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INTELLIGENT TRANSPORTATION INFRASTRUCTURE DEPLOYMENT ANALYSIS SYSTEM

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ABSTRACT

Much of the work on Intelligent Transportation Systems (ITS) to date has emphasized technologies, standards/protocols, architecture, user services, core infrastructure requirements, and various other technical and institutional issues. ITS implementations in the United States and elsewhere in the world have demonstrated benefits in the areas of safety, productivity, efficiency, and environmental impact. However, quantitative benefits and satisfactory cost estimates are not available or cannot be derived for many components of the ITS, whether deployed individually or in some integrated fashion. The limitations of existing analysis and evaluation capabilities coupled with the lack of strong empirical evidence presents a major knowledge and data gap for infrastructure investment decisions involving ITS alternatives. This paper describes the over-arching issues and requirements associated with the analysis capabilities required for a systematic, faithful, and rigorous evaluation of the impacts of deploying ITS in a metropolitan area. It then describes the conceptual framework of a modeling system that will provide a preliminary analysis capability to support ITS deployment analysis and evaluation.

BIOGRAPHY

Ajay K. Rathi

Dr. Ajay K. Rathi (left) is Program Manager for the Intelligent Transportation Systems Research at Oak Ridge National Laboratory. He is an internationally renowned authority in the area of transportation systems modeling and analysis. His professional career, with over 15 years of experience, has spanned industry, government, and academia. He has performed work for several federal, state, and local government agencies in the United States, as well as for the World Bank, on a variety of transportation problems. He is a registered professional engineer and a member of several committees of the Transportation Research Board, ITS America, the American Society of Civil Engineers, and the Society for Computer Simulation. He is the author or co-author of over 100 technical books, reports, papers, and presentations.

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John A. Harding (right) is currently a Highway Research Engineer with the U.S. Department of Transportation's Federal Highway Administration (FHWA). Mr. Harding has experience in the areas of transportation planning, traffic operations, and intelligent transportation systems. He was involved in the planning and operation activities with the state of New Jersey and state of Virginia Departments of Transportation. Mr. Harding's intelligent transportation system experience includes the development of study scenarios for the FHWA's National ITS Architecture effort, guiding research efforts associated with the planning and operational aspects of an automated highway system, and the development of a prototype system that uses the Global Positioning System (GPS) to automate the collection of travel time data. In his current assignment, he is involved in the development and execution of FHWA's Advanced Traffic Management Systems (ATMS) research and development.

INTRODUCTION

Many metropolitan areas in the United States now have aspects of Intelligent Transportation Systems (ITS) in early deployment and plan additional deployment. In January 1996, the U.S. Department of Transportation (USDOT) announced a new initiative called Operation TimeSaver. The major objective of this initiative is the creation and implementation of a national intelligent transportation infrastructure designed to save time and lives, and to improve the quality of life. The goal of Operation TimeSaver is to build a U.S. intelligent transportation infrastructure within 10 years, incorporating a vast array of current and future ITS services and technologies. The program's aim is the rapid (i.e., during the next decade) deployment of ITS services and technology in 75 of the largest U.S. metropolitan areas with the greatest mobility challenges and also installation and upgrade of ITS services elsewhere as resources permit (USDOT 1996).

The initiation, undertaking, and support of major initiatives such as Operation TimeSaver are based on the generally accepted notion that the application of current and evolving ITS technologies to transportation systems can provide more efficient and effective solutions to multimodal transportation problems. And there is considerable empirical evidence to support the enthusiasm. ITS implementations in the United States and elsewhere in the world has demonstrated benefits in the areas of safety, productivity, efficiency, and environmental impact.

However, estimation of the consequences of alternative ITS strategies or intelligent transportation infrastructure deployment on transportation systems' performance and life-cycle costs associated with ITS deployment are often shrouded in uncertainty (MITRE 1996). Simple questions such as 'what are the expected traffic operational benefits from an advanced traffic adaptive control system or a traveler information system for a region during the peak hours' have not yet been answered (Glassco 1995). In addition, research and development has not to date established and verified methods of evaluating the energy, environmental, and safety impacts of ITS.

The limitations of existing analysis and evaluation capabilities coupled with the lack of strong empirical evidence -- in many possible scenarios of deployment -- presents a major knowledge and data gap for infrastructure investment decisions as they relate to ITS deployment. State, local, and regional transportation authorities, with responsibility for near-term and long-range transportation plans in their regions, need tools and information sources that will allow a systematic assessment of ITS deployment options as alternatives to and/or enhancements of traditional highway and transit investment options. Currently, robust analytic tools are not available to perform such assessments. Failure to provide planners with the tools to reliably assess the impacts of ITS investments could greatly handicap the deployment of ITS. Decisions are then more likely to be based upon an incomplete assessment and consideration of the full range of transportation options, as well as the range of potential impacts of those options (Federal Highway Administration 1996).

In response to this perceived lack of analysis capability in support of the Operation TimeSaver initiative, a Task Force was established by the Federal Highway Administration (FHWA) of USDOT to assess the analytical needs required to support full consideration of ITS deployment.* The primary goals of this task force are to identify the overarching issues, develop the requirements, and suggest a research strategy to help meet the analysis needs associated with ITS deployment and intelligent transportation infrastructure investment decisions.

This paper presents these overarching issues and requirements -- dentified by the FHWA Task Force -- associated with the analysis capabilities required for a systematic, faithful, and rigorous evaluation of the impacts of deploying ITS in an urban area. This is followed by a discussion and review of relevant modeling efforts. Next, a two-track research approach recommended by the Task Force is presented. Finally, the paper describes the conceptual framework of a modeling system that will provide a preliminary analysis capability to support ITS deployment analysis and evaluation. This system, called IDAS for Intelligent transportation infrastructure Deployment Analysis System, is envisioned as a modeling system to provide quick-response and sketch planning capability for systematic and quantitative evaluation of the relative costs and benefits of intelligent transportation infrastructure investment options—as an alternative to and/or enhancement of traditional highway and transit infrastructure investment options.

OVERARCHING ISSUES FOR ITS IMPACT ASSESSMENT

In order to effectively support and foster ITS deployment, analysis systems must respond to the particular challenges posed by analysis of ITS user services and characteristics. At the same time, these analysis systems should be capable of evaluating traditional infrastructure investments such as added lanes, transit, and high-occupancy-vehicle (HOV) lanes. And to ensure ready adoption and use by analysts, the systems need to be fully compatible with existing network and demographic databases, as well as with analytical methods. There should be maximum integration of new methods with existing ones in terms of databases and analytical concepts. Care should be taken to avoid requiring planning staffs to have parallel capabilities in more than one analytical framework.

As a starting point for discussion, we list below some of the issues that are believed to affect the overall short- and long-term analytical requirements. This list does not cover all issues but is an attempt at characterizing the larger context of which the capabilities designed to evaluate ITS must be a part. These overarching issues and requirements for analytic capabilities have been reviewed with full consideration of the current and planned analysis capabilities that will be used to develop transportation plans and programs.

- In this era of heightened fiscal constraint, decision-makers need to understand the relative cost-effectiveness (both benefits and costs) of alternative transportation investments, in

* The authors are the members of this FHWA Task Force.

various combinations with each other, as well as of traditional capacity-expansion proposals, and to perform trade-off analyses of both systems and project-level impacts.

- The planning and project development process involves attention to transportation problems and solutions in an iterative process leading to a reduced number of options studied at a greater level of detail. Analytical capabilities are needed to support all of these study contexts—regional, subregional, corridor, and facility-level.

- Continuing concern for environmental quality requires thorough environmental impact assessment especially of air quality, in advance of incorporating projects into transportation plans and programs. The scale and scope of travel forecasts need to match recent (and projected) advances in modeling mobile source emissions.

- Contemporary demographic, development, and lifestyle factors ultimately dictate the magnitude and pattern of travel growth and must be represented in the analytical framework within which evaluations are performed.

- Lifestyle and economic conditions are adding to the complexity of travel, necessitating the need to differentiate between travel market segments, including places of origin, destination, trip purpose, and departure/arrival times of the various user groups.

- Planning and programming operational improvements require understanding of the operational characteristics of the system, including concepts of capacity, congestion, incidents, travel time, speed, variability in speed/flow, flow smoothness, comfort, reliability, and level of service in a *dynamic and evolutionary* context.

- Faced with making investment decisions involving nontraditional projects, decision-makers need timely information on potential impacts in easy-to-understand formats. Informational reports are needed on potential measures of effectiveness (congestion, travel time, speed, delay, etc.), as well as on the background characteristics of transportation systems in order to perform environmental, energy, and safety analyses for all project alternatives, at various planning horizons.

- The rapid pace of travel growth and technological change suggests that transportation planners need to be able to plan for alternative futures and efficiently assess the impacts of alternative strategies under a wide range of scenarios.

- Greater customer focus and sensitivity to governmental roles and responsibilities in service delivery suggest that evaluations need to be able to target the impacts of alternative public investments to individual user groups.

PRELIMINARY MODELING REQUIREMENTS

While the presentation of the overarching issues above is an attempt to characterize the environment that will impact any new modeling effort that may be undertaken, one of the primary goals of the FHWA Task Force was the identification and development of the short- and long-term analysis and modeling requirements. A requirement contains an explanation of a function that needs to be performed and an indication of how the function may be accomplished given various constraints. The preliminary list below is an attempt at characterising the content of a requirements list associated with the development of ITS analysis capabilities (both in the short term and in the long term). As stated earlier, different levels of details may be incorporated in short-term and long-term analysis capabilities. This list is to complement the overarching issues that characterise the larger environment while providing a sense of focus on the aspects of the internal environment that constrain the analysis of ITS.

Listed below are the requirements of the modeling system to support decision-making as it relates to ITS deployment. These requirements are labeled with a prefix 'S' to indicate that they are requirements of the proposed system(s).

S1. The system shall provide capability to examine the trade-offs in deployment of ITS technologies compared to traditional infrastructure investments. For example, the system should allow the user to examine impacts that accrue from investment in regional freeway traffic management compared to an HOV lane in an existing freeway corridor.

S2. The system shall provide capability to examine the trade-offs in deployment of ITS technologies in isolation and in combination. For example, the system shall provide capability to examine the impacts of regional traffic management compared to regional transit information (i.e., provision of static schedule and travel time information) in isolation. It should also provide capability to examine the impacts of regional transit information fully supported by freeway and surface street surveillance based on real-time travel data.

S3. The system shall provide capability to examine the trade-offs in deployment of alternative sequences of ITS technologies over time. Investment in ITS services should be viewed as a series of infrastructure and services additions over a period of time. The infrastructure required to support services will vary from region to region depending on the level of infrastructure development and the goals, objectives, and resources available to the region. The system shall be capable of accounting for additions to infrastructure occurring over time and provide parameters that characterize the impact of various sequences and combinations of these infrastructure additions/extensions.

S4. The system shall provide capability to explicitly monitor impacts for alternate ITS services deployed over time. The system should be capable of producing a broad

range of quantitative impact measures and monitoring their evolution over time as changes are made to the infrastructure. The system should assess the stream of impacts that would accrue in the short-term, medium-term, and long-term planning horizons with requisite changes in demand (i.e., induced demand, regional land use, destination choice, mode choice, and route choice) and supply over time.

S5. The system shall assess the distribution of impacts of alternate ITS services deployment to different user groups. A useful feature of the system in support of decision making would be the ability to generate and compare impact estimates for different user groups (e.g., by demographics or regional grouping, socioeconomic groups, auto ownership, route, mode, access to advanced traveler information systems, etc.).

S6. The system shall be capable of providing operational measures of effectiveness (congestion, travel time, speed, delays, utilization, productivity, etc.) as well as transportation system characteristics to perform energy, environmental, and safety assessment for the various planning horizons, at different levels of aggregation and for various types of groups.

S7. To meet the Clean Air Act requirement, the system shall provide capability to directly assess, or produce the necessary information for evaluation of, long-term environmental impacts, specifically emissions and fuel consumption impacts of ITS deployments.

Some specific modeling or representation requirements (with prefix 'M' for modeling) are listed below. This is not a complete list of modeling/representation requirements. New requirements may be added based on the input from the intended users i.e., Metropolitan Planning Organizations (MPOs). On the other hand, some of these requirements may be relaxed if considered not so critical for the purposes of impact analysis and assessments.

M1. The system shall be designed so that it can be used to assess the impacts of different ITS deployment architectures such as distributed (e.g., in-vehicle information processing), decentralised (e.g., ITS services localized to different zones of a large network and based on the local traffic conditions and different levels of ITI deployment) and centralised control, guidance, and management systems.

M2. At a minimum, the system should consider the following elements in estimating the travel demand: socioeconomic factors (such as income, auto ownership, ability to purchase/subscribe to ITS services), induced including latent demand, and transportation-related factors (such as traffic conditions in a network). Transportation demand attributes that can be categorised by trip purposes and time periods—including trip making decision, mode choice, departure time, route choice, and destination choice—should also be accounted for by the system.

M3. The supply analysis of the system should consider the following elements of the transportation system: capacity, congestion, incidents, travel time, speed, flow smoothness, comfort, reliability, and level of service.

M4. The system shall explicitly account for time-varying demand and supply interactions [e.g., origin-destination (O-D) flows, departure time, route selection, and capacity changes due to signal timing].

M5. The system shall explicitly account for the inherently stochastic nature of the transportation system.

M6. The system shall provide capability to handle appropriate time intervals for assessment of impacts for varying planning horizons—short term (2 years), medium term (5 years), and long term (15 to 20 years).

The 15-to 20-year planning framework leads one to consider models as fundamentally planning models, i.e., they must be able to deal with forecasts of employment and residential location and generate required travel demands over time. At the same time, there is an obvious need to represent traffic flow processes in some detail, as the interactions of vehicles and the ITS are the primary mechanism of generating impacts.

M7. The system shall accurately provide capability to represent initially the intelligent transportation infrastructure including the communication infrastructure (information network) to capture the impact for the different information gathering, processing, and dissemination strategies used by these systems. The efficiency and usefulness of ITS services is dependent on the quality, accuracy, reliability, and accessibility of the information.

M8. The system shall accurately represent the interaction of the ITS services so that a clear understanding is provided to the user of the consequences of alternative ITS deployments over time. The system shall be capable of analyses at the regional, subregional, corridor, and facility levels.

M9. The system shall be capable of representing automobiles, transit vehicles, and commercial vehicles with or without the full range of ITS technologies likely to be available for the forecast period.

M10. The system shall represent ITS technologies at sufficient detail to allow trade-off analyses. The system shall faithfully represent the key infrastructure elements of ITS [i.e., communications, sensors/detectors, signal systems, variable message signs (VMS), controllers, computers, etc.].

At one extreme, this capability may lead to the need to code the explicit location of all communications infrastructure used in the region; at another extreme, this can be modeled off-line using analytic techniques. An example is the modeling VMS and their implications for network congestion. There may be a need to explicitly model

the location of VMS at particular points in the network, as opposed to simply specifying the presence of VMS on a facility or corridor.

M11. The system shall accurately represent a region's intermodal transportation network, including its highway network, major and minor arterials, and mass transit routes.

M12. The system shall adequately model (or represent) dynamic aspects of traffic flow, including spill-back, incidents, merging, and weaving, and their impact on overall transportation system.

These requirements try to establish an understanding of the capabilities needed in order to properly analyse the impacts of ITS. In a later section of this paper, some of these requirements have been translated into an initial analysis system (i.e., IDAS) concept. This initial system concept is the first step in a sequence of efforts that will contribute to ultimately producing a system that meets these and future requirements.

RELEVANT MODELING EFFORTS

In March 1995, the MITRE Corporation prepared a report for the ITS Joint Program Office (JPO) of USDOT entitled *A Survey of Federal Highway Administration Sponsored Traffic Modeling Projects* (Glassco 1995). In addition to documenting the modeling and simulation projects currently sponsored by the FHWA, the MITRE report identified the gaps or overlaps among the ongoing efforts. The analysis of gaps and overlaps is approached through a comparison of projects and models against each other and against identified modeling capabilities required by the sponsors or evolving transportation analysis paradigms. The effort also involved a survey of traffic planners and operations managers to learn of their modeling needs.

A report by Oak Ridge National Laboratory (ORNL) provides another and somewhat updated review of ongoing modeling efforts in the United States, with emphasis on modeling activities that may be useful in analysis and evaluation of ITS impacts (Rathi 1995). Using the MITRE report as the starting point, the ORNL report provides a comprehensive review of the modeling efforts vis-à-vis requirements of the ITS impact analysis and associated modeling capabilities. The requirements identified in the ORNL report formed the basis of much of the discussion by the FHWA Task Force and the requirements presented earlier in this paper. For the benefit of the reader who may not have access to the MITRE or ORNL reports, the major ongoing modeling efforts in the United States are summarized below.

TRANSIMS

The TRansportation ANalysis and SIMulation System (TRANSIMS) is being developed under the Travel Model Improvement Program (TMIP) sponsored by the USDOT, the Environmental Protection Agency (EPA), and the U. S. Department of Energy (USDOE). TRANSIMS is a set of integrated analytical and simulation models and supporting databases.

The TRANSIMS method deals with individual behavioral units and proceeds through several steps of detailed simulations of travel. The modeling system predicts trips for individual households, residents, and vehicles and then performs a very detailed simulation of execution of these trips on the transportation network (Smith et al. 1995). Characterised frequently as 'ambitious' and 'a fresh approach,' this long-term project effort (currently in its fourth year) is intended to provide an unparalleled analysis capability for transportation system design, evaluation, and planning. Los Alamos National laboratory (LANL) is leading this project effort, which hopes to satisfy the requirements of the Intermodal Surface Transportation Efficiency Act (ISTEA) and the Clean Air Act Amendments (CAAA).

VNTSC

This project, conducted by the Volpe National Transportation Systems Center (VNTSC), is to date perhaps the most relevant and direct attempt by the FHWA to address the issue of assessing the impacts and potential benefits of ITS technologies. The project's objective was to provide analytical tools necessary to assess the potential benefits of ITS strategy. The VNTSC effort has not met the objectives as originally envisioned. Nonetheless, the effort has produced some good reports covering areas such as definition of ITS strategies, identification of key traveler behavior variables that would be influenced by ITS technologies and strategies, and interrelationships between these variables. The VNTSC report also contains a table summarizing the deficiencies of existing models and an evaluation of several simulation models (Volpe 1995).

TRAF

The FHWA has developed a family of traffic simulation models collectively called the TRAF family. The current members are NETSIM, FRESIM, NETFLO, and FREFLO. In the early 1990s, the macroscopic models from the TRAF family (NETFLO and FREFLO) were integrated into a package called CORFLO (for CORridor traffic FLOw simulation). Recently, NETSIM and FRESIM models have been integrated in a model family called CORSIM. The FHWA has funded the development, testing, and enhancements of these modeling systems and associated utility programs for many years under several different contracts from its Research and Development Offices (Intelligent Systems and Technology Division) at the Turner-Fairbank Highway Research Center (TFHRC). CORSIM is still in the beta testing stages and is expected to be released in 1997. CORFLO has been in general distribution now for almost three years.

CORSIM allows the user to perform a microscopic simulation of the traffic operations in a urban corridor network comprised of freeways and surface street segments. Using time-based, stochastic simulation, CORSIM simulates virtually any configuration of traffic networks and interactions, including complex configurations such as lane additions/drops, lane blockages, HOV facilities, reversible lanes, parking lots, transit systems, incidents, ramp metering, diversion, and surveillance detectors. CORSIM models driver response to traffic control systems and other driver behavior such as gap acceptance and lane-changing

decisions. CORSIM simulates the movement of each vehicle in the system once every second (CORSIM 1995).

CORFLO provides functional capabilities similar to CORSIM for the most part, albeit using a flow-based simulation rather than very detailed simulation of individual vehicles and their performance. Unlike CORSIM, however, CORFLO includes a traffic assignment logic applicable to the entire network (CORFLO 1993).

NISS

The National Institute of Statistical Sciences (NISS) has started a new project entitled 'Measurement, Modeling, and Prediction of Infrastructural Systems' under the sponsorship of the National Science Foundation (NSF). Two research thrusts of the project with implications on FHWA modeling efforts are travel demand forecasting for urban transportation and network modeling for ITS, with emphasis on systems for real-time route guidance and planning (Rathi 1995).

DTA

ORNL has undertaken the technical management of a large FHWA research program aimed at developing algorithms for a deployable dynamic traffic assignment (DTA) system and synthetic O-D matrices. The Massachusetts Institute of Technology (MIT) and the University of Texas at Austin (UTA) were awarded contracts for the Phase I of this project in September 1995. The DTA system is being designed to serve as an integrator between the Advanced Traffic Management Systems (ATMS) and Advanced Traveler Information Systems (ATIS) and provide the following capabilities:

- estimation and prediction of traffic network states; and
- descriptive and prescriptive route guidance information for the traveler based on such estimates.

The estimation and prediction of traffic network states is a capability that is needed for both on-line applications (in traffic management centers) as well as off-line planning applications such as those required by the FHWA and the MPOs. These capabilities are not supported by the existing planning and simulation models, which do not take into account the dynamic nature of unique travel decisions. As such, the capabilities derived from the DTA system may be essential for the assessment of the impacts of ITS alternatives.

PURDUE

With funding from Indiana DOT and the FHWA, Prof. Kumares Sinha and his colleagues at Purdue University are also attempting to develop a framework for assessing ITS benefits. Basic components of the framework are based on extensive research done in recent years with funding from Transportation Research Board (TRB), FHWA, and Indiana Department of

Transportation (INDOT). These include O-D matrix estimation, behavioral models for route choice with ATIS, dynamic incident response decision making, real-time traffic assignment, incident prediction based dynamic traffic assignment, and regional air quality modeling.

The ITS technologies being deployed in the northern Indiana area (the Borman Project and the Indiana Toll Road) have generated the need for analytical tools to evaluate the impact of alternative ITS technologies. The Borman Expressway ATMS project is part of USDOT's Gary-Chicago-Milwaukee ITS Priority Corridor. Another focus area for the Purdue researchers is the calibration, validation, and verification of these models and an information management system for monitoring and tracking the transportation system's performance in future years to validate the modeling frameworks and assumptions (Rathi 1995).

DYMOD

Dr. Bruce Janson (University of Colorado at Denver) and his colleagues have continued their work on the DYMOD (Dynamic traffic MODel) model, which provides a means for predicting time-varying traffic conditions in fairly large yet quite detailed urban transportation networks. DYMOD is formulated as a mathematical programming problem, and as such it is an integrated model unlike the simulation-assignment based dynamic traffic flow models (Rathi 1995).

PROPOSED TWO-TRACK DEVELOPMENT APPROACH

The research strategy for planned efforts is based on the available tools as well as expected end-products from the several ongoing modeling efforts. After considerable debate and discussion, a two-track tool development effort has been suggested by the FHWA Task Force. The two-track effort is an attempt to serve the short- and longer-term evaluation needs of intelligent transportation infrastructure and then ITS deployment and to make best use of the ongoing efforts. Track 1 would concentrate on the development of a sketch planning tool envisioned to be available in 18 to 24 months. Track 2 of the development envisions the enhancements to the TRANSIMS model for supporting intelligent transportation infrastructure simulation and analysis.

The sketch-planning tool i.e., IDAS to be developed in Track 1 is envisioned to serve the immediate short-term analysis needs as well as to serve as a scoping tool when TRANSIMS is operational. The tool will enable the analysis of intelligent transportation infrastructure components in isolation or combination against traditional transportation solutions. The initial versions of the sketch-planning tool will have to be compatible with and complementary to the current state-of-the-practice analysis that is being conducted on traditional transportation solutions. It is anticipated that the tool will provide rough estimates of impacts related to capital and maintenance costs, travel time performance, and the estimation of emissions, fuel consumption, and safety impacts.

Track 2 will be an effort to augment the development of TRANSIMS to provide a mechanism by which ITS modeling and analysis capabilities can be implemented. During fiscal year 1997, the suggested research plans call for specifying ITS functions and TRANSIMS representation of these functions. TRANSIMS, for example, will represent system surveillance and detection capabilities, adaptive traffic signal control, and the system functions needed to enable the communications between them. Through this effort, an array of ITS functional representations will be incorporated into TRANSIMS that will enable the evaluation of the various ITS components, (e.g., ATMS and ATIS). The incorporation of ITS functions will be accomplished through a case study procedure that will culminate in testing these TRANSIMS capabilities in a field application.

It is also proposed that after the initial development, IDAS and TRANSIMS would still need to be maintained, upgraded, and technically supported. To facilitate the maintenance and use of each of these tools (and other FHWA-developed models) a service center concept is being discussed. The service center is envisioned as the first user of the tools. As the first user, the service center will be able to assist both government agencies and consultants in using the tools. The service center, while having no exclusive rights to the tools, will provide the administrative, technical maintenance, and user support functions required to enable use of the tool. The service center would become self-supporting after an initial establishment period made possible by federal funds. The service center concept is an effort to provide the necessary foundation that will expedite the deployment of the latest analytical capabilities (Federal Highway Administration 1996).

IDAS FRAMEWORK

As discussed earlier, IDAS is defined as a sketch-planning analysis capability to support near-term ITS deployment analysis and evaluation. IDAS builds from the basic four-step modeling process by providing capabilities to enhance networks to represent ITS, analyze the impacts of ITS, provide life-cycle cost estimates, and compare the results of alternative improvements. Figure 1 illustrates the conceptual framework of IDAS.

As shown in Figure 1, existing network data and the output of the traditional four-step transportation planning process will serve as the major input and starting point for IDAS. Network data includes any existing data that can be supplied to construct a network representation of a system over various stages of a 20-year planning horizon. The most prominent network data input will be the planning networks commonly constructed in conjunction with the four-step planning process. Other data, such as data from various geographic information systems (GIS) can also be used to construct or supplement the planning networks. The thicker-lined boxes in the figure designate the modules or the capabilities provided by the IDAS program. The following section describe the various IDAS components in detail.

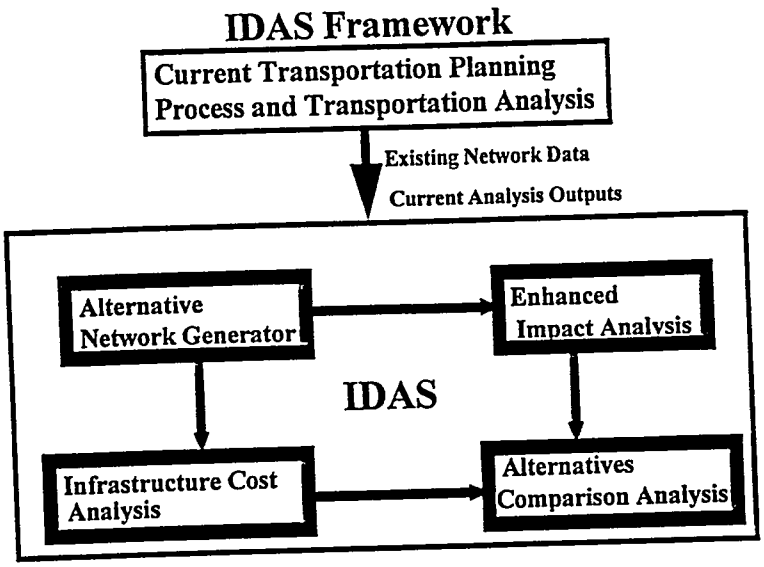

Figure 1—IDAS Framework

ALTERNATIVE NETWORK GENERATOR

Purpose: Supports disaggregation of data to a detailed micosimulation level and the representation of ITS supporting infrastructure. Provides functions that enable, though a network depiction of the transportation system, the indication of ITS and sequencing of improvements (conventional, ITS, and combinations) over a 20-year planning horizon.

Input Existing network data, e.g., planning networks GIS databases, information on network characteristics.

Output: Alternative networks that contain information on improvement attributes, including ITS infrastructure attributes. Provides the information necessary to conduct cost analyses and the structure and information needed for ITS impact analysis.

Description: The Alternative Network Generator function is a graphical interface that enables the sequencing of improvements over time to be compiled over a 20-year horizon, and the capability to include various ITS infrastructure improvements along with the conventional improvements. For example, this module would enable the creation of alternative 'ITS' to be created from alternative 'conventional'. Each alternative contains a group of improvements that are combined to form an alternative improvement plan. In this example, alternative 'conventional' may include a lane widening, a merge area improvement, and a new road. The 'ITS' may include the lane widening and the new road, but replaces the merge area improvement with a integrated ramp metering system. To construct the initial alternatives, the module can take as

input the various planning network data. This alternative can then be augmented with other data, such as GIS, to increase the plan's detail as warranted for analysis linking. Improvements can be broken down into incremental phases over a 20-year horizon. The module will be able to handle both conventional and intelligent transportation infrastructure deployment. The initial alternative can be edited to add or substitute in an ITS solution to create another alternative. The interface will also have the capability to identify the infrastructural improvements that will have to accompany any ITS solution. The end product of this module will be a set of alternatives that contain various improvements, conventional and ITS, that are planned to be phased in over a 20-year planning horizon.

ENHANCED IMPACT ANALYSIS

Purpose: To facilitate the analysis of ITS impacts using existing networks, performance, and the best knowledge concerning the nature of ITS impacts. This module calculates impacts due to intelligent transportation infrastructure investments on an individual and system wide basis over a 20-year planning horizon.

Input: Alternative network files from the Network Generator module and transportation analysis outputs from conventional four-step travel forecasting procedures.

Output: Amended parameters that indicate the impacts of incorporating or introducing ITS improvements. Various amended parameters may support other analyses such as air quality and fuel consumption. All parameters are used to generate files and measures of effectiveness that support presentation of impact results and alternative comparison analysis.

Description: The Enhanced Impact Analysis module is the 'brain' of IDAS. It is envisioned to be implemented as a customized spreadsheet with parameters representing the intelligent transportation infrastructure impacts for various possible deployment scenarios. This module's functions are to organize and tabulate network and system operational parameters that are obtained from existing analysis methods (i.e., four-step processes); calculate ITS impacts based on the synthesis of the results from operational tests and/or modeling exercises; calculate individual improvement and alternative system operational measures of effectiveness; and produce measures of effectiveness over a 20-year planning horizon for both individual improvements and the associated alternatives according to the specified improvement phasing. The measures of effectiveness produced by this module can then be used to compare individual improvements as well as alternatives in the Alternatives Comparison module. No new traffic or travel model development activity or interface is planned for this module at this point. However, the scope of the planned development

effort includes development of analytical techniques to estimate the impact of all intelligent transportation infrastructure components, estimation of impacts associated with integration of intelligent transportation infrastructure components, and development of parameters that identify impacts for the region, subregion, and specific improvements phased in over a 20-year horizon.

INFRASTRUCTURE COST ANALYSIS

Purpose: To calculate and distribute the life-cycle costs of the supporting infrastructure necessary to operate and integrate the various ITS improvements in each alternative. The cost calculations will account for all aspects of intelligent transportation infrastructure, broken down into project phases over a 20-year horizon in user defined time increments.

Input: Alternative network files from the Alternative Generator module cost figures, parameters for conventional and intelligent transportation infrastructure components, and cost factors for the 20-year horizon.

Output: Cost figures for each alternative and specific improvements. Output will consist of raw cost data for the development of various presentation graphics and a cost file formatted for use with the Alternative Comparison module.

Description: The Infrastructure Cost Analysis Module will calculate the life-cycle costs of the alternatives and each alternative's individual improvements. If the alternative is broken down into phases, the cost analysis module will be able to track capital as well as operation and maintenance cost per phasing period over the 20-year horizon. The cost analysis will provide insight into the cost differentials between conventional improvements and intelligent transportation infrastructure related improvements that require a new type of technological systems infrastructure investment. For example, to implement a freeway management system over time that includes variable message signs (VMS), ramp metering, and incident detection may necessitate installation of a communications medium such as fiber optic cable along the freeway corridor. The cost of the fiber optic cable must be included into the cost analysis of each component, and each component must account for a logical share of the cost of the supporting infrastructure.

ALTERNATIVE COMPARISON ANALYSIS

Purpose: Supports comparison of alternative improvements through a generalized multilevel criteria structure. The module will provide information concerning the merits of various alternatives and improvements.

Input: Alternative network files, impact analysis parameters and MOEs, criteria weighting.

Output: Alternative and individual improvement ranking indicators and criteria sensitivities.

Description: The Alternative Comparison module is envisioned as a decision support system. This module interfaces with the Cost Analysis and Enhanced Analysis modules. This module will support alternative and improvement comparisons and comparison sensitivity analysis. Outputs from this module will be a ranking of alternatives, and improvements. The comparison will be conducted based on a multilevel criteria structure. This structure will be based on ISTEA requirements and goals for transportation system improvement performance. For specific regional analysis, the module will support customization of the criteria structure. This customization will include the addition or deletion of criteria, the modification of criteria ranking or relationships, and the modification of overall goals. However, care needs to be taken when modifying the structure or the addition of criteria that it remains supported by the Cost or Supplemental Analysis modules. If unsupported criteria are added, other means must be derived to provide the input to these additions. The culmination is an Alternative Comparison module that will provide a structured process by which all alternatives can be fairly evaluated.

CONCLUSIONS

ITS technologies can help improve safety and mobility, air quality and energy efficiency, and the overall efficiency of the existing transportation infrastructure. This, in turn, will enhance economic productivity and help sustain the economic growth in a region. Cities, counties, states, and metropolitan areas throughout the world are spending or planning to spend considerable sums of infrastructure improvement funds on deploying ITS in their regions. Yet, quantitative benefits and satisfactory cost estimates are not available or cannot be derived for many components of the ITS, whether deployed individually or in some integrated fashion. The deficiencies in existing analysis and evaluation capabilities coupled with the lack of strong empirical evidence in many possible scenarios of deployment presents a major knowledge and data gap for infrastructure investment decisions involving ITS alternatives.

This paper has described the overarching issues and requirements associated with the analysis capabilities required for a systematic, faithful, and rigorous evaluation of the impacts of deploying ITS in a metropolitan area. It then described the conceptual framework of a modeling system IDAS that will provide a preliminary analysis capability to support ITS deployment analysis and evaluation.

IDAS is envisioned as a modeling system that will provide quick-response and sketch-planning capabilities for systematic and quantitative evaluation of the relative costs and benefits of ITS deployment options—as alternatives to and/or enhancements of traditional highway and transit infrastructure investment options. At present, the IDAS framework is a conceptual-level explanation of what are perceived to be the essential capabilities needed to meet the objective of the FHWA's research initiative. However, this discussion and presentation is only at a concept level. Additional investigation will be required to determine the exact nature of each module and the interfaces needed between modules.

A contract award for IDAS development is expected to be made in the spring of 1997, with a completion target of 18–24 months after the award.

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