like a shotgun blast.

In a summary of planning reviews being performed by FTA and FHWA, Lyons concluded that most long range plans must become more strategic, through framing and evaluating realistic future alternatives.[19] Similarly, Behn and Vaupel note that because the future is inherently uncertain, it cannot be precisely predicted. Better computer models may help reduce uncertainty but they cannot eliminate it. Truly better computer models will be those that provide not only best guesses or median estimates, but also some measure of uncertainty.[20]

The transportation planning process should be revised to recognize the uncertainty inherent in transportation modeling, and particularly in forecasting model inputs. A substantially different transportation planning process needs to be constructed that explicitly recognizes uncertainty, deals with alternative futures, and maximizes future flexibility. A decision process that recognizes these factors should produce plans that are less deterministic, instead allowing future plans and projects to respond more dynamically to changing conditions and policy directions. These possibilities will be addressed in the following sections of the study and will result in proposals for revision of the planning process to incorporate the explicit recognition of uncertainty into the metropolitan transportation planning process.

Examples of Forecast Performance

It can be instructive to review examples of the past performance of transportation forecasts to see just how accurate our forecasts have been.

Tampa Urban Area Transportation Study

In 1970, a comprehensive urban area transportation study was undertaken for Tampa. As done in all studies of this type, long range traffic volume forecasts were prepared. This particular study developed traffic forecasts for the year 1985. As part of this research, a comparison has been made of the actual 1985 traffic volumes with those forecasts made in 1970. The results are summarized in Table 4 on the following pages. Of 87 different links for which it was possible to compare actual 1985 traffic counts with those forecasted in 1970, the errors ranged from -78 percent to +281 percent, with an average absolute link error of 57 percent–hardly the kind of estimates we would like to be using for major capital planning purposes.

Tampa CBD Employment Forecasts

During the early to mid-1980s, several forecasts were prepared of future employment in the Tampa central business district (CBD). These forecasts are illustrated in Figure 1 on page 20. Forecasts done in the early 1980s projected CBD employment to be at 75,000 to 80,000 by the year 2000 and were used to justify a proposed automated downtown people-mover (DPM) system. Only recently have transportation planners and elected officials been willing to admit that the employment densities needed to support a DPM will not materialize. As a result, the DPM was recently removed from the City's long range plan.

In the mid-1980s, new forecasts were made for use in the Tampa Interstate Master Plan Study and for a study of rail transit options for Hillsborough County. By then, it was clear that CBD employment was not on track to 80,000 by the year 2000; instead it was forecasted that employment would be in the 55,000 range by the year 2000, but would still be approaching 90,000 by the year 2010. These forecasts were used as a basis for determining long range needs of the Tampa Interstate System and to promote a regional rail transit system. The reality is that in the years since 1980, employment in the Tampa CBD has been very flat, falling in the 26,000-28,000 range in 1994. Unfortunately, these highly erroneous employment forecasts were the basis for major capital facility planning in the City for a period of a decade or more.

Interstate Highway Estimates

In an analysis by Pell and Meyberg of forecasts of traffic on urban Interstates, it was reported that traffic was overestimated by 24 and 21 percent, respectively, for seven and three year forecast periods. The authors conclude that "...one of the most damning practical criticisms [of the urban transportation planning process] is that the forecasts produced ... are incorrect."[21]

ITE Systems Study Comparisons

A 1980 Institute of Transportation Engineers report evaluated the accuracy of urban transportation forecasts.[22] The report compares the actual results with the demand forecasts for a number of major urban area transportation studies. Detailed comparisons for five urban area transportation studies were made: Milwaukee, Chicago, Washington, D.C., Seattle-Tacoma, and Spokane. In addition, transportation forecasts for three mega-projects were examined: the (San Francisco) Bay Area Rapid Transit System, the Dulles International Airport in Washington, D.C., and the Dallas-Fort Worth International Airport.

Despite evidence to the contrary, the report concluded that travel forecasting methods have performed quite well. For the Southeast Wisconsin study, county level estimates of population and employment were compared with observed levels for the period from 1963 to 1972. The method of reporting appears biased toward a favorable result, as it is reported that county level population ranged from -11.4 percent to +16.8 percent of the forecasted values, while the regionwide total was -6.7 . This comparison of the total values, obscures the fact that a 1963 Milwaukee population of 1,086,500 was projected to grow by 10 percent to 1,197,400, whereas the observed condition was a decline of 2 percent, to 1,060,500. Although this may translate to a seeming modest error of -11.4 percent in the total population, the forecasted growth increment was off by 120 . And, although the aggregate employment estimates for the region were within 2.8 , individual counties ranged from -19.9 percent to +57.5 percent. Again, if the growth increment were used as the comparison, the county level errors would range from -108 percent to +400 percent.

Ascher takes note of the significance of a 10 percent deviation in a 10-year population forecast, noting that, "Considering that the bulk (generally over 80 percent) of the population 10 years hence is already alive when a 10-year forecast is made, a 10 percent discrepancy can only be regarded as a major error."[23] For the Chicago area, a comparison of 1970 characteristics with forecasts prepared in 1956 revealed population 10 percent lower, employment 14 percent lower, and weekday person trips 10.6 percent lower than the forecasted values.

For Spokane, a comparison of 1975 characteristics with forecasts prepared in 1965

Table 4
COMPARISON OF ACTUAL 1985 TRAFFIC VOLUMES WITH THOSE FORECAST IN 1970; TAMPA URBAN AREA TRANSPORTATION STUDY

		1985 Actual	*1985 Projected*	*Vol/Count*	*%Error*	*Abs Error*
US 301	NE of Stacy Rd.	5.8	9	1.55	55%	55%
	SW SR 579	10.1	10	0.99	-1%	1%
	E of I-75	7.8	12	1.54	54%	54%
	SW of I-75	11.0	12	1.09	9%	9%
I-4	E of Seffner Lake Rd	47.3	24	0.51	-49%	49%
	N of Buffalo/MLK	56.5	48	0.85	-15%	15%
	N of Columbus Dr	62.6	55	0.88	-12%	12%
	E. of I-275	109.9	73	0.66	-34%	34%
SR 580/Hills. Ave	E of Seffner Lake Rd	7.6	7	0.92	-8%	8%
	S of I-4	13.4	7	0.52	-48%	48%
	E. of 56th	35.4	10	0.28	-72%	72%
	E of 22nd	34.7	11	0.32	-68%	68%
	E of Nebraska	41.4	30	0.72	-28%	28%
	E of SR/597	40.8	12	0.29	-71%	71%
	E of Kennedy Rd	47.7	24	0.50	-50%	50%
	W of Hanley	37.9	23	0.61	-39%	39%
SR 60	W of Brandon Rd	41.4	24	0.58	-42%	42%
	W of Lakewood Dr	44.5	25	0.56	-44%	44%
	W of Faulkenburg Rd	42.3	17	0.40	-60%	60%
	W of 50th St	29.7	19	0.64	-36%	36%
SR 45/50th St	N of Madison Ave	41.7	32	0.77	-23%	23%
	S of Palm River Expy	32.5	28	0.86	-14%	14%
	S of Frank Adamo Dr	35.5	36	1.01	1%	1%
	S of 574	40.6	25	0.62	-38%	38%
	S of I-4	36.4	17	0.47	-53%	53%
SR 585A/40th St	S of Hillsborough	23.8	14	0.59	-41%	41%
	S of 24th Ave	18.1	13	0.72	-28%	28%
	N of Expwy (39th St)	20.4	24	1.18	18%	18%
Expwy	W of 50th St	16.3	31	1.90	90%	90%
	E of 22nd St Cswy	27.0	67	2.48	148%	148%
	S of Frank Adamo Dr	26.0	90	3.46	246%	246%
	SE of Jackson St	19.0	64	3.37	237%	237%
	S of Brorein St	22.5	85	3.78	278%	278%
	N of Platt St	23.6	90	3.81	281%	281%
	W of Bayshore Blvd	19.5	53	2.72	172%	172%
	E of Dale Mabry Hwy	14.9	50	3.36	236%	236%
	W of 685	28.4	45	1.58	58%	58%
	W of West Shore Blvd	19.6	53	2.70	170%	170%

revealed population to be 14.8 percent lower, employment 1.2 percent lower, and auto trips 8.1 percent lower than forecasted values. Comparable results were reported for the Seattle region and for the Washington, D.C. mass transit study. Much more substantial differences were reported for the BART system and for the two airport studies in Washington and Dallas.

Yet this study concludes that travel forecasting methods have generally performed quite well. The conclusions of this report

Table 4 (continued)

		1985 Actual	*1985 Projected*	*Vol/Count*	*%Error*	*Abs Error*
I-275	N of Bearss	23.5	10	0.43	-57%	57%
	N of Fletcher	48.7	23	0.47	-53%	53%
	N of Fowler	61.8	39	0.63	-37%	37%
	N of Busch	84.9	46	0.54	-46%	46%
	N of the Hillsborough River	105.6	56	0.53	-47%	47%
	N of Sligh	119.0	68	0.57	-43%	43%
	N of Hillsborough	120.6	65	0.54	-46%	46%
	N of MLK/SR 574A	111.7	80	0.72	-28%	28%
	N of I-4 Interchange	120.2	64	0.53	-47%	47%
	E of Florida	116.9	91	0.78	-22%	22%
	E of N Blvd	123.9	92	0.74	-26%	26%
	W of McDill	139.6	75	0.54	-46%	46%
	W of Dale Mabry	111.1	60	0.54	-46%	46%
	E of SR 60	84.8	58	0.68	-32%	32%
	Howard Frankland	70.9	55	0.78	-22%	22%
Kennedy	W of Platt	7.6	12	1.58	58%	58%
	E of Jefferson	10.5	18	1.71	71%	71%
	E of Florida	12.1	13	1.07	7%	7%
	E of Howard	23.7	12	0.51	-49%	49%
Tampa St	N of I-275	9.4	9	0.96	-4%	4%
Nebraska	N of Bearss	18.6	19	1.02	2%	2%
	S of Bearss	18.0	7	0.39	-61%	61%
	N of Fletcher	21.6	7	0.32	-68%	68%
	S of Fowler	22.1	13	0.59	-41%	41%
	S of Busch	24.9	13	0.52	-48%	48%
	N of Sligh	20.1	18	0.90	-10%	10%
	S of Hillsborough	14.4	12	0.83	-17%	17%
	N of I-4	16.9	26	1.54	54%	54%
Florida/SR 685	N of Bearss	14.2	10	0.70	-30%	30%
	N of Fletcher	14.6	9	0.62	-38%	38%
	N of Fowler	16.1	9	0.56	-44%	44%
	N of Linebaugh	25.3	15	0.59	-41%	41%
	N of Busch	31.4	15	0.48	-52%	52%
	N of Waters	25.7	13	0.51	-49%	49%
	S of Waters	20.9	15	0.72	-28%	28%
	N of Sligh	17.4	19	1.09	9%	9%
Busch/Temp Ter Hwy	W of 56th	31.1	13	0.42	-58%	58%
	E of US41/Nebraska	37.6	11	0.29	-71%	71%
	E of Armenia	29.6	12	0.41	-59%	59%
	E of Dale Mabry	32.7	8	0.24	-76%	76%
Dale M./US92	S of Hillsborough	59.9	26	0.43	-57%	57%
	S of Tampa Bay Blvd	61.4	31	0.50	-50%	50%
	S of Columbus	55.5	34	0.61	-39%	39%
	N of Kennedy	44.6	32	0.72	-28%	28%
	N of Bay to Bay	28.0	21	0.75	-25%	25%
	S of Euclid	23.0	18	0.78	-22%	22%
	N of Interbay	23.6	26	1.10	10%	10%
Columbus/Spruce	W of Dale Mabry	33.4	15	0.45	-55%	55%
	W of West Shore Blvd	27.9	6	0.22	-78%	78%
	AVG	40.8			avg err	57%
					%rmse	65%

support the assertion of de Neufville that transportation planning forecasters "...are evidently loath to discuss the weaknesses of the techniques that constitute their professional expertise."[24]

British Case Studies

In 1981, the Transport and Road Research Laboratory published the work of Mackinder and Evans, which reports on a study in which forecasts from 44 British urban transportation studies undertaken between 1962 and 1971 were compared with actual occurrences.[25] The report notes the three main types of error in forecasting: errors in measurement of the data, errors in the specification of the model, and errors in the prediction of the future year inputs to the model.

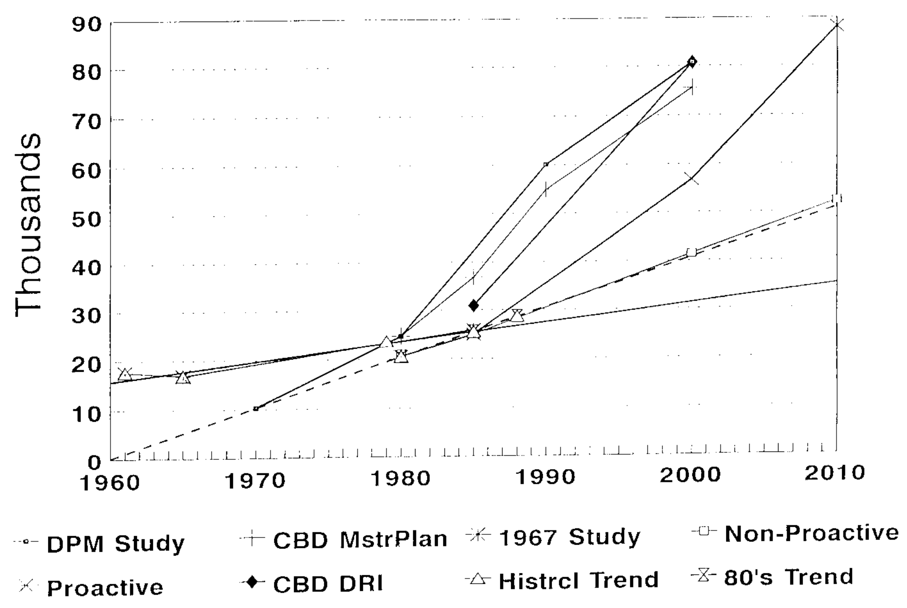
The study was limited to comparisons of study area aggregate statistics, which can be expected to have much less error than statistics related to particular zones or links. Even at this aggregate level of analysis, it was found that nearly all of the forecast items considered were significantly overestimated. On average, population was overestimated by 20 percent, and highway and public transit trips by 30 to 35 percent. If one were to measure the errors in forecasting the incremental change in various parameters, the results would be much worse. Average forecasted population growth was three times the observed growth, while forecasts of the growth in total person trips were over six times the observed growth.

It appears that these forecasts were made during an economic boom period, which was anticipated to continue into the future. The reality was a period of economic stagnation and recession. Furthermore, the authors note that it might be expected that local authorities would err on the optimistic side when estimating future growth, since a predicted decline in prosperity would be unthinkable.

Guideway Transit Case Studies

A number of studies have examined the forecasting accuracy of the urban transportation planning models as applied to fixed guideway transit projects. A 1982 article by Talvitie, Deghani, and Anderson compared predicted and observed modal split values in Baltimore, San Francisco, and the Twin Cities.[26] This article is particularly relevant considering that Deghani is one of the principal demand modelers for Parsons Brinckerhoff, one of the leading firms in the world in terms of major transit capital investment analysis. They note that "the total prediction error is uncomfortably large ... between 25 and 65 percent of the predicted value; a good rule of

Figure 1
TAMPA CBD EMPLOYMENT FORECASTS



thumb is that the error is 35 percent of the predicted value."[27] They go on to ask an interesting question:

> Given that the present travel demand models are not very accurate, can they be used to provide forecasts to justify a given action whose real basis must be kept concealed? In short, is purposeful misuse of travel demand models possible? The results of the present paper tend to suggest that such misuse is possible, ... that input data can be biased toward a given "policy" direction.... Given the present practice of substantial Federal funding for certain types of alternatives, which in practice reduces planning to making a case for an alternative eligible for large sums of Federal monies, it is indeed appropriate to inquire about the susceptibility of models to misuse rather than inquire solely about their accuracy.[28]

One of the most influential (and controversial) recent transportation research works was reported by Pickrell.[29] Eight U.S. cities that have invested in rail transit projects are examined: Washington, Atlanta, Baltimore, Miami, Buffalo, Pittsburgh, Portland, and Sacramento. Forecasts of ridership and costs that were the basis of local decisions to implement these systems were compared with the actual costs and ridership experienced. The author reports that ridership estimates have been consistently grossly overestimated, while costs have been consistently underestimated.

As the author notes, virtually all of these projects are the largest local public works projects ever undertaken. It is indeed alarming that the actual benefits realized are much less than expected. He notes that decisions to implement these major capital investments have been made based on very small forecasted differences in performance between alternatives, whereas the actual performance of the selected alternatives have been substantially different than the forecasts.

If forecasting errors are large in comparison to the differences in alternatives, the planning process cannot be relied upon to guide decisionmakers toward sensible decisions. The author also raises the possibility that the large forecasting errors reflect a bias in favor of these projects that gets manipulated into the planning process. In effect, he suggests that the models are often used to support the preconceived solution.

Of the cities examined, only Washington and Atlanta experienced ridership levels close to the forecasts; however, in both of these cases, it is reported that growth in downtown employment was much greater than anticipated, so the ridership comparisons are very favorably skewed. Actual transit ridership was about half of the forecasted levels in Buffalo, Pittsburgh, and Portland, about a third of the forecasted levels in Sacramento, and only about a fourth of the forecasted level in Miami.

Of considerable interest is the finding that these forecast errors seem to be less related to errors in the demographic input factors than to inaccuracies in forecasting transit performance measures and interpretations of model outputs. Notably, input assumptions about feeder bus service and transit service frequencies were generally somewhat more optimistic than the subsequent facts.

The report also documents the prevailing optimism in capital and operating costs of systems in the planning stages. These costs were generally substantially underestimated in the planning process.

The author points to the significant federal share in the financing of these projects as a possible explanation for the systematic optimism in the estimation of ridership and costs. He points out that there was little motivation for local officials to question analyses that supported locally favored technological solutions when the financial impacts are largely shifted to the nation as a whole. He suggests that the process has been used by local officials to compete with their counterparts from other cities for federal discretionary expenditures, which promote optimistic assertions.

He points to the sad conclusion that the planning process for many of the largest local infrastructure projects in this nation is systematically unable to produce reliable information upon which to base public investment choices.

The author identifies several possible remedies. One suggestion is to shorten the planning horizon, so that uncertainties inherent in long-range futures will be reduced. As an extreme, he suggests basing ridership forecasts for rail transit on the current year land use conditions. He also cites the need to acknowledge the level of uncertainty in forecasts of this nature and to apprise local officials of the financial risks of potential errors. To reduce the federal financial obligations, he suggests that federal participation be set as a fixed amount rather than a fixed percentage, where cost overruns are born by the federal treasury in the same percentage as the estimated commitment.

Some of the same projects analyzed by Pickrell were also evaluated by Wachs, who extended the discussion of underlying cause.[30] Wachs also compared forecasts made of patronage and cost for rail rapid transit systems with the actual observed values. Examining the cases of Miami, Baltimore, San Francisco, Washington, and Atlanta, he noted a systematic bias toward high patronage forecasts and low cost estimates when compared to actual subsequent verification. In fact, these biases are reported to have been always the case. He refers to the work of Ascher, who points out that core assumptions are more important to the accuracy of forecasts than technical methods.[31]

One contributing cause is cited by Evans, who notes that in 1979 forecasters were expecting gasoline prices of $4-per-gallon by 1990, an estimate that turned out to be 300 percent too high.[32] In constant dollars, the comparison would be even more dramatic. This example has particular relevance to the urban transportation planning process, as assumptions about fuel cost are part of forecasting future ground transportation volumes.

Thompson has similarly expressed extreme skepticism regarding recent forecasts of ridership for high speed rail systems.[33] Paraphrasing Winston Churchill, he notes that "as for high speed rail forecasting, seldom ... has so much been projected for so many based on so little."[34] He notes that several important factors cause forecasts to be wrong. Nature is nonlinear, whereas models often are linear. He particularly cautions against extrapolating regression coefficients far outside actual experience. He notes that forecasters sometimes focus on the wrong things. For example, in the Northeast Corridor, a great deal of attention was focused on modal characteristics, but the factors that really determined the outcome were total population and income trends, which received little attention. He strongly advocates that demand forecasts be kept simple, and that they focus on the important factors.

Airport Demand Examples

Richard de Neufville has been one of the most effective proponents of methods for dealing with uncertainty in transportation planning. However, his efforts have focused almost exclusively on airport and aviation systems planning. He discussed the characteristics of the master planning process as applied to airport planning. The process consists of forecasting loads and performance, evaluation of alternative sites and designs, and selection of the best plan. It is noted that the entire process rests on the forecasts, which are normally quite detailed, including numbers of passengers of different types, proportion of aircraft of different types, capacity of the air traffic control system, and others, for a period decades into the future. The master plan process then systematically selects the optimal design for the adopted set of forecast conditions.

He then challenged the basic premise of the master plan process, asserting that the harsh reality is that we cannot predict the future. Long-term forecasts, the premise of the entire exercise, are simply not credible. He concluded that the master planning process makes the plan indefensible, as the forecasts are speculative, the impacts are indeterminate, and the proposed plan is not best.[35] Figures 2 and 3 illustrate comparisons of aviation forecasts with the observed number of passengers and passenger-miles.

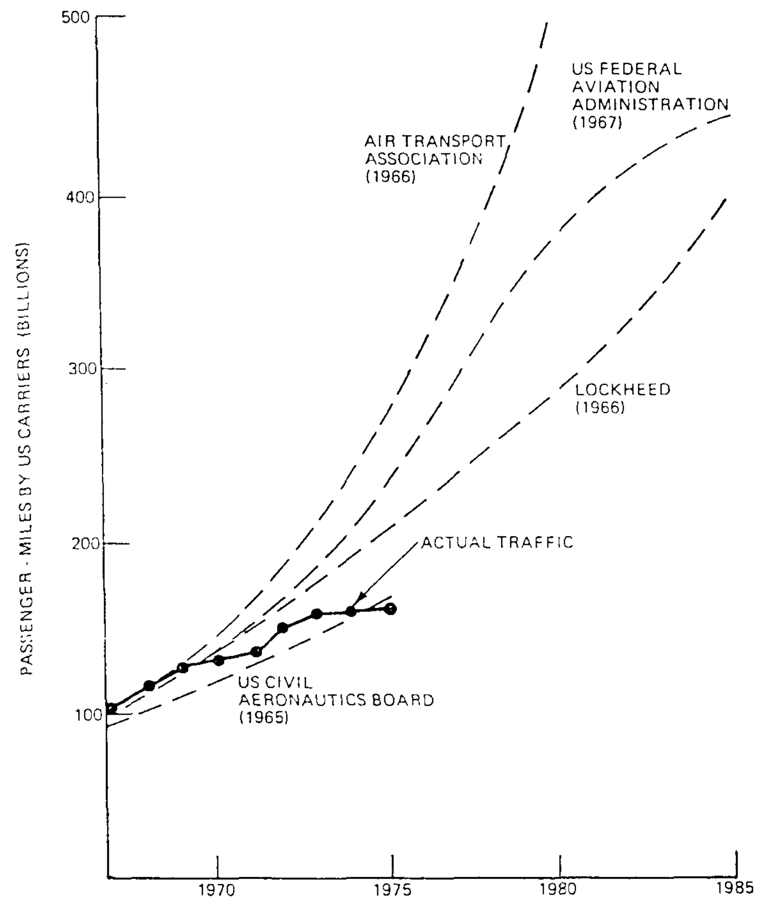
Technological Forecasting

Ascher noted the susceptibility of transportation forecasts to technological factors. As an example, he cited a Lockheed executive who predicted in 1956 that a family type convertiplane would be developed within 15 years and that the family automobile would largely be replaced by it. He observed that forecasters have to be somewhat cautious to the alluring possibilities of technology.[36]

In his excellent work on technological forecasting, Schnaars noted a serious bias toward optimism.[37] Although his book covers a wide range of technologies, a number of them relate to transportation, including VSTOL (vertical or short takeoff and landing) aircraft, intelligent vehicle and highway systems (IVHS), high speed rail, and other futuristic forms of transportation. He pointed to numerous claims of the early and mid 1960s, which foresaw widespread use of IVHS technologies by the early 1980s. While a number of new technologies have warranted the optimism held for them (notably VCRs, microwave ovens, and computers), he held that there is generally a serious bias toward optimism. He noted that, "The successes tend to be conservative in their outlook, while the failures foresee fantastic changes. The successes call for smaller, slower changes and reject radical innovations."[38]

Evans reinforced this skepticism, noting the recent preoccupation and massive investment in IVHS research based on predictions of vehicles traveling at enormous speeds a few feet apart on automated highways.[39] He noted that such a system

Figure 2
A COMPARISON OF VARIOUS FORECASTS WITH ACTUAL AIR TRAFFIC



Source: de Neufville, Airport Systems Planning (Cambridge: The MIT Press, 1976, p. 48.

quantitative statistics tells us that the larger the sample, the less likely that a sample mean will vary by a fixed amount from the global mean.

Misconceptions about Chance Events

Tversky and Kahneman also reported on intuitive misconceptions about chance events.[54] They cited numerous examples of subjects that expect a very small sample of observations to be representative of the global outcome, whereas small samples can be expected to deviate systematically from the global mean. They used an example in which subjects were questioned on the randomness of two comparative sequences of coin flips. In reality, one would expect occasional sequences of all heads or tails, whereas intuition leads us to expect much smaller deviations from alternating heads and tails. In fact, if left to our intuition, we would construct random series that have much less variation from the long term expectation than observed in natural occurrences.

Slovic, Kunreuther, and White confirmed these findings about inaccuracies in subjective probabilities.[55] They cited examples that revealed the inability of subjects to deal with basic statistical factors, perceptions of randomness, and judgments of correlation and causality.

Another example was cited by Dawes, who noted that people have particularly difficult times evaluating compound probabilities. She reported a number of experiments in which subjects commonly overestimate compound probabilities, often estimating their joint probability to be greater than the individual probabilities of their components. That is, people will commonly assign a higher probability to the likelihood of A and B than they would assign to A or B individually.[56]

Socio-Political Bias in Forecasting

Given the difficulty we have as individuals, can it be any wonder that group decisions are even more confounding? This is the subject of the following section.

While the preceding section dealt with individual errors in perception, this section addresses errors due to "group-think." These types of errors relate to interpretations given to data by social or political groups. Such errors are even more difficult to deal with, because they transcend our ability (or inability) to develop accurate models. Since they often involve decisions as part of a political process, they generally demonstrate not only our lack of individual ability to deal objectively with information but the considerable bias introduced by conflicting values and by differing objectives of groups of decisionmakers.

As observed by Ascher, an important distinction between corporate planning and government decisionmaking is that in the former there is general agreement about the organizational goals and objectives. Government organizations are responsible to diverse political constituencies, which may result in controversy because forecasts imply priorities which are not held by all policy makers. Forecasts that underscore a priority which is out of political favor are likely to be ignored, whereas forecasts that support politically favorable positions are likely to be embraced. Ascher concludes that the acceptability of a forecast depends not only on its perceived accuracy and plausibility, but also on the acceptability of the priorities it promotes.[57]

Media Bias Toward Dramatic Forecasts

Popular media can bias our perceptions of current trends. Evans cited media bias in reporting forecasts.[58] He noted that forecasts we read and hear about are systematically biased due to a strong market for the dramatic—either predictions of doom or predictions of a wonderful new future. A prediction that some factor will remain largely the same as it is today generates no news and little interest, no matter how accurate it may be. Preoccupation with high technology IVHS options provides a case in point.

Correlation Among Forecasters

Schnaars made an observation called "The Zeitgeist," in which he suggests that during a particular historical period forecasters read the results of each others' forecasts, yielding a high level of correlation among forecasters.[59] Most of us have observed this phenomenon, not just in forecasting, but in everyday life. How often have we glibly repeated some "factual" account, only to find that the fact was nothing more than a rumor that had gained credibility from widespread repetition?

Forecasting What We Desire

One of the most difficult biases to correct is the pressure to forecast what we desire, rather than what is most likely to occur. As noted in a report prepared by the United States DOT and the EPA, the forecasted distributions of regional population and employment are often an erroneous input to the transportation planning models because of the influence of political compromise rather than technical expertise. The report noted that local officials want forecasts to reflect the successful implementation of land use policies that prove to be difficult to enforce.[60]

The example cited previously of the level of employment in the Tampa central business district is also a good example of this phenomenon. At the time, the desire of decisionmakers to bring about a strong central business district resulted in long range forecasts that projected unrealistic levels of employment concentrated in the CBD. Unfortunately, these unrealistic forecasts were used as a basis for including many capital-intensive facilities in the CBD. These included an automated, elevated downtown people-mover system, massive additions to the Tampa Interstate Highway system, and premature plans for a CBD-focused rail transit system.

Accept Confirming Forecasts/ Suppress Contrary Evidence

Human nature being what it is, most of us are far more willing to entertain evidence that supports our view of the world and resistant to accept evidence that contradicts our views. Hogarth noted that it is very common for people to seek information that confirms existing notions, rather than to seek information that may conflict with their hypothesis.[61]

Over the past 25 years, the author has personally observed a number of similar situations, which might be called the "sacred cow" phenomenon. At times, rail rapid transit has been a beneficiary of the sacred cow phenomenon, in which proponents generate a popular level of support which dares public opposition to surface; when it does, the opposition is discredited as not being visionary, living in the past, and so on.

Indeed, in one Florida county, the author served as project manager of a guideway transit alternatives analysis. When normal 20-year forecasts failed to yield a reasonable cost-effectiveness result, intense pressures were applied to developing a 50-year forecast of demand. Even with this "buildout" alternative, it was impossible to justify the high capital-intensive alternative preferred by a few vocal advocates. Instead, a staged program of implementing an at-grade light rail system was recommended as a first stage, with time-staged addition of major grade crossings, as warranted by patronage and permitted by funding availability. Because the recommendation did not support the preconceived notions of the advocates, the author's consulting firm was eliminated from consideration for subsequent phases of project development, in favor of a competing firm that promised to be riding the first train by a date and time-certain 10 years into the future. As a point of information, the county has yet to take any of the serious steps necessary to move into a guideway transit program.

Intelligent transportation systems (ITS) are another current popular sacred cow. With generous federal support, ITS advocacy organizations have dictated a circle-the-wagons" mentality among ITS proponents. They see their mission as convincing the world of the merits of their solution, for which we just need to find the right problem. Serious research, which might suggest limitations, is actively discouraged. Certainly there have also been many cases of massive highway projects being treated as sacred cows.

The overriding feature of the sacred cow is that objective debate is discouraged; only supportive data is accepted, while limiting or negative data are discouraged.

Proponents Want to Predict with Certainty

Stuart and Schofer noted that uncertainty is covered up or ignored, as decisionmakers tend to prefer oversimplified, single-valued forecasts.[62] This characteristic was explained by Behn and Vaupel, who note that proponents of a particular course of action are generally unmotivated to recognize the uncertainties in their proposal. Instead, their motivation is generally to predict the benefits of their proposal with a great deal of confidence and certainty.[63] De Neufville points out that individual experts are often quite positive about their estimates but to disagree with other experts.[64] An interesting example of disagreement among experts can be found in a recent report in the *Tampa Tribune*, "Economy 1995: What's in store for the Tampa Bay area next year?" Expected estimates of percent change in housing starts range from -1.8 to +7.6; expert estimates of population change ranged from 1.1 to 2.4 percent.[65] Morgan and Henrion noted that if experts produce different conclusions, this information should not be discarded, as the differences of opinion may be very informative.[66]

Bias of Advocacy; Forecasting Ethics

Hall cited the San Francisco BART system as a major planning disaster, based on the major overestimate of ridership and underestimate of cost.[67] He cited the work of the consulting team as being self-serving and emotional, noting one of the final conclusions of the consultant, "We do not doubt that the Bay Area citizens can afford rapid transit; we question seriously whether they can afford not to have it."[68] He also cited work by Melvin Webber, who noted that 1976 ridership levels were only 51 percent of those forecast in 1962 for 1975. He also noted that, whereas the expectation was that 61 percent of riders would divert from cars, only 35 percent actually did. Most surprising were the 1962 forecasts that, by 1976, BART would be producing an operating surplus of $11 million, while the reality was an operating deficit of $40.3 million.

In reflecting on the errors with BART as noted previously, Hall offered several explanations.[69] He noted that the BART system was posited on the willingness of Californians to abandon the California lifestyle–single family homes and the flexibility of the private automobile. He noted that the problem to be solved was framed in terms of the desires of the planners, rather than the potential users. He cited the conventional wisdom of the time, which saw almost all transportation planners pointing toward basic changes in lifestyle as being desirable and likely in the near term. He also cited the likelihood that the appointment of the consultants already indicated a desired selection of approach. As in other studies, a problem seems to be the inherent bias of political decision-makers and society in general, who have already decided what they want and are not interested in objective appraisal.

Hall noted similar problems with the BART cost estimates, which were accepted without careful scrutiny.

> The fact was that everyone wanted to believe the predictions, because they seemed to offer a way out of serious present problems. Because of this desire, there was a mass suspension of disbelief, and almost ideological commitment to a new system.[70]

Wachs also dealt with the issue of ethics in forecasting, asserting that:

> the competitive, politically charged environment of transportation forecasting has resulted in the continuous adjustment of assumptions until they produce forecasts which support politically attractive outcomes. The complexity of the mathematical models obscures the fact that the forecasts are more critically dependent on assumptions than they are on mathematical manipulations and that assumptions and parameters are continually adjusted until the intended choice is justified by the forecasts.[71]

For example, he noted that patronage projections for the Los Angeles rail system were based on auto fuel efficiency of 17.5 mpg in the year 2000, whereas EPA anticipates average fuel efficiency of vehicles in use in 2000 to be 24.6 mpg. This assumption led to a systematic overestimation of rail ridership. Similarly, in Miami, a 400 percent increase in the price of downtown parking was assumed, yet there has been no public policy action to make this happen. He noted one study, in which the models predicted insufficient ridership, which the modelers considered to be unrealistic. To correct this situation, assumed highway speeds were reduced from 45 mph to a "more realistic" 30 mph. Obviously, this simple assumption substantially increased the forecast of rail ridership.

He went on to note that:

> The apparent complexity of the models ... tends to mask the fact that the social and economic relationships incorporated in the models are gross oversimplifications of reality.... The most critical assumptions are frequently unreported.... The models usually embody dozens of simple assumptions of questionable validity, which support the predetermined positions of the agencies paying for the forecasts.[72]

He reported similar results for cost forecasts, which are systematically low. He noted that he is convinced that most of the forecasts used in the planning of America's rail transit systems are statements of advocacy, rather than unbiased estimates produced by politically neutral scientists. He believed that "while few forecasters engage in blatant falsification..., many are transformed in subtle steps from analyst to advocate by the situation in which they perform their work."[73]

Planners' Unwillingness to Admit Uncertainty

Who wants to admit that their forecasts are full of uncertainties? Certainly not the professional planning community. In his article on the siting of the Sydney Airport, de Neufville articulated best that a major obstacle to dealing with uncertainty will be overcoming the objections of a professional staff who make their living preparing forecasts. These professionals can hardly be expected to acknowledge freely that their expensive efforts and staff cannot make accurate predictions. They will fight the recognition of uncertainty.[74]

In his earlier work on airport planning, he was even more direct:

> An ... important feature of air, and indeed of all other forms of transport, is our inability to predict traffic demands accurately. There can consequently be little confidence in any statements about what level of investment may be needed, at what time, to service traffic. This unpleasant fact is acknowledged far too rarely.... Leaders making investment decisions do not want to appear to be gambling substantial ... resources on risky projects.... This suits forecasters well since they are evidently loath to discuss the weaknesses of the techniques that constitute their professional expertise. The result is that

> practically everyone associated with transportation planning more or less indicates that they can provide reasonable estimates of future traffic. Actually, they do not and cannot. A comparison of predictions and realizations demonstrates that the errors inherent in forecasting traffic volumes are systematically large....

Estimates of the costs of constructing facilities to meet any level of demand are also uncertain.[75]

Planners' Tendencies to Advocate Large Projects

Gifford observed that the poor representation of uncertainty in urban transportation planning can lead to excessively large and permanent facilities. By extension, he argued that if uncertainty were accurately represented, projects would generally be smaller with shorter design lives.[76] Hey made similar arguments for decisionmaking by private firms, demonstrating that, for the risk-averse firm, output under conditions of uncertainty should be less than output under certainty.[77] Since capital costs are incurred in the present while benefits accrue in the uncertain future, financial risks can be substantial.

Hall supported this position, noting that transportation planning professionals "are concerned with career maintenance and advancement, which leads them to support interventionist policies based on large injections of public funds."[78]

Other Observations About Forecasting and Decisionmaking

A number of additional insightful observations have been made about current forecasting methods and the way we use forecasts in political decisionmaking.

Bounded Rationality or Satisficing Behavior

Dawes presented a rationale for satisficing rather than optimizing behavior, arguing that because exhaustive consideration of alternatives is time consuming and costly, it is common behavior to search for solutions until an acceptable one is reached, at which point acceptance is made.[79]

Slovic et al. provided considerably more discussion.[80] They contrasted the decision-making process of maximization of expected utility with the satisficing, or bounded rationality, process. Whereas the former assumes a complete search of alternatives to maximize expected utility, the bounded rationality model takes into account the limits of the decision maker's perceptual and cognitive capability.

In the bounded rationality model, it is recognized that cognitive limitations force one to construct a simplified model of the world to achieve satisficing solutions, which focuses on achieving a satisfactory but not necessarily optimal solution. The authors noted that firms demonstrate satisficing behavior by following fixed decision rules (standard operating procedures) where possible, and by "reacting to short term feedback rather than trying to forecast the future (which is too uncertain)." They noted that a firm's search for new alternatives is normally prompted by a failure to satisfy one or more goals. Thus, their behavior is adaptive, given the complexity of the environment and cognitive limitations. They also cited the example of a policymaker who, recognizing his inability to avoid error in predicting consequences, instead moves through a succession of small changes. With this approach, previous predictions can be tested before moving on to each further step. They went on to note that the decisionmaker never has available the full range of alternatives, as local regulations or cultural traditions eliminate some alternatives from consideration, and lack of awareness eliminates others.

The relevancy of this satisficing behavior is important as it exacerbates the problems with the master planning process. Not only is there uncertainty in our forecasts, but it is also impossible to consider all possible alternatives. As a result, when we develop a master plan, it is limited not only by the realities of uncertainty, but also by the number of alternatives we can afford to examine.

Core Assumptions

The work of Ascher, in particular, is noteworthy.[81] Most important of his observations is the primacy of core assumptions. He argued that core assumptions are more critical than the sophistication of the forecasting method, that the underlying core assumptions are the major determinants of forecast accuracy, and methodologies are basically the vehicles for determining the implications of core assumptions that have been chosen. He asserted that when the core assumptions are correct, the choice of methodology is secondary. Further, he argued that improvement in techniques does not compensate for erroneous core assumptions. In fact, he argues for a better balance between the development of more sophisticated techniques–which has been the major preoccupation of leading forecasters–and the currently neglected search for ways to establish core assumptions. For long-term economic models, he noted that the most crucial factors are changes in the underlying structure of the economy, such as productivity changes, oil embargoes, military conflicts, and other factors which are very difficult, if not impossible, to foresee.

'Assumption Drag'

Ascher introduced the term "assumption drag," which he used to describe the characteristic that, once an assumption becomes embedded in the conventional wisdom, its use continues well beyond the point where it is contradicted by empirical data.[81] He cited this with a particular example, related to population forecasting, in which assumptions about fertility rates were carried forward much longer than warranted by empirical observation. He notes that it can be difficult to distinguish between short term aberrations, which may be only temporary deviations from a prevailing trend, and long term structural change. He cautioned that forecasters should carefully examine the behavioral assumptions underlying any forecast to determine whether they are based on antiquated data and theory.[82]

Error Increases with Duration

Another point made by Ascher is that the longer the forecast period, the greater chance that conditions affecting the forecast will change.[83] Therefore, longer range forecasts are intrinsically more difficult and in general are likely to be less accurate.

Brod noted that there is one thing certain about any forecast: to some degree it will be wrong. He noted that information about relative uncertainties should be a part of the public sector decisionmaking process. He also observed that the farther into the future projections are made, the more uncertainty there is and the greater the risk of producing forecasts that deviate greatly from actual outcomes.[84]

Maldonado demonstrated this characteristic by comparing aviation forecasts for various time periods.[85] He examined the accuracy of the aviation forecasting process, by comparing 5-, 10-, and 15-year forecasts of total annual operations with the actual results for 22 airports in the FAA New England region. Forecast accuracy was evaluated by the ratio between forecast and actual operations. For five-year forecasts, this ratio of forecast/actual ranged from 0.64 to 1.96, for 10 years .58 to 2.40, and for 15 years 0.66 to 3.10. The dispersion of results, as measured by the standard deviation of this ratio, also increased as the time duration increased, from 0.30 to 0.54 to 0.69. It was observed that there seemed to be no correlation between forecast error and size of the facility.

Conclusions included that forecasting errors were large and that errors tend to get larger with time. While this conclusion may seem obvious and perhaps even trivial, it has enormous implications for transportation planning practices, which typically plan for 20 or more years into the future. Lowe and Richards also noted that, although it may be tempting to suppose that in the long run errors cancel each other out, it is more likely that they reinforce each other.[86]

Chapter 4

Possible Strategies and Methods

As noted earlier, one definition of planning holds that it is "a formal or ordered process in which men seek by forethought to affect action so as to bring about more desired states than it is anticipated would otherwise occur."[87] This definition serves as a useful reminder that a society does have preferences that are worth pursuing, in contrast to just letting things happen. This reaffirmation is important, in that we can recognize the full range of uncertainties and inabilities to forecast, and yet desire to move toward the attainment of certain goals.

Strategies

Indeed, that is the objective of this research: to recognize uncertainty, yet not be paralyzed by it; to move proactively toward the attainment of valued societal objectives, yet deal explicitly with the changes we cannot predict. A number of approaches have been suggested by others to make decisions in spite of uncertainty. These are presented in the sections that follow.

Strategic Planning

A number of authors have advocated the use of strategic planning as a means of recognizing and dealing with the contingencies that may materialize. Maldonado advocated that, instead of unique plans defined for point estimates that describe our best guess of future events, we need appropriate strategies to deal with the uncertainty in the types of projects needed.[88] He advocated a strategic planning process that recognizes our inability to predict the future and instead concentrates on examining options for dealing with a range of possible outcomes or futures. The process also puts a premium on future flexibility and on the provision of insurance measures.

Bryson offered an excellent summary of strategic planning methods specifically tailored to public sector organizations.[89] He dealt at some length with the Harvard "SWOT" model, which enumerates strengths, weaknesses, opportunities and threats to an undertaking, and then deals with measures to take advantage of the positives and minimize the negatives. He noted that a major purpose of strategic planning is to prepare an organization to respond effectively to the outside world before a crisis emerges.

Bryson noted that forces and trends are often dominated by four categories– political (values), economic, social, and technological. He made an interesting observation that, in his experience, members of an organization's governing board, particularly if they are elected, are better at identifying threats and opportunities than are its employees. He concluded that incremental decisionmaking can be very effective if it is tied to a strategic sense of direction.

Promote Objectivity

The importance of promoting objectivity has been noted by several commentators. Certainly the work of Wachs[90] and Pickrell[91] reported earlier begs for the assurance of objectivity in the planning of guideway transit projects. Evans included an impassioned plea for objectivity in research, as he recognized the difficulty in keeping advocacy out of research findings. Polzin offered some specific suggestions for creating an environment for objectivity.[92] He suggested a formal peer review process for major investment alternatives demand forecasts. He also spoke against dedicated single purpose agencies, such as commuter rail authorities or expressway authorities, which have a vested interest in a particular technology or solution.

Ranges of Assumptions

Many of the researchers cited either directly advocated or surely implied the importance of incorporating a range of assumptions into any forecasting exercise. Ascher, for example, noted that forecasts should reflect not just what is likely to occur, but also potential surprise outcomes.[94] Lowe and Richards cite the hazards of predicting inputs to the models, and also argue that errors are more likely to reinforce each other than to cancel out.[95] In reviewing the effectiveness of the urban transportation planning process, Lyons noted that long range transportation plans need to address the key issues that will face an area over the next 20 years.[96] In particular, plans need to address realistic future alternatives.

Stuart discussed a planning process that was used by the Southwest Wisconsin Regional Planning Council (SEWRPC) to test a range of alternative socio-economic futures, land use plans, and transportation systems. A range of assumptions were made for regional growth, energy availability, female labor force participation, income growth, and population and employment growth. Each of the growth scenarios was accompanied by two alternative land use plans, representing centralized vs. a decentralized development patterns. Six modal combinations were also tested, representing differing combinations of bus and guideway transit. An initial testing of 24 combinations of modal and development alternatives was performed. One of the challenges of the SEWRPC process was presenting the information in a way that was comprehensible to decisionmakers.[97]

As noted earlier, Ascher recognized the importance of core assumptions; indeed, that core assumptions are much more important than the particulars of a forecasting technique.[98] Schnaars draws the following conclusions:

> The most important advice for improving the accuracy of growth market forecasts is to challenge the assumptions that underlie the forecasts.[99]
>
> There is absolutely no evidence that complicated mathematical models provide more accurate forecasts than much simpler models that incorporate intuitively pleasing rules of thumb.[100]
>
> Do not be swayed by the sophistication of the forecasting method or the forecaster. Be suspicious. Be especially suspicious of forecasts that are based on accelerating trends of growth.[101]
>
> It is important to remember that a trend has no life of its own. A trend is the reflection of the underlying economics of the market.[102]

Following this advice can be difficult to do. As Evans pointed out:

> Although the prediction methods of astrologers and academics differ, two taboos seem to apply equally to each. First, it is socially gauche to question the foundations on which their predictions rest. Second, it is positively hostile to question how an individual's earlier predictions matched what actually happened....[103]

Highlight Uncertainties

Many authors have emphasized the importance of highlighting (rather than disguising) the uncertainties involved in forecasts. Behn and Vaupel cited Enthoven, who said that good analysis should help the decisionmaker by telling him how the choice depends upon key judgments rather than trying to provide the answer. A good analysis will search out and highlight the key questions of value, the uncertainties and the intangibles, and not bury them.[104]

Flexible Approaches

Recognition of uncertainty leads many to advocate flexible and incremental approaches to implementation. Khan noted that for many types of transportation systems, investments can be made sequentially, with acquisition or protection of right of way as the first step of partial implementation.[105] However, generally, we plan by preparing detailed master plans, which offer little opportunity to change the course of system development should circumstances necessitate such a change. He goes on to argue that partial implementation of a small scale demonstration project can be an effective means of updating assessments of probable outcomes of demand and technological uncertainty.

I agree with this approach, to an extent, particularly when it comes to new technologies such as electronic toll systems. Small scale tests have proven to yield considerable information that will be valuable in full scale implementation. There are also limitations to the demonstration approach, particularly for systems in which the utility is highly related to the scale of implementation, such as regional rail systems, small scale demonstrations may do little to enhance understanding of demand.

In advocating flexible approaches to planning, Khan noted that the consequences of any plan cannot be forecast precisely. He argued that it is therefore risky to choose a system for a specific location 20 or more years into the future. "Clearly, rigid master plans that define what projects to implement at what future time are inappropriate."[106] He argued that system plans need to be flexible enough to be altered to suit changing conditions. He cited a need for methodological requirement that for any forecasting element all the relevant risks must be assessed and their probable effects should be taken into account.

Hall presented a similar viewpoint, stating:

> ...by its nature [the best course] does not at all necessarily involve one-shot decisions. On the contrary, it will often suggest a risk-avoiding strategy, based on minimal commitments at each stage where a decision is necessary. This would generally mean an incremental or adaptive approach ... rather than a major new departure; it would suggest enlargement and adaptation of existing airports rather than building new ones, piecemeal improvement of roads at their most congested points rather than new motorways, and incremental upgrading of existing ... rail technology rather than the invention of completely new concepts.[107]

He went on to elaborate:

> ...because of the great uncertainty inherent in nearly every planning decision, the golden rule remains: do the minimum necessary, and leave tomorrow's decision for tomorrow.... Of course, the simple solution would seem less sexy to the politicians. It would build them no monuments; nor would it provide them with vainglorious election promises.... Muddling through is no bad prescription for the ordering of public affairs, so long as it is done with intelligence and foresight.[108]

Friedmann argued similarly that the engineering or rational model of planning is no longer valid and should be abandoned.[109] He diminished the importance of long range planning and argued for more emphasis on the here and now. In his scrutiny of rail transit forecasting efforts, Pickrell urged that the planning horizon be shortened, so that uncertainties inherent in long range futures will be reduced. As noted earlier, Pickrell suggested basing ridership forecasts for rail transit on the current year land use conditions.

Maldonado advocated a planning process that does not rely heavily on any forecast, but accepts a wide range of possible futures; the outcome is not a single best choice, but a procedure that emphasizes the importance of the first step, the range of alternative next steps and the possible path.[111]

In a related topic, Gifford noted the phenomenon of path dependence, where outcomes of alternative paths might turn on rather small-scale events.[112] He presented examples of how rather small, seemingly innocuous, actions led to the firm trajectory down a particular path. He dealt at some length with concepts of increasing returns-to-scale economics and how they affect the development of systems. He gave the example of coordination effects, whereby the benefit (or cost) of using a system is directly related to the number of users. Examples include urban congestion, telephone systems, fax, and language. Another example of economies of scale involves the case of large setup costs, which require large numbers of users to drive the average costs down. He cites another example of economies of scale: learning by doing, which says that the more experience in a particular method, the lower the cost of applying that method. Gifford noted that once a particular method or technology becomes ingrained, the costs of conversion can be prohibitive, even if the ultimate long term costs might be lower.

Manheim delivered a paper at the 1977 TRB Annual Meeting in which he called for a substantially different emphasis in the urban transportation planning process.[113] Where decisions on actions to be taken in future years have not been made yet, or are contingent on alternative outcomes of earlier actions, these contingencies can be shown in the planning process.

He argued that the only truly firm decision is an implementable one: how to spend next year's dollars. He noted that an important issue in choosing an action for implementation is its degree of "commitment" versus "flexibility"; if this action is implemented, which future options will be foreclosed and which will still remain open. Building on this theme, he made reference to the traditional long-range planning process, which produced an "adopted" plan for a time many years away; then implemented the plan by programming, designing, and constructing the specific projects included in the plan. In his view, this approach is not appropriate; instead, the function of the long-range plan should be to assess the long-range consequences of near-term actions, assessing which alternative future options are left open and which are foreclosed by specific implementation actions. He noted that project decisions do have system effects, and it is essential that the long run consequences of short run decisions be made clear.

Manheim went on to argue that, by focusing on only one future system, the master planning approach loses flexibility to revise plans. The implementation program is geared toward the construction of one plan for one target year and ignores uncertainties in funding, community preferences, and the impacts of a particular action. He stated that transportation options must be developed with the knowledge that today's decisions are based on an imperfect understanding of the future of a region. Unforeseen changes may require new responses and adaptations that are impossible to fully anticipate. Unfortunately, the urban transportation planning process has not changed much in the years since this article was written.

Thompson supported the position advocated by Manheim, by suggesting that dynamic programming models be applied to infrastructure systems. He stated that, in a dynamic model the operative decision is either to do something now, yielding long-term consequences, or to do nothing now, yielding only short-term consequences up to the next decision point.[114]

Lee offered similar comments to those of Manheim. In particular, he offered some useful insights into the relationship of the time horizon to the level of detail required in planning, citing three levels of detail.[115] The first level is strategic planning, in which the long term is dealt with by keeping an eye on the future so that future options are not foreclosed by current actions, unless the narrowed choice is recognized and accepted. The second is tactical planning, in which hard decisions are made among alternatives. The third is implementation planning, in which plans are translated into physical reality. He noted that, at any given time, all three types of planning occur, with strategic planning looking ahead to check the implications of current implementation activities and tactical alternatives under consideration. Neumann and Pecknold recommended an incremental approach that relies heavily on decision analysis.[116] They cited the example of the California freeway system master plan, which will probably not be implemented as planned, and certainly will not be implemented on the planned schedule. Had this been recognized at the time, there might have been an intermediate system that would have better served the realistically attainable needs.

These issues might be considered in relation to the Tampa Interstate System Master Plan, which adopted the traditional approach of developing a master plan to serve demands forecasted to exist 20 years into the future. Currently, designs are being prepared for small pieces of the future mega-highway widening needed to serve the 20 year demand. Our current planning process has us on a path in which we will have segments constructed to meet anticipated 20 year needs, while other segments are failing to meet current needs. Perhaps we would have done better to adopt a time-staged approach, making incremental improvements on a year to year basis.

Neumann and Pecknold also noted that unforeseen changes may require new responses and adaptations that are impossible to anticipate at the time of plan preparation.[117] They observed that plans are not implemented instantaneously, but rather as a series of stages over time. At the end of the first stage, the subsequent stages should be revised in light of new information or changes that have occurred.

A number of writers have advocated some important corollaries of the incremental approach: to defer irreversible decisions as long as possible, to preserve future options, and to emphasize flexibility. De Neufville strongly recommended this approach, while also recognizing the political difficulty in doing so:

The recommended strategy for anticipating and adapting to events is not glamorous. It does not provide officials with opportunities for making bold decisions or unveiling impressive plans. A flexible strategy may thus not appeal to political bosses who wish to leave their mark on the earth. But it does have the advantage of preventing these officials from looking like fools in a few years.[118]

Gifford noted that, if uncertainty is great, the rational policy is to avoid irreversible decisions; if uncertainty is small, the rational policy is to design to achieve long-run economies of scale.[119] He went on to state that the challenge in planning is how to mediate between the short-term exigencies of democratic pluralism and the longer term, but questionable, norms of planning. He suggested an alternative approach that focuses on postponing irreversible decisions as long as possible and keeping their scale to a minimum, identifying and preserving options and collecting good intelligence. He argued that this approach conserves resources, since it would use no more of a resource than required to serve near term and relatively certain demand.

Schnaars offers that "a flexible strategy keeps options open for as long as possible. It postpones commitment until the last possible moment. Then, a quick move is made."[120]

In examining decisionmaking for private firms, Hey also advocated a flexible approach, as he notes that, "One feature that emerged particularly strongly ... was the importance of flexibility ... to both the firm's behavior and its achievement."[121] Meyer and Miller also offered a number of measures to deal with uncertainty in the planning process, including building flexibility into the design of the system, and using decision theory techniques.[122]

In his discussions of incremental planning, De Neufville emphasized the importance of risk-avoidance and of insurance measures.[123] He noted that decision analysis forces planners to look for designs that provide insurance against poor performance and that will function well whatever happens. He pointed out that building flexibility into the system costs money. A design without flexibility can always be better for any one specific set of design conditions, but designs with flexibility will be better in more circumstances, better on average, and thus better overall. Khan also took special note of the need to be prepared for unforeseen circumstances through various insurance or contingency measures.[124]

Schnaars presented an important corollary to the arguments for flexibility–the importance of robust solutions:

> If a firm cannot hope to ascertain which future it will face, it can develop a strategy that is resilient no matter which of many outcomes occurs. A robust strategy is designed to perform well over more than one outcome, irrespective of which is later realized.[125]

He went on to note that:

> A key advantage of a robust strategy is that it takes the emphasis off the development of accurate forecasts and places it squarely on the uncertainty of future outcomes.... A robust strategy is not without drawbacks. By definition, it is risk-averse and is unlikely to prove optimal for any outcome.[126]

Methods

Sensitivity Analysis

One possible method of evaluating a range of assumptions is through sensitivity analysis, which typically varies values of input variables one at a time, in effect estimating the partial derivative of an objective function with respect to one input variable. Classical sensitivity analysis considers the relationship between inputs and outputs at a single point. It could be useful in evaluating small incremental changes from a known starting point. Cai and Haas, for example, applied sensitivity analysis to the problem of gravel road improvements.[127] Morgan and Henrion offered a caution on the use of sensitivity analysis, noting that although it may measure the rate of change of output with respect to a given input, it ignores the uncertainty in the input variables themselves.[128]

Several authors discounted the usefulness of sensitivity analysis to forecasting of large scale systems. They argued that often the combined effects of several input variables reinforce an effect and produce an output that is very different from what any of the individual sensitivity analyses would indicate.[129, 130, 131] Brod went on to offer a risk analysis approach, in which probability distributions are attached to each input variable, based on expert and public panels.[132] The panels are used to help shape the risks associated with all underlying judgments and assumptions. Participants in the expert panels were asked to estimate the median, the 10 percent lower limit, and the 10 percent upper limit for each variable. Proprietary software was then used to generate probability distributions corresponding to the three points estimated by the panel. He noted that this process serves to inform decisionmakers about the real risks involved and the importance of various assumptions. He then mad use of a Monte Carlo simulation model, to evaluate the outputs, based on the probability distributions associated with the input variables.

Scenario Analysis

An alternative approach, advocated by Abeelen and Hoekert, is the use of scenario analysis.[133] Godet also offers a critique of the classical forecasting process, instead advocating the use of scenarios–a multiple view of an uncertain world.[134] Meyer and Miller cited a number of advantages to the scenario approach, including low cost and an ability to address a wide range of alternatives.[135] Morgan and Henrion noted that a major benefit of doing scenario analysis is to stretch the analyst's thinking by generating unexpected combinations of possible events which might otherwise be ignored.[136]

With the assistance of the Center for Urban Transportation Research, the Metro Dade Transit Authority (MDTA) recently constructed possible scenarios, as part of a strategic planning exercise.[137] The scenarios combine a dozen or more potential factors into a series of coherent scenarios, ranging from the best case to the worst case. Each scenario assumes a condition associated with international commerce, tax base, investment in transportation infrastructure, federal and state transportation policy, and a myriad of other factors. As MDTA continues to contemplate the range of scenarios, they will be much better prepared to deal with the ultimate events as they occur.

Recently, the preparation of a new long range transportation plan for Tallahassee, Florida, has made a dramatic leap in the state of practice in Florida by explicitly evaluating three alternative land use scenarios.[138] The urban transportation planning modelling process was applied to each of the land use scenarios, taken with the existing plus committed transportation network. As a result, it was possible (within the reliability constraints of the models) to evaluate the different transportation deficiencies resulting from each of the land use scenarios.

Schnaars also advocated the use of scenario analysis, which does not pretend to predict the future. Instead, it postulates a set of plausible futures, each of which is possible. Contrary to many of the decision analysis advocates, he urged not attaching probabilities to multiple scenarios, as he believes it conveys a sense of precision that does not exist.[139]

A number of methods have been devised for systematically defining and dealing with multiple scenarios. Khan advocated making use of subjective assessment of uncertain factors through group assessments, Delphi studies, and decision-theoretic approaches.[140] However, Slovic et al. caution that the distortions of subjective probabilities are often large and difficult to eliminate.[141] Brod also offered a caution about producing a "high" and a "low" estimate, based on alternative scenarios. He believed that this approach is ineffective, as it gives no indication of the likelihood of the outcomes.[142]

Several researchers developed methods of encoding probabilistic inputs into public policy decisions. Morgan and Henrion present techniques for encoding and for calibrating subjective probabilities.[143]

Sassone and Schaeffer presented a technique for dealing probabilistically with an output variable that is a function of multiple discrete probabilistic inputs.[144] Each input variable is allowed to take on several values, each representative of a particular range (e.g., high, medium, low), and subjective probabilities of occurrence are assigned to each outcome. In effect, all combinations of joint probabilities can then be enumerated and a probability density function and a cumulative probability function can be constructed. The technique presented may be an effective means of presenting probabilistic output values for transportation planning purposes.

Decision Analysis

Raiffa was a pioneer in the development of decision analysis methods. He authored one of the earliest books on methods of systems analysis, which has survived as a classic of decision analysis. His methods require the use of subjective probabilities applied to the creation of a decision tree.[145] A sample decision tree is depicted in Figure 4. He noted that the analysis of decisions under uncertainty requires a five-step process: 1) list options for information gathering, experimentation, and action; 2) list events that may occur; 3) arrange in chronological order information that can be acquired, and the choices that can be made as time goes by; 4) apply values to outcomes; and 5) judge the probabilities of outcomes.

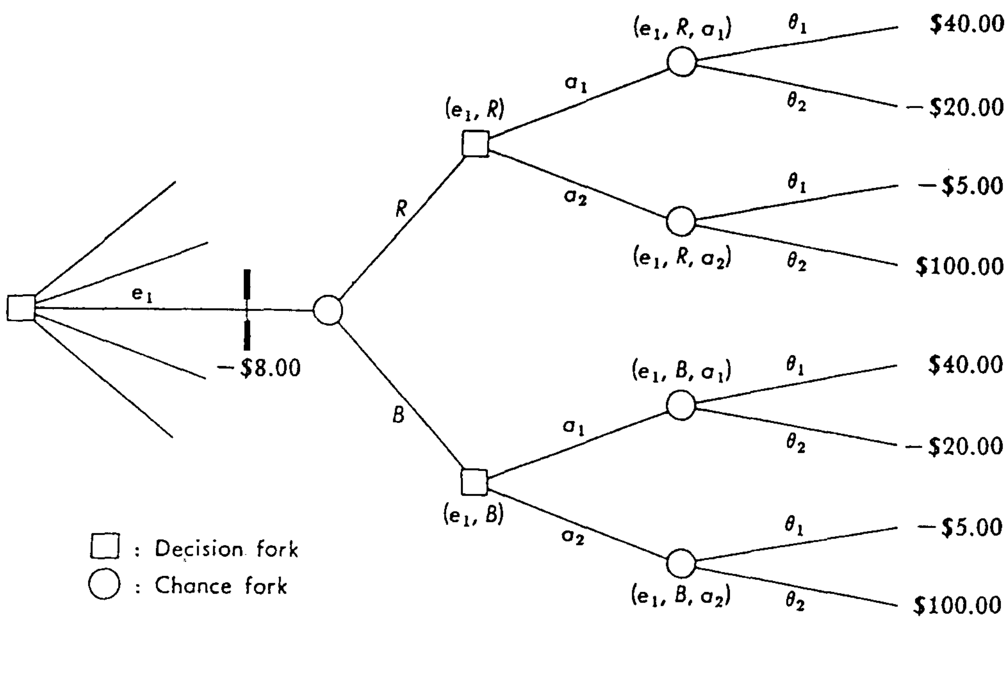
His approach made intensive use of decision flow diagrams or decision trees, and requires that preferences be scaled in terms of utilities and that uncertainties be scaled in terms of probabilities. He distinguished between expected monetary value and expected utility, applying a decision making rule of maximizing expected utility. He examined risk-aversion and the rationale for deviating from expected monetary value.

Raffa's approach is carried out in a four-step process: 1) reduce the problem to a decision flow diagram; 2) assign utilities to outcomes; 3) assign probabilities to the branches at chance forks; 4) determine the optimal strategy by computing expected utility values.

It would make sense to base small decisions relative to total worth on expected value, but base large decisions on risk averse measure of utility.

Neumann and Pecknold described a decision analysis approach that recognizes the possibility of a number of outcomes in response to each stage of action. They made use of decision trees to compute expected values of alternative actions, based on probabilistic responses to each action. They presented a specific example of the application of their approach to the planning for

Figure 4
EXAMPLE DECISION TREE



Source: Raiffa, Decision Analysis (Addison - Wesley, 1970), p.11.

a major highway project in Santa Barbara, California. Their conclusions included some fundamental philosophical observations that:

> The role of systems planning ... is to carefully anticipate the choice issues that must be resolved as planning continues and to devise tentative sequences of improvements based on potential outcomes from these choices.... The time-staging approach is decisive, by requiring action on first-period plans, and realistic, by recognizing that it is neither desirable nor necessary to make tentative decisions over a long time horizon. While leaving future decisions open until more information is obtained, staging strategies take into account possible future options and events and are able to evaluate the most flexible direction for present decisions.[146]

De Neufville offered one of the most complete treatments of the principles of decision analysis to public policy. Moreover, his writings on the subject have encompassed a period of at least 20 years. In his textbook, he presented an approach to the application of decision analysis. He advocated the use of decision analysis, with subjective probabilities, and the maximization of expected utility.[147] More recently, Dr. Neufville noted that, in many cases, when the impacts of actions occur many years into the future,

> it is probably specious to estimate probabilities of chance events.... Thus a full numerical decision analysis is not a useful exercise; ... [instead] the decision analysis should focus on the structure of the results of the decision analysis.[148]

He further advocated the use of decision analysis as a strategy for a sequence of decisions. He argued that the explicit recognition of uncertainty in the analysis of public policy issues can be turned into a strength of the approach. He elaborated that the crucial reality is that we do not and cannot know what the future will bring.[149] He reiterated that a major obstacle to the decision theory approach will be overcoming the objections of a professional staff who make their living preparing forecasts. These professionals can hardly be expected to acknowledge freely that their expensive efforts and staff cannot make accurate predictions. They will fight the recognition of uncertainty. As a practical matter, decision analysis has virtually never been used in transportation planning. He notes that decision analysis recognizes that any alternative will have a range of effects that are unpredictable, and that any long-term project involves a sequence of choices concerning its configuration. Decision analysis forces the planner to recognize the performance under other scenarios, when it might be a real embarrassment.

Chapter 5

A Recommended Approach to Transportation Decisionmaking

This report has provided numerous illustrations of the failures of past forecasts, errors in individual perceptions, the complications of social and political bias, other characteristics of decision making error, and possible strategies and methods. The most significant problems with current transportation planning practice are summarized below:

1. The inability to predict the future. Uncertainty exists in future demand, technology, costs, resource availability, and values. Imponderable and unpredictable events will shape the future in ways we cannot hope to anticipate.
2. Current travel demand models are limited in their ability to replicate the present, much less forecast the future.
3. Even if travel demand models were perfect, uncertainties in the input variables are enormous, and to a large extent unpredictable.
4. Limitations in intuitive decisionmaking often result in fallacious interpretations of information.
5. Social and political bias is a strong contributor to errors in anticipating future events and to our willingness to deal with uncertainty.

Our inability to develop reliable forecasts of future conditions dictates substantial changes to the way we do urban transportation planning. An observation made by Schnaars is that, "asking the right questions is superior to finding elaborate answers to the wrong questions."[150] In many respects, the current urban transportation planning process does the latter–it gives elaborate answers to the wrong questions.

Schofer made a bold statement that if all long-range transportation planning ceased few people would notice.[151] One of the reasons for the limited influence of long-range planning has been the proven inaccuracy of the forecasts, suggesting that although much research has focused on sources of error and ways to reduce them, not enough attention has been directed at characterizing uncertainty and conveying useful information about it. He observed that neither decisionmakers, citizens, nor planners deal well with uncertainty, necessitating better methods to convey uncertainty to lay persons.

Strategic Transportation Planning Requirements

A number of approaches to dealing with uncertainty have been described. Some of them have been applied to other fields, particularly corporate planning. A very few of these methods have been applied to the transportation sector. Notable among these have been efforts by de Neufville to incorporate uncertainty into airport planning. Virtually no serious efforts have been made to incorporate consideration of uncertainty to decision making about urban transportation investments. We might begin by summarizing the features that an alternative strategic transportation planning process should exhibit.

Understandable to Decisionmakers and the General Public

The urban transportation planning process must be understandable to political decisionmakers and to the general public. The process of making decisions about public investments in transportation is fundamentally a political process. For any possible action, some will benefit and others will lose, and it is the role of elected decision makers to make trade-offs among conflicting and divergent community values. Ultimately, many decisions about project priorities are made by elected representative bodies: Metropolitan Planning Organizations, Boards of County Commissioners, and City Councils. With the new mandates of ISTEA, there will be more and more emphasis on involvement of the public in the decision making process.

One of the most serious indictments of the current urban transportation planning process is that it is *not* understandable to the general public. Indeed, there are few professional transportation planners who understand the underlying technical assumptions of the existing urban transportation planning process. The new process needs to be practical in terms of ease of understanding by elected decisionmakers and the general public.

Reasonable Financial Resources to Carry It Out

A pragmatic consideration is that decisionmakers will rightfully demand that transportation funding be principally applied to capital and operating expenses of transportation facilities. Planning, although it is extremely important, cannot consume more than a small percent of the total transportation budget, or it will not be tolerated. Thus, the new process must make prudent and strategic use of financial resources.

Promotes Objectivity

The new process should promote objectivity. While it cannot (and should not) remove the politics from decisionmaking, the new process should promote the separation of politics from forecasting. Clearly, political trade-offs are the essence of the decisionmaking process, but the trade-offs should be based on information that is objective and not contrived to support a predetermined political agenda.

Incorporates Ranges of Assumptions

Previous sections clearly demonstrated the importance of assumptions, and the difficulty of guessing the right assumptions. The new process should therefore incorporate ranges of assumptions to attempt to reflect better the possible outcomes.

Highlights Uncertainties

No matter what models are used and what assumptions are used, ethical considerations mandate that uncertainties be highlighted for decisionmakers and for the public. Uncertainties can relate to numerous factors, including demand, technology, costs, resource availability, and values. Most importantly, in sharp distinction common current practice, assumptions should be clearly recognized and highlighted.

Places a Premium on Flexibility

Once we admit the reality of uncertainty, the importance of flexibility becomes paramount. In a future that holds unanticipated surprises, we need to place a high value on retaining future options. The planning process should therefore identify which options are foreclosed by a given near term action.

Putting It All Together: A New Strategic Urban Transportation Planning Process

As noted previously, the reality of uncertainty does not imply we should abandon planning. It does demand that we explicitly recognize uncertainty and deal with it in our planning process.

Although work is continuing, a number of recommendations can be made at this time to better incorporate uncertainty into the planning process. The specific steps that are recommended at this time include:

1. Define a strategic vision.
2. Identify uncertainties: a classic strategic planning process.
3. Plan for the short run with an eye on the long run.
4. Incorporate independent peer reviews.
5. Promote flexibility.
6. Implement incrementally major transportation capital investments.

A Strategic Vision

The process that is envisioned would begin with a strategic vision. Indeed, any meaningful planning process must have a vision of a desired outcome. If we adopt the definition of planning cited earlier–"a formal or ordered process in which men seek by forethought to affect action so as to bring about more desired states than it is anticipated would otherwise occur,"[152] it is imperative that we have some future state in mind as an objective. In the absence of a vision, it matters little what process is used.

Elected officials, as representatives of the general public, must be able to articulate a vision of what they want their community to be "when it grows up." The vision needs to be articulated in terms that reflect the desired characteristics of the system at some time in the future. Of course, the vision need not be a dramatic departure from the past. If a community is content with its current character, the vision might be just "more of the same." On the other hand, the vision might call for sweeping changes to the character of the area.

Because of the critical interactions of transportation and land use, the vision will need to incorporate land use, community development protection of natural resources, and transportation. For long range planning, the vision will necessarily be strategic–it will incorporate the general desired features, but will not specify precise details, as these must be responsive to the unknowable details of the future. For example, the vision may reflect a strong preference to intensify the development of the central business district, an increased transit orientation, and the preservation of natural resources. Alternatively, it might call for continued decentralization of employment, reliance on the automobile, and development of more "edge cities." However, for planning to matter at all, there has to be a preferred outcome that is clearly established by the community and by its elected decisionmakers. In the context of Florida's growth management statutes, it would be highly appreciate for a community visioning process to occur as part of the refinement and development of local government comprehensive plans.

Developing a consensus on a strategic vision and, indeed, all phases of development of a transportation plan, must embrace the whole community. In the spirit of ISTEA's renewed emphasis on community involvement, it might be expected that a regional visioning process would include a series of grass roots community meetings to allow the preferences of the community to be known. It will be an important role of the professional staff during these consensus-building community meetings to provide factual information about the range of possible costs, benefits, and impacts of various elements of a strategic vision. It is important that the community visioning process focus on major strategic objectives, and not on the details of implementing a vision. For example, community visioning might address the importance of a strong CBD, the role of alternatives to the automobile, a general program of livable roadways, and similar objectives, but should steer away from details of location, design and operation, which need to be responsive to future unpredictable events.

Identify Uncertainties: A Classic Strategic Planning Process

Once a strategic vision has been articulated, the recommended process would undertake a classical strategic planning process which identifies strengths, weaknesses, opportunities, and threats to reaching the desired outcome. The inclusion of this activity represents a radical departure from traditional planning practice, which evaluates all available information to estimate a single expected value for each variable.

The responsibility for identifying these uncertainty factors will fall to the professional planning staff, but planners would do well to include a measure of involvement by the general community and by elected decisionmakers. Often the professional planning staff become so involved in the sophistication of the models and the approach that they overlook the important assumptions and uncertainties of the process.

The presentation of strengths, weaknesses, opportunities, and threats should be made to the elected decisionmakers in a workshop type format, allowing considerable give and take to the discussion. The product of the strategic planning process should be an identification of all conceivable risks and a proposed action for dealing with those risks. If a particular risk materializes, it might dictate actions on the part of the public body to counter the event, or it might dictate modifying the vision to be realistic.

Several generic uncertainties should be addressed by all transportation planning efforts. These include the most fundamental assumptions regarding inputs to the transportation planning models: population, labor force, and employment. Explicit consideration should be given to the potential for error in each of these important variables. In spite of best available projections from BEBR, what is the chance that study area population, labor force or employment will be 10 percent higher or lower than the best guess estimate? 20 percent higher? Errors of this magnitude need to be expected and anticipated. Certainly the consideration of these factors needs to recognize the particular attributes of a region.

A critical element of a new process should be the clear enunciation of all assumptions. This practice will require a new awareness on the part of professional staff to the importance of assumptions in the analytical process.

Plan for the Short Run, with an Eye on the Long Run

It was previously noted that uncertainty increases with duration. Certainly this is not a major revelation. Surprisingly, it is a fact that is frequently ignored. To reiterate, the current transportation planning process is based on the assumption that we can forecast precisely the values of population and employment for hundreds of traffic analysis zones 20 years into the future. We then test alternative transportation system configurations to select the one that optimally serves the forecasted population and employment levels and distributions. The reality, of course, is that forecasts of activities 20 years from now, disaggregated into hundreds of traffic analysis zones are sure to be wrong; in turn, the optimal system is sure to be different than the one selected.

A recommendation of this project is that the focus of transportation planning on the 20-year horizon be changed. Instead, it is recommended that the focus be on current deficiencies, and on the five-year horizon. Initially, as suggested by Pickrell,[153] alternative actions for coping with immediate deficiencies would be evaluated. The traditional transportation planning models could be run with current year traffic analysis zonal data to test alternative actions to correct current deficiencies. Of course this approach will retain errors associated with the transportation models, but will eliminate errors introduced by forecasts of socio-economic factors. Following this application, forecasts would be made of conditions five years into the future. Importantly, assumptions and uncertainties would be clearly illuminated.

Subsequently, based on the outputs of the five-year forecasts of socioeconomic and traffic conditions, the forecasts would be extended to a 10-year horizon. Similarly, at the conclusion of the 10-year forecast, an extension would be made to 20 years. Each step along the way, projects would be identified to meet transportation system deficiencies in each increment: the five-year forecasts would identify improvements needed in the initial five-year period. Each increment would include projects needed in the subsequent period. Since virtually all programming decisions are made within a five-year, and certainly a 10-year, horizon, and since a 20-year horizon does justice to the long range view, it is believed that a 15-year increment is unnecessary.

It is recommended that only one set of input variables would be used for the evaluation of current improvement project, and for the five-year forecast. Although there will undoubtedly be some unanticipated events, even over a five-year period, their impact on travel demand should be relatively minor. For the longer range forecasts, input variables would explicitly include three scenarios: one representing a future believed to be the most likely to occur, one representing a significantly lower rate of growth, and one reflecting much stronger growth than currently anticipated. For the 10- and 20-year horizons, traffic forecasts would be made for each of the three scenarios.

The emphasis would be on selecting a good short term plan to meet the needs of the initial five-year period, but a sequence of improvements would be identified for each subsequent increment. In contrast to the current process, which is predicated on optimizing the response to a highly uncertain 20-year forecast, the recommended process is focused on optimizing responses in a shorter five-year time frame, with an eye on the long term.

Clearly, this process will require significantly more analytical effort than the current process. It suggests one set of input variables for the current timeframe and for the five year view, with three scenarios for the ten and twenty year increments. It is suggested that a problem structure similar to that used in the recent update of the Tallahassee long range plan be applied. Each economic scenario could be applied to an initial network consisting of the existing plus committed (E+C) transportation system. Deficiencies based on the E+C network would be identified. The result could be expected to involve more model runs: 3 scenarios x 2 time intervals + one scenario each for the current and five-year periods, would translate to eight base condition runs. Additional runs would be required for testing alternative network solutions. However, in this age of powerful desktop computers, such a requirement can be managed.

Over the past decade, one of the revolutions in our society has been the widespread availability of powerful desktop computers. This revolution has been manifested in the transportation planning profession by the widespread availability of complex simulation models. Even so, our basic approach to defining alternatives has not substantially changed to take advantage of the availability of computing power.

Incorporate Independent Peer Reviews

For many years, Florida DOT has been implementing a strong value engineering program, which assembles teams of professionals with diverse skills to review conceptual and final project designs. FDOT views the program as highly successful and points to millions of dollars in savings. Apparently, one of the keys to the success of the program is the involvement of professionals disassociated with the project in a rigorous review process. All of us have experienced instances in which our close day-to-day participation in a project has blinded us to factors that are evident to outsiders. It is easy to get so involved in a project that we "cannot see the forest for the trees."

It is recommended that the preparation of regional transportation plans, major corridor analyses, and major activity center studies incorporate a new task, an outside professional peer review. To accomplish the same benefit as value engineering, it would be critical that those selected to perform peer reviews be disassociated from the project and have a considerable degree of expertise in the transportation planning process. The principal purpose of the outside peer review would be to review all planning process assumptions, both explicit and implicit, and to critique the reasonableness of results. To minimize adverse impacts on the planning process, it is recommended that an initial peer review be conducted at the conclusion of the development of zonal input data and definition of alternatives, but prior to running the transportation models. Part of the task of the peer review would be to explicitly document uncertainties and assumptions (explicit and implied). Subsequently, a second peer review would be conducted following the application of the transportation models and the identification of improvement projects.

Promote Flexibility

Once we admit the reality of uncertainty, the importance of flexibility becomes paramount. In a future that holds unanticipated surprises, we need to place a high value on retaining future options.

One measure that could be implemented to preserve future options and to emphasize flexibility is the early acquisition of transportation rights of way. There are a number of techniques available to preserve rights of way. Florida DOT has purchased a number of railroad rights of way being abandoned as active freight lines. Examples include the Tallahassee to St. Mark recreational trail and the Pinellas Trail. Both of these reflect long range preservation of corridor resources, while making practical use of them in the short term as recreational resources. To the extent that similar rights of way can be acquired elsewhere, and to the extent that they are in the path of clearly developed or developing areas, additional advance right of way acquisition should be undertaken. The decision about modal development can be deferred into the future. Perhaps future conditions will dictate development as rail transit corridors, bus-only roadways, auto-only parkways, mixed use highways, or separated bikeway and pedestrian routes. It is recognized that right of way reservations for future transportation systems will present difficult political challenges.

The future Suncoast Parkway, located on the Florida West Coast, is an excellent example of how early recognition of a potential corridor has led to strong actions to acquire the corridor for transportation purposes before encroaching development makes such corridors impractical. On a statewide basis, it would be well worth some serious map analysis to identify possible corridors in high demand areas, that could be the subject of advance right-of-way acquisition.

Another effective method of right-of-way preservation is through the formal adoption of an official map depicting transportation corridors, or in Florida, through the transportation element of the local government comprehensive plans.

An important implication of uncertainty is that technologies that can be implemented in usable increments may have an advantage. For example, for guideway transit alternatives, dedicated busway facilities might offer such potential (more about this in the next section).

Incremental Implementation of Major Capital Investments

Much of the research presented in this report points toward the desirability of incremental implementation of major projects. As previously cited, Hall observed that:

> ...by its nature [the best course] does not...necessarily involve one-shot decisions. On the contrary, it will often suggest a risk-avoiding strategy, based on minimal commitments at each stage where a decision is necessary. This would generally mean an incremental or adaptive approach ... rather than a major new departure.[154]

> ...because of the great uncertainty inherent in nearly every planning decision, the golden rule remains: do the *minimum* necessary, and leave tomorrow's decision for tomorrow....[155]

One of the most controversial categories of transportation investments is the implementation of major fixed guideway transit projects, such as urban rail rapid transit systems. Currently the only Florida systems are Dade County's METRO system, the Tri-Rail system, and the Jacksonville Skyway Express. However, there have also been serious proposals for various forms of guideway transit systems in Hillsborough, Pinellas, and Orange counties. In addition, on a statewide basis, there continues to be a great deal of interest in the prospects for an intercity high speed rail system.

Unfortunately, the planning that has been applied to these systems reflect many of the pitfalls associated with the current urban transportation planning process. Risks and uncertainties, particularly as they relate to future ridership and costs, have made it impossible to muster the necessary political support to implement such systems. These systems are typically represented in the form of optimistic assessments of outcomes 20 to 50 years into the future.

Can it be any surprise that elected officials are reluctant to commit to systems that will involve massive present costs in return for uncertain future benefits? Because we make only grandiose plans, all we have to show is plans. We don't give enough attention to the here and now. We might actually implement something one step at a time, whereas the likelihood of implementing a plan based on projections decades into the future seems highly unlikely.

There is an alternative approach that embraces many of the desirable features cited in earlier sections. Instead of the "one-shot" long range picture of the desired system decades into the future, an incremental approach is recommended. Such an approach might begin by offering express bus service using makeshift park and ride lots. Similar approaches have been successful elsewhere, making use of church parking lots, or of underutilized shopping center parking spaces. Low cost lease arrangements can be made with owners of these facilities much less expensively than immediately constructing public park and ride lots. As demand increases, permanent and perhaps more ideally located park and ride facilities can be constructed.

As warranted by demand, dedicated high occupancy vehicle (HOV) facilities can be implemented, within existing transportation rights of way. If dedicated HOV lanes are impractical, preferential bus treatments can be constructed that allow buses to circumvent specific high congestion delay points. As each of these actions is taken, based on affirmation in the form of ridership, political support for the next increment of investment will build. Ultimately, the addition of a guideway transit system can be justified, with the park and ride infrastructure already in place.

The same philosophy holds for major highway capital investments.

The example of the Tampa Interstate System Master Plan Study was previously cited. The study adopted the traditional approach of developing a master plan to serve demands forecasted to exist 20 years into the future. Currently, designs are being prepared for small pieces of the future mega-highway widening needed to serve the 20 year demand. Our current planning process has us embarked on a path in which we will have segments constructed to meet anticipated 20 year needs, while other segments are failing to meet current needs. Only recently has there been a recognition of the critical need to make interim improvements in advance of the "ultimate" solution. Perhaps we would have done better to adopt a time-staged approach, making incremental improvements on a year to year basis.

Additional Research Needs

The measures recommended above will go a long way toward recognizing the uncertainties in the transportation planning process. However, work is continuing on integrating these methods of dealing with risk into a more unified and replicable approach.

Summary of Recommended Actions

Following is a summary of the specific modifications recommended for the urban transportation planning process;

1. Define a strategic vision of what is desired for the area. Incorporate widespread community involvement. The vision should include land use, community design, and transportation elements, and protection of natural resources.

2. Identify uncertainties, including strengths, weaknesses, opportunities, and threats to reaching the desired vision.

3. Plan for the short run, with an eye on the long run.

   - evaluate possible improvements based on current traffic and land use conditions.

   - develop a single "best guess" forecast of conditions five years into the future.

   - highlight uncertainties and assumptions.

   - develop 10-year and 20-year forecasts, based on three distinct economic scenarios representing a future believed to be the most likely to occur, a future believed to be more pessimistic than anticipated, and a future believed to be more optimistic than anticipated.

4. Incorporate independent peer reviews into key stages of the planning process. Document uncertainties and assumptions.

5. Place a premium on actions that maintain flexibility and preserve options as long as possible.

6. For every major transportation capital investment, develop an incremental implementation plan that undertakes usable portions of the major investment in a sequential program.

7. Monitor early stages of implementation to confirm or to contradict anticipated responses.

8. Proceed with further implementation as warranted by early stage monitoring.

9. Continue with the development of methods to integrate these methods into a unified and replicable approach.

Hopefully, the implementation of this new strategic approach to transportation planning will allow us to recognize uncertainty, yet not be paralyzed by it; to move proactively toward the attainment of valued societal objectives, yet to be prepared for the changes we cannot predict. It is toward this end that this research is dedicated.

Endnotes

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"A New Strategic Urban Transportation Planning Process"

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