THE FUTURE OF TRANSPORTATION MODELING
FINAL REPORT
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Submitted by

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16. Abstract

The scope of this study is to determine the new trends and approaches in transportation modeling and assist transportation professionals in reviewing features of alternative software packages, evaluating them, and comparing their capabilities. Information for selected packages has been collected through publicly available software information, scientific and industry publications and through direct communication with the developers and/or vendors. A survey has been conducted, to obtain the perspective of software package users and determine the strengths and limitations of various widely used packages. A VB-based application which facilitates the comparative evaluation of selected packages has been developed. The application may be used to review the features of any package considered in the analysis, compare several features of any two packages and determine interconnectivity between alternative packages. The outcome of this work may assist transportation experts in determining which software tools are the most appropriate ones for their particular applications and in selecting the tools that are needed to cover their modeling needs.

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SUMMARY

The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, the Clean Air Act Amendments (CAAA) of 1990, the Transportation Equity Act of the 21st Century (TEA-21) and other transportation initiatives have brought new challenges to the transportation professionals and have increased the pressure on state and local planning agencies to improve their modeling abilities.

Computerized tools are used to address these challenges and have evolved throughout the years to substantially increase the size of the problem and the number of alternative problem solutions an engineer, planner, or analyst may consider, thus increasing productivity and reducing the costs associated with these analyses. Computerized tools have thus become a necessity for any transportation professional. The abundance of software packages available in the market creates many practical questions for users and managers, such as: "What program should I buy?" "Would this particular program cover my specific needs?" "Is there a program that can do it all?"

The scope of this study is to determine the new trends and approaches in transportation modeling and assist transportation professionals in reviewing features of alternative packages, evaluating them, and comparing their capabilities. A list of features to be reviewed for each software package has been developed. Related information has been collected through publicly available software information, scientific and industry publications and through direct communication with the developers and/or vendors. A survey has been conducted to obtain the perspective of software package users and determine the strengths and limitations of various widely used software packages. A database containing information for each software package, uniformly organized based on the selected features has been developed along with a VB-based application which facilitates the comparative evaluation of selected software packages. The application may be used to review the features of any software package considered in the analysis, compare several features of any two

software packages and determine interconnectivity between alternative software packages.

The outcome of this work may assist transportation experts in determining which tools are the most appropriate ones for their particular applications and in selecting the tools that are needed to cover their modeling needs.

INTRODUCTION

Transportation plays a key role in the economy of industrialized nations. In the United States, about 15 percent of the Gross Domestic Product is accounted for by the transportation sector. To find solutions for complex problems, transportation experts have traditionally used models for transportation planning, engineering, and management.

Transportation planners use the term 'models' extensively. This term is used to refer to a series of mathematical equations that are used to represent how choices are made when people travel. Travel demand modeling was first developed in the late 1950's as a means to do highway planning. The increasing need to look at problems such as transit, land use issues, and air quality analysis resulted in adding various techniques to deal with these problems, thus modifying the modeling process. Furthermore, models are used to evaluate the impacts of proposed alternative solutions, including infrastructure improvements and environmentally friendly options.

With the advancement of computers and to address the changing needs for transportation, transportation models have evolved throughout the years and software packages have been developed to implement these models and address the needs of the transportation professionals. Several new tools are currently available and many more are being developed, each with their different capabilities and application areas. There is a pool of software packages available for transportation professionals to choose from and users have to carefully consider their needs so as to select the best tools to satisfy their modeling requirements without spending money unnecessarily.

Need for this Study

Computerized tools are used to substantially increase the size of the problem and the number of alternative problem solutions an engineer, planner, or analyst may consider, thus increasing productivity and reducing the costs associated

with these analyses. Computerized tools have thus become a necessity for any transportation professional. The abundance of software packages available in the market, however, creates many practical questions for users and managers, such as: "What program should I buy?" "Would this particular program cover my specific needs?" "Is there a program that can do it all?"

This research intends to give an overview of selected software packages, so that their potential applications can be evaluated. It aims to assist transportation professionals in reviewing features of alternative packages, evaluating them, and comparing their capabilities. More specifically, this research intends to assist the NJDOT Bureau of Systems Development and Analysis in selecting the appropriate tools to cover their modeling needs.

Scope

Many important changes have occurred during the past few years in the use of transportation planning methods. The latest software packages offer increased flexibility with a greater ability to respond to the requirements of the users. The primary purpose of this research is to present a comprehensive introduction to new trends and approaches of transportation modeling methods. The scope of the research includes:

- Identification of the most widely used, publicly as well as privately developed computerized software packages.
- Review of the basic functions and capabilities of the software products.
- Evaluation of widely available and prevalent software products by obtaining both the developer and the user perspective.
- Development of an interactive tool to assist in the comparative evaluation of alternative software packages.
- Identification of current and future trends in transportation modeling.

- Identification of new challenges posed by the current issues in transportation, which may be met by adopting a flexible modeling approach for particular or varied needs.

Methodology

Figure 1 shows a graphical representation of the methodology that was developed and used for the purpose of this study.

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                    │    LITERATURE REVIEW     │
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          │   NJDOT TECHNICAL ANALYSIS -         │
          │   FUTURE MODELING NEEDS              │
          │   ASSESSMENT TOOL                    │
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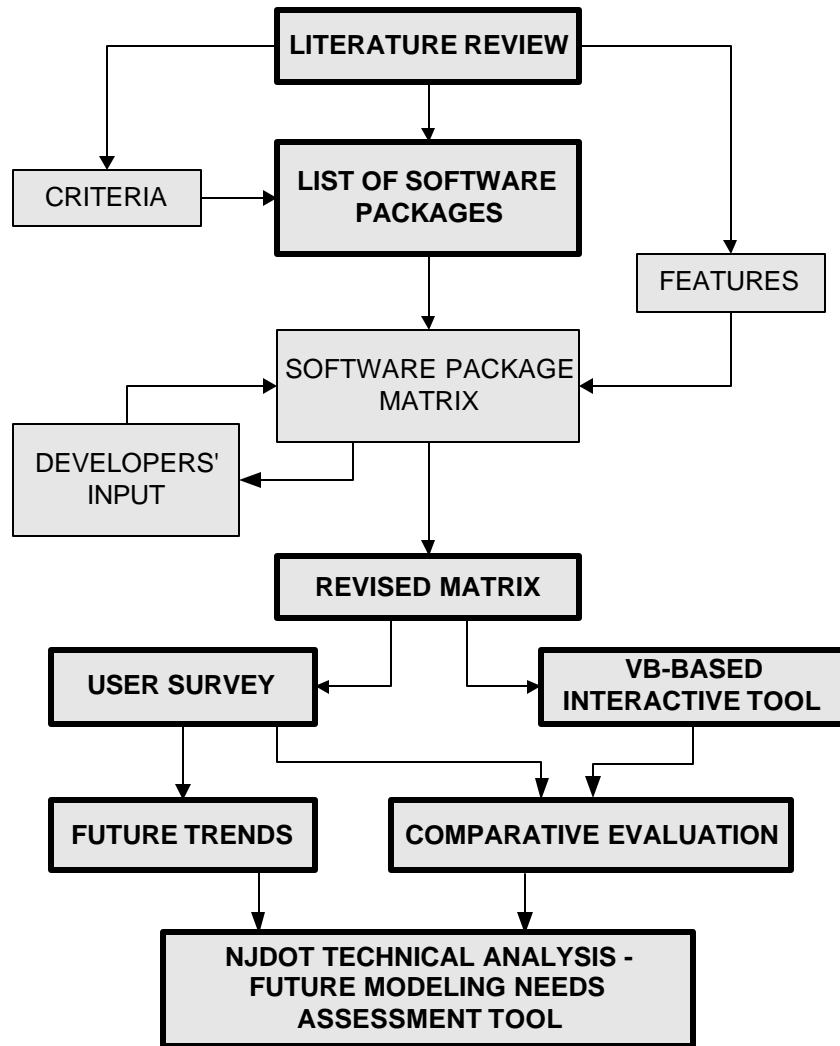
Figure 1: Graphical Representation of Methodology of Work

A thorough literature review, including software package availability, development stages, applications, and their use in the modeling process was

conducted. Transportation journals, textbooks, ITE and DOT standards manuals, and the Internet were used as sources for this information. Next, based on a set of criteria regarding their type and application areas, a list of software packages to be considered in this study was developed. To better organize the information and to facilitate comparative evaluation, a set of features of the software packages was selected. Using these features, the information collected on each software package was organized in a matrix format. This analysis is similar to the one presented in *The Urban Transport Monitor* (April 5, and April 17, 2002). The Urban Transport Monitor study presents the results of a survey, the scope of which is to gather information on six widely used transportation planning software packages and present this information on an easy to read tabular form. A similar survey was performed on traffic impact software packages and the results were presented in the March 21, 2003 issue of The Urban Transport Monitor. In the study presented in this report several additional software packages have been reviewed based primarily on the features used in The Urban Transport Monitor study and on some additional features that were considered to provide useful information about the software packages.

The rows of the matrix are the software packages and the columns are the features. A typical element of the matrix is the description of a particular feature for a particular software package. The matrix was sent out to software developers for review and comments. Each developer received the part of the matrix that was related to his/her specific product and was asked to comment on the content of the matrix and provide any additional information that was deemed necessary. Based on the findings of this survey the matrix was updated. The revised matrix was also sent out, for review and comments, to a group of transportation experts, who comprised the advisory board for this project. Although the content of the matrix was considered by the advisory board members to be appropriate, the matrix seemed to be difficult to read and to be used for comparative evaluation of selected software packages. For this reason an interactive tool was developed using Visual Basic. Users of this tool may

select the software packages and the features they wish to compare or obtain information for. A table is thus created, which provides a summary of the selected features for the selected software packages.

A software package user survey was conducted next, to determine the users' perspective. As part of this survey a contact list was developed, containing primarily consulting firms in New Jersey. Some additional contacts were provided by the NJDOT. Results from this survey regarding the extent and purpose of usage as well as user satisfaction with specific software packages were summarized and conclusions on future trends in transportation modeling were drawn. The last part of this work comprises the development of a tool to be used by the NJDOT Bureau of System Development and Analysis in assessing their future modeling needs. This tool summarizes information on the software packages, facilitates the comparative evaluation of various packages and determines the set of tools that would cover a wide spectrum of applications typical to a state DOT based on interconnectivity among various tools, costs, and the level of usage of the software packages in the NJ transportation industry.

The following sections present the various steps of this methodology along with findings and concluding remarks. These sections include: literature review; set of criteria that were used to determine the list of software packages to be considered in this study and the features that are highlighted; a summary list of the software packages, the software matrix; the interactive tool for comparison of the software packages; the users' survey, summary of its findings and future trends; the needs assessment tool; and finally a summary of the research findings.

LITERATURE REVIEW

Transportation modeling deals with the relationship of land use to travel patterns and travel demand, planning, design, evaluation, and programming of transportation systems, including facilities and services for roadways, transit, terminals, parking, pedestrian facilities, bikeways, and goods movement.

Transportation planners are increasingly concerned with issues such as economic effects and environmental concerns; improving co-ordination between land use and transportation system planning; examining interactions between planning, design and operation of transportation services; maintaining a perfect balance between transportation related energy use, clean air and water.

To perform these types of analyses, transportation professionals use various models. These models may be broadly classified as conceptual, mathematical or physical. Conceptual models are used for structuring problems; mathematical models provide a convenient mechanism for simulating the operation of a system and evaluating its performance under a variety of input conditions or model constraints; physical models are a small version of a real system.

A model allows manipulation of a number of alternatives without expensive experimentation on the real world system. Along with manipulation of various alternatives, models assess the effects of generated alternatives on the system. The basic uses of models include the following:

- Enable forecasts to be made.
- Evaluate alternative plans.
- Investigate the makeup of the system and the structure of interactions within it.
- Explain the principles of operation of the system.
- Improve decision-making, which should not be based exclusively on intuitive judgment.

Transportation systems are very complex and, typically, large scale, so use of models is necessary in their study, design, analysis and evaluation. Transportation modeling was first developed in the 1950's. Since then several models have been developed and many software packages have been produced, to implement these models. The following sections provide an overview of both modeling efforts and software package development and

availability in the US and Europe; present an overview of the transportation planning process; discuss the interconnectivity of various subsystems in an urban or regional environment and their relation to transportation analysis; and the review of a study performed for the Florida DOT with a scope similar to the work presented herein.

Overview of Transportation Modeling in the US and Europe

The US Experience

An historical overview of transportation planning in the US is presented in Reed and Weiner[1] and is summarized here. The early emerging settlements in the Atlantic coast of North America required a transportation infrastructure. After the American Revolution both the state and federal government were too burned by war debt to be able to afford a significant infrastructure program. Colonial law largely followed the European tradition of having local governments be responsible for road construction and maintenance. In 1971, the Society for Promoting the Improvement of Roads and Inland Navigation submitted the first nationwide transportation plan to the Pennsylvania legislature.

The efforts of transportation planning evolved in 1930's and 1940's with the beginning of highway and transit planning activities. These activities intended to improve the design and operation of transportation facilities and focused mainly on upgrading and expansion. Early urban transportation planning studies were primarily systems-oriented with a twenty-year time horizon and region-wide in scope largely as a result of legislation for the National System of Interstate and Defense Highways. Legislation required that major highways be designed for traffic projected twenty years into the future. This approach continued through the 1960's. In the early 1970's planning processes turned attention to shorter-term time horizons and the corridor-level scale. This was a result of a realization that long-range planning had been dominated by concern for major regional highway and transit facilities with only minor attention being paid to lesser facilities and the opportunity to improve the efficiency of the existing system. By the 1980's urban

transportation planning had become primarily short-term oriented. It shifted from facility expansion to provision of transportation services. By early 1990's the era of major new highway construction was over in most urban areas but the growth in urban travel was continuing unabated.

New approaches needed to be found to serve this travel demand since there was only limited highway expansion possible. Traffic congestion was leading to degradation of the urban environment. Selected application measures of transportation system management (TSM) proved to have limited impacts on reducing congestion. This provided the need for more comprehensive and integrated strategies. Many transportation agencies entered into strategic management and planning process to identify the scope and nature of changes, develop strategies to address the new issues and to better orient their organization to function in this new environment. Focus was shifted towards longer-term time horizons, integrated transportation management strategies, wider geographic applications of these strategies and renewed interest in technological alternatives. The major issues that concerned transportation planning during the latter half of 1960's and 1970's included safety, citizen involvement, preservation of park land and natural areas, equal opportunity for disadvantaged persons, environmental concerns like air quality, transportation for the elderly and handicapped, energy conservation and revitalization of urban centers, concerns for deterioration of the highway and transit infrastructure and its effect on economic growth.

Theoretical Developments

The theoretical foundation of the modern planning models has its origin in the 1950s. Beckmann, McGuire, and Winsten[2] formulated the user equilibrium principle as a mathematical programming problem. They used the Kuhn-Tucker conditions to show that the solution to this problem is equivalent to the user equilibrium conditions. A computational algorithm that may be used to solve this problem was developed the same year by Frank and Wolfe[3]. Procedures for

specific purposes were integrated into an urban travel forecasting process in the early urban transportation studies in the 1950's. Through the 1960's improvements in planning techniques were made primarily by practitioners, and these new approaches were integrated into practice fairly easily. The FHWA and UMTA carried out extensive activities to develop and disseminate analytical techniques and computer programs for use by state and local governments. The Urban Transportation Planning System (UTPS) became the standard computer battery for urban transportation analysis by the mid 1970's, and is still used in transportation planning practice today.

To simplify the complex planning process, the Urban Transportation Modeling System (UTMS) is divided into four stages - trip generation, trip distribution, modal split and traffic assignment - executed in sequence. The main shortcoming of the four-step process is that it lacks a theoretical footing in behavioral, economic, and systems engineering theory. The process, as developed and used, neither recognizes nor seeks an equilibrium solution, a solution that will satisfy both demand and supply relationships. Experienced planners try to deal with these problems by introducing feedback loops in order to model the interactions between network (supply) and travel volume (demand). However, as is shown in Boyce et al.[4], using an iterative four-step procedure with feedback does not produce the desired result. Professional practitioners need to understand the requirements of the desired equilibrium solutions and insist that their software developers correctly implement the algorithms required to compute these solutions.

During the 1970's new travel forecasting techniques were developed for the most part by the research community, largely in universities. These disaggregate travel forecasting approaches differed from the aggregate approaches being used in practice at the time. They used new mathematical techniques and theoretical bases from econometrics that were difficult for practitioners to learn. Moreover, the new techniques were not easily integrated into conventional planning practices. Numerous mathematical formulations and efficient algorithms were

developed during the 1970s to model network equilibria. [See references 5,6,7,8,9 and 10] This effort continued during the 1980s with several major contributions during this period. [See references 11,12,13,14,15,16,17,18,19 and 20] Boyce et al.[22] presents applications of existing theoretical models that combine O-D, mode and route choice in the analysis of a large-scale network in the Chicago region. Boyce and Zhang[23] use multi-level programming to derive combined models. The papers mentioned above present models of traffic assignment, combined mode choice and traffic assignment, or combined O-D, mode choice and traffic assignment.

The requirements of the Clean Air Act (CAA) Amendments of 1990 forced a reevaluation of travel forecasting procedures. New approaches have been developed and used to satisfy CAA requirements and take advantage of the increasing computing power. These approaches, including Dynamic Traffic Assignment and microsimulation capabilities are discussed in more detail in the following sections.

Several transportation planning software packages have been developed and are currently used to automate the four-step process. Examples include QRS II, EMME/2, TRANPLAN, MINUTP, and TP+, to mention a few.

The advent of geographic information system (GIS) technology has greatly enhanced the efficiency and accuracy of network specification and coding. Most of the transportation planning packages has the capability to integrate with GIS and GIS-based applications have been developed. VIPER for example, TP+'s graphical user interface, can also read and write Environmental Systems Research Institute (ESRI) Shape files, which have emerged as a standard cross-platform format for GIS systems, and convert between formats. GIS based transportation planning packages include TransCAD and UFOSNET.

To estimate the environmental impacts of traffic and meet the requirements of CAAA, results of the above models may be used within emissions estimation models such as MOBILE [24]. This approach to estimating emissions lacks

precision, since the above transportation planning models use average speed estimates and is insensitive to traffic conditions. For a more accurate estimate of vehicle emissions, dynamic assignment models may be used.

In most of the procedures used within the above software packages, flows of vehicles and people through the network are not explicitly represented within the time dimension, meaning that there is no attempt to estimate when a given vehicle will actually travel over a given link. These procedures actually assume that each vehicle is simultaneously located on every link on its chosen routes, and they assign all flow "simultaneously" to all links on the chosen route. This is obviously an unrealistic assumption because each vehicle can be on only one link at a time and each vehicle must travel through time as well as space as it moves from its origin to its destination. [25] For many regional transportation planning applications, the static assignment might be acceptable and, with a properly validated network, can yield useful results. For certain applications, however, such as detailed emissions modeling and traffic operations modeling, the static representation of network performance is not sufficiently accurate. Many dynamic assignment software packages are emerging at varying levels of commercial availability. Examples include DYNASMART[26], VISTA[27], INTEGRATION[28], PARAMICS[29], and TRANSIMS[30]. As one of the requirements of this study was to take a closer look into the relatively newly developed program TRANSIMS, a report including a comprehensive review and experiences from its applications is included in Appendix A. The modeling philosophy of TRANSIMS is unique as compared to the other software packages that are being reviewed herein. For this purpose, TRANSIMS has not been included in the software review and summary matrix sections that follow.

Advancement in the area of freight transportation modeling is very limited compared to passenger models. There are many similarities between passenger and freight modeling processes, however, there are also distinct differences, which need to be addressed in the freight planning process. Models that have been developed for strategic planning of freight transportation are presented in

Guélat et al.[31] and Crainic et al.[32]. The focus of the first paper is on the representation of a multimode multiproduct network. The second paper presents a strategic rail-modeling framework. Models presented in both papers were implemented in an interactive-graphic system for the strategic analysis and planning of national freight transportation systems called STAN.

There were several early developments in modeling freight network. [See references 33,34, 35, 36 and 37.] Friesz et al. presents an excellent overview of these developments and provides the most analytically sophisticated model for predicting freight flows. [See references 38, 39, and 40] The model called the "freight network equilibrium model" (FNEM) explicitly treats the decisions of both shippers and carriers for an intermodal freight network with nonlinear cost and delay functions that vary with commodity volumes to model congestion externalities. Harker and Friesz[41, 42] tied together the concepts of spatial price equilibrium and shipper-carrier equilibrium in a model called the "Generalized Spatial Price Equilibrium Model" (GSPEM). GSPEM is probably the most complete predictive model of freight transportation.

Currently, there are no transportation modeling approaches which account for both passenger and freight considerations. Some of the transportation planning packages that were reviewed in this section has the flexibility to account for freight flows. Typically, however, for these types of applications, major modifications of the existing models are required and caution should be exercised to develop meaningful models. Planning agencies are now required to include freight considerations in their planning process. As the increasing population keeps spreading out and the Gross National Product keeps growing, there is an expected increase in commercial vehicle activity interacting with passenger activity and this needs to be considered in transportation models.

The European Experience

The most well known early European examples of equilibrium models were the ones developed by the UK's TRL (Transport and Road Laboratory) starting in the

early 1970s with the RRLTAP suite and, for strategic studies, the CRISTAL set of equilibrium models.

Later, efforts were directed towards two (seemingly opposing) directions:

Application in the "European conditions" of the more sophisticated disaggregate demand models that were first developed in the US, and

"Simplifications" of the conventional models, to achieve economies in the data required and the computer power, or simply the expertise required

In the first category, the work of the Hague Consulting Group and the Free University of Amsterdam, as well as of the University of Karslrue's group in Germany, are prominent among European researchers, but a number of other "European applications" of disaggregate demand models is also very prominent and merit specific study.

On the other hand, the drive to produce simplified models was directed by the Organization for Economic Co-Operation and Development (OECD) in Paris. The national reports (Urban Traffic Models, 1974) by seven of its member countries (Belgium, Ireland, United Kingdom, Finland, Denmark, Canada, Spain) revealed a concentrated effort at model simplification, directed towards five types of simplification:

- Restriction to two trip purposes (home/work, and home/other).
- Adopting a less detailed level of traffic zoning (e.g. regional rather than more detailed).
- Adopting "once- through" tree building and loading algorithms.
- Simplifications to the model formulas in order to incorporate all the three first steps of the four-step process into one, and
- Simplifications related to the data collection methods and the use of models developed in other urban areas.

At the same time and in parallel to the above two distinct trends, national governments encouraged researchers towards the development of special types of models to meet national or local needs. The most prominent examples are the German and Scandinavian efforts to produce "National" models[1]. The principal characteristics of these models were that they were built around conventional model techniques and incorporated many "simplification" features especially in the data collection stage as well as in the "aggregation" levels used in the modeling.

At the European Union's (EU) level, the Directorate General for Transport and Energy (DG TREN, former DG VII) has funded some very interesting work too, on modeling in the field of Transport. In the 1980s most of this (EU funded) work focused on developing models of transport demand (passenger and freight) on all member countries. The models used were of the "conventional" four-step type, but were based on a concentrated effort by all 12-member states (at that time) with data collection, modeling and evaluation. A European passenger and freight demand forecasting model framework was set up in DG VII. This framework formed the basis for all planning and forecasting work within the Commission through the 1980s.

In the 1990s the modeling work within the EU, has been combined with a parallel effort to produce benchmarking indices and quality indicators in the field of transport, especially Urban Transport. The European Commission has thus funded a number of projects starting with its "4th Framework Program of Research and Development" (4th FP, 1994-98) centered on modeling and benchmarking, and focusing on both scientific and technical aspects of modeling and benchmarking techniques. Examples include project Improved Structure and Organization for urban Transport Operations of Passengers in Europe

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[1] Examples are to be found in the work promoted by the Technical University of Aachen (published in the Proceedings of the Scientific Workshops organised regularly in the 70s and 80s by the Traffic Engineering section of this University, also in the work funded by the Federal Ministry of Transport of Germany – see for example the various Schriftenreiche "Forrschung Stadtverkehr" of the BundesMinisterium fur Verkehr)

(ISOTOPE), comprised of the description and comparison of existing urban transport models as well as of the organizational structures for public transport operations in urban areas in the European countries. Another example is the project Quality Approach in Tendering/Contracting Urban Public Transport Operations (QUATTRO), designed to make recommendations to authorities, operators and manufacturers in order to improve quality in public transport, including the use of forecasting models and benchmarking.

On another level the European Committee for Standardization (Committee Europeene de Normalization - CEN) set up its Transport Working Groups under the general title Transport Committee 278 (TC278) which included a sub group on modeling. Further work was funded under the 5th Framework Program (1999-2001), which is due to finish at the end of 2001. Examples are the project State-of-the-Art in Benchmarking of Quality in Public Transport (EQUIP), which performed among other activities reviews of the methodologies and indicators used for forecasting passenger transport demand and categorized the methodologies and indicators.

A parallel effort from private enterprises has produced transportation modeling products that are well known and used in the US transportation industry. Examples include PARAMICS and OMNITRANS. OMNITRANS is compatible with INTEGRATION, which is a microsimulation software package. Compatibility between OMNITRANS and INTEGRATION makes switching back and forth between static and dynamic models an easy operation. This capability is also available through the integration between VISSIM and VISUM.

Similar to experiences in the U.S., freight transport has not received an equal level of attention by European researchers as the modeling of passenger transport demand. Examples of freight transport modeling remain scarce. A most notable effort is the work carried out at the University of Trieste in Italy, and the Italian Center for Research in Transport (CSST) based in Turin. A set of freight

transport demand models was developed and tested in Italy in the mid 90's with data from the Italian traffic census.

The Transportation Planning Process

Initial transportation planning studies focused on the development of a comprehensive highway plan. Over the years the above perspective has been changed to develop a comprehensive plan for the transportation system as a whole. In addition to this change, which puts emphasis on the various modes of transportation, greater emphasis has been attempted on the integration of land use and transportation plans, and the comprehensive evaluation of policy alternatives. Some of the major objectives of these studies include provision of comprehensive and continuing guidance for the development, evaluation, and implementation of future transportation in urban-rural activities; the comprehensive evaluation of alternative planning policies, and the allocation of priorities for future investment and development.

There is abundance of transportation planning models in existence, ranging from regional travel demand models that are mainly concerned with the movement of a large number of individuals in a regional system, to discrete traffic models that are concerned with the movements of individuals in a smaller subsystem. For a thorough review of the transportation planning process, the reader may see Stopher and Meyburg [43], 1975 and Chang and Meyers, 1999. [44]

<u>Regional Travel Demand Models</u>

Regional travel demand models examine the mass movement of persons within a study area and are an integral part of, and input to transportation investment decisions. Regional travel demand modeling along with travel forecasting analysis is used in:

- Conceptual engineering and planning to size facilities and estimate capital costs.

- Transit operations planning to determine operating policies and estimate operating costs.
- Financial analysis to forecast fares and toll revenues.
- Environmental analysis to examine the impacts from region wide air quality to congestion on individual highway links.

The regional travel demand models are based on observed data, which is used to develop, calibrate and validate the evolved models. The following section briefly covers the data elements required for the development of any regional travel demand model.

Inventory and Data Requirements

Inventory comprises the development of databases for evaluating existing travel demand and existing transportation performance, and a basis for predicting demand and future system requirements. This is crucial in establishing the base conditions for the models that are to be developed.

Data collection includes information on zoning of the local area, land use data, demographic and economic data, inventory of supply of transportation facilities and travel desires and demands within the study area.

Land Use Models

Land use and transportation are closely inter-related. Transportation has a major impact on land use and hence should be considered when a land use plan is developed. A modeling approach to land use allocation can be used to determine the impact of transportation facilities on growth patterns. Allocations are usually determined based on availability of open land use and accessibility that is provided from a proposed transportation plan. The modeling process finds a balance between supply and demand for both land use and transportation. It indicates how land use change is driven by changes in the transportation system.

Four Step Planning Process

Models are continually adapting, changing and improving with new research advances, as well as demands placed upon them. The traditional and sequential "four-step process" is still used in the majority of planning purposes. The steps that are generally considered part of the four-step sequential process include: trip generation, trip distribution, mode choice and traffic assignment. [See references 45, 46 and 47]

Discrete Models

Discrete modeling allows the analysis of individual movements of traffic at the microscopic level, while the regional travel demand model allows analysis at a macroscopic level. There are numerous factors that often play a significant role in determining whether a regional transportation model should be developed or if another analysis tool should be used, including cost and time resources and level of detail required. A discrete model may analyze corridors in a region and provide information down to the individual intersection level, while most regional travel demand models use a metropolitan region as the study area. The two main types of discrete modeling include traffic simulation and site traffic analysis. [46]

GIS and Transportation Planning Models

In recent years, efforts have been made to integrate geographic information system (GIS) technology with transportation modeling. GIS may assist in building transportation networks and traffic analysis zones (TAZs). GIS technology has made it easier to perform sub-area analysis and to modify the TAZ structure. Transportation agencies use GIS for network coding and socioeconomic data manipulation, and to display data from travel forecasting models. GIS applications in transportation planning are primarily in the following three areas: preparation of input data for traffic demand modeling, establishment of an integrated database, and displaying of modeling output. [48]

Emissions Models

The 1990 Clean Air Act Amendments (CAA) require analysis of transportation programs for conformity with air quality implementation plans in regions that are in non-compliance with clean air standards. To examine conformity of transportation plans, Metropolitan Planning Organizations (MPOs) and other agencies rely on computer models simulating the interaction between transportation and land use.

EPA's mobile source emission estimation tools and underlying emission factors focus on the estimation of mobile source emissions based on average operating characteristics over broad geographical areas. Other notable efforts are the Comprehensive Modal Emissions Model (CMEM) developed by UC Riverside under NCHRP Project 25-11; TRANSIMS, under development by Los Alamos National Laboratory through the U.S. Department of Transportation; and MEASURE, developed by Georgia Tech under cooperative agreement with EPA's Office of Research and Development. The MOBILE6 vehicle emission factor model is a software tool for predicting gram per mile emissions of HC, CO, NOx, PM, and toxics from cars, trucks, and motorcycles under various conditions.

Limitations of Transportation Planning Models

Currently there are no uniform standards laid for determining model accuracy. A thorough review of all input data is necessary before using it within a model. Likewise, all output from any model should be reviewed for reasonableness before officially declaring the results of the model. Furthermore, since all planning software packages and models have their own modeling approaches and assumptions, the user must be aware of all these assumptions and limitations of the model.

Models versus Software Packages

There exists an important distinction between transportation planning models and transportation planning software packages. [46] Models serve as analysis tools for transportation planners and they aid decision-makers in evaluating alternative proposals for a transportation issue. Models are basically mathematical equations that are established by research and practical efforts. They represent some aspects of traveler behavior or transportation system and are important because transportation plans and investments are based on what the models say about future travel. Model estimates are the basis for transportation plans and are used in major investment analysis, environmental impact statements and in setting priorities for investments. [49]

A transportation software package is a tool to implement transportation models already developed. Usually, a transportation-planning model is made up of several sub models (e.g., trip generation, trip distribution, mode choice, trip assignment). [46] Mathematical models can be used to represent each of these sub-models. These mathematical models are then implemented in various transportation planning software packages.

Interconnectivity of Subsystems and their relation to Transportation Analysis

The transportation infrastructure of a region is part of a complex system. Transportation, land use patterns, the environment, the economy, and society are all interconnected subsystems that depend on and interact with each other. To model these interconnected subsystems independently from each other fails to acknowledge the significant dependence of one subsystem on another.

This section identifies five different models or subsystems that are to combine together to describe the interconnectedness of each subsystem into one model. These subsystems are the transportation network, land use patterns, population, the environment, and the economy. The transportation network includes the

transportation supply provided by the multimodal network. The land use patterns contribute to the demand placed on the land use patterns. The population subsystem describes the social patterns of the society and also affects the demand placed on the network. The quality of the environment is affected by emissions and water quality. Finally, the economy is dependent on how efficient the transportation network is in meeting the needs of the land use patterns and population of the study area.

Due to legislation such as ISTEA and the Clean Air Act Amendments, there is increasing pressure on state and local planning agencies to improve their modeling abilities to include these important relationships. However, many of the current tools available excel in modeling only one or two of the subsystems described above. Other software programs require output from other models to model a particular subsystem. The interconnectivity of software packages used to model each subsystem is based on the easiness with which the output from one model may provide input to the following one. To be able to evaluate the interconnectivity among the various packages, one must be able to understand the issues involved and the problems modeled within each step.
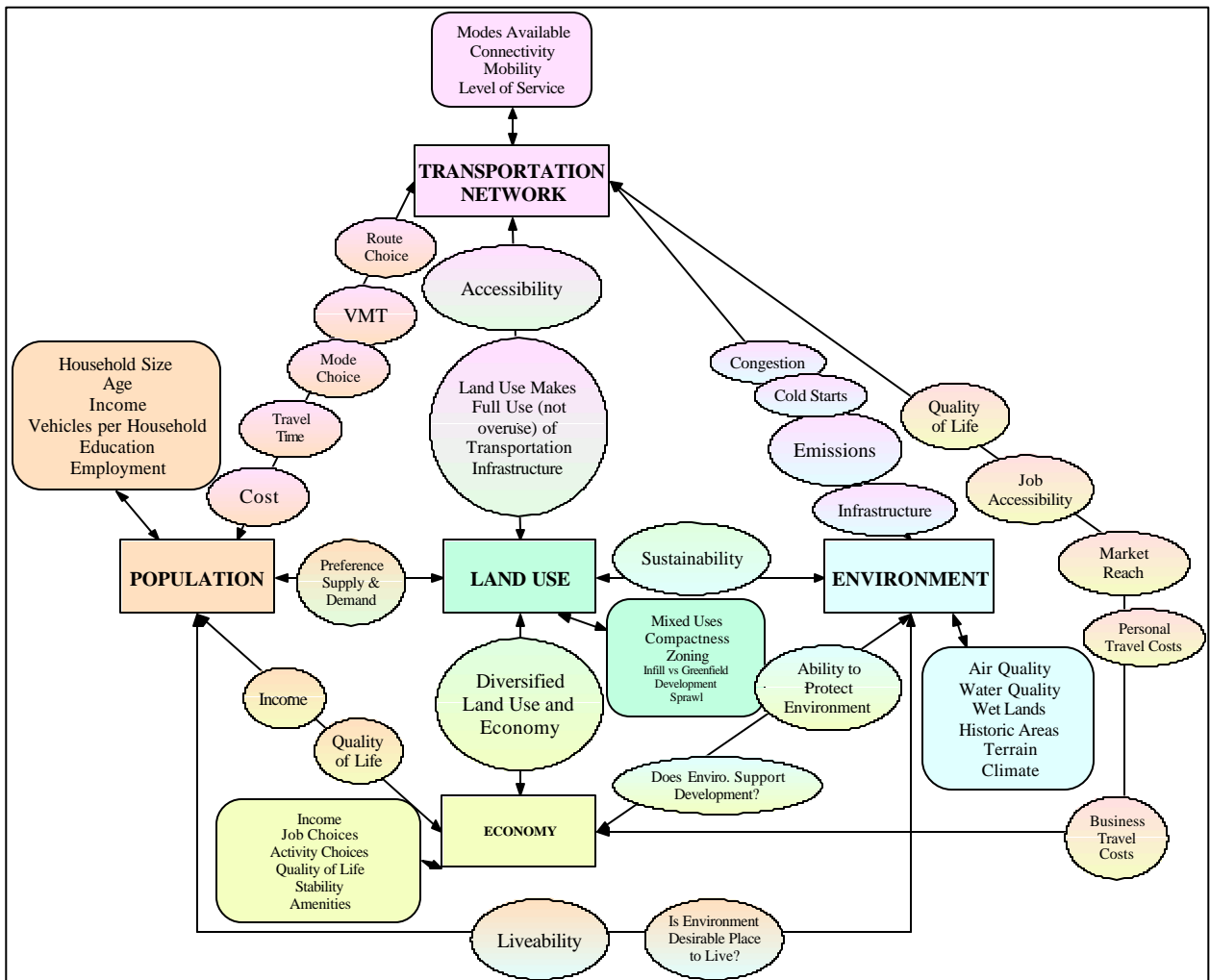
Figure 2: The Interconnected Subsystems

Figure 2 illustrates the various subsystems and how they are related to one another. Ideally, a model or series of models could cover all of these areas to truly model the dynamics of a region.

The Florida DOT Study

The Florida Statewide Model Task Force formed a blue-ribbon advisory panel of seven national experts as a means to evaluate the strengths and weaknesses of the current modeling framework and determine whether additional modeling

methods and tools should be added to their Florida Standard Urban Transportation Model Structure (FSUTMS). FSUTMS is a uniform framework, which is used to run models in all metropolitan areas in the State of Florida.

The blue ribbon panel identified transportation model functionality and software system criteria. There are many considerations when selecting a software platform for transportation modeling. The important questions/criteria identified by the panel include:

- How does it interface with other software?
- How does it store data and what are the Input-Output routines?
- What is the processing speed?
- How does it build highway and transit paths?
- What are the GIS and spatial analysis capabilities it poses?
- How does it edit the network?
- How does it generate reports?
- How are different components of the model tied together?
- How are scripts customized?
- How does it calculate matrices and link flows?
- What are the component applications?
- What is the operating system?
- How is everything displayed?
- How is it tied into other Florida Models?

The project steering committee considered the following four software packages:

- TransCAD (Caliper Corporation)
- CUBE/TP+/Voyager (Citilabs)
- VISUM (ITC/PTV)
- EMME/2 (INRO Consultants)

Two software packages were selected for further evaluation. Both Caliper Corporation and Citilabs provided some updated materials for TransCAD and CUBE/Voyager. Following the receipt of all of the materials, the consultant team of the steering committee was given specific assignments with regard to the testing and evaluation of TransCAD and CUBE/Voyager. After the evaluation and the national survey among the users that followed, the software packages were even, meaning that both were good enough to be selected. Since only one could be selected, each committee member was asked to vote for one particular software package and from that procedure TransCAD was selected to be used in FSUTMS.

LIST OF SOFTWARE PACKAGES

Criteria for Software Package Selection

The software packages that were considered in this research were selected based on several criteria, including their uses, functions, dimensions and the aims of their models. Criteria on the <u>uses of the software packages</u> include the following:

- Considered to be the current state-of-the-practice for transportation planning.
- Capable of modeling traffic operations, analysis, review, and application of traffic data to the operation of transportation facilities.
- Capable of modeling traffic design that incorporates the determination of travel patterns and parking characteristics of transportation users in the planning and design of transportation facilities.
- Consider the application of land use and economic data in the development of policies for financing transportation improvement.
- Capable of modelling issues such as the development of toll roads, the evaluation of measures for congestion containment, the noise

and pollution impact of urban traffic, the development of transit services, and freight planning.

- Capable of interfacing with GIS database and applications.

Regarding the <u>functions of their models</u>, the software packages may be used for description, prediction and forecasting. Description comprises the use of a model in the location where it was calibrated and for circumstances that are not changed from those that exist at the time of calibration. Prediction is the process of estimating the changes in the performance of the system being modeled that result from changes in the characteristics of that system. Forecasting is the use of a model to estimate system performance for a specified time in the future, usually for the location where the model was calibrated.

Various <u>dimensions or categories of models</u> are helpful in determining their appropriate uses in the transportation planning process. Eight dimensions may be proposed to describe, in a formalized manner, the types of models that may be constructed. These are:

Descriptive, Predictive or Planning Models: *Descriptive Models* replicate relevant features of an existing phenomenon. They give no key to future predictions, but help generate reliable values of hard-to-measure variables from considerably easier-to-measure variables. *Predictive Models* provide relationships between the various features of a system. The *Planning Models* instead of just predicting what will occur in the future incorporate an attempt to evaluate the model outputs.

Deterministic or Probabilistic Models: *Deterministic Models* specify the actual outcome of events. The outcome of the model is that an event either occurs or does not occur. *Probabilistic Models* will indicate a probability of certain outcomes, as a result of certain causes.

Analytical, Statistical or Simulation Models: An *Analytical* or *Statistical* solution can be obtained when the system to be modeled exhibits a tight logical structure

and the internal functional relationships within the system are uncomplicated by discontinuities. When a system cannot be evaluated using analytical or statistical models, simulation is used. A *Simulation Model* specifies an inventory of possible events and indicates the immediate consequences of each event for one or more variables.

Cross Sectional or Temporal Models: In *Cross-Sectional* models time is not considered as an element and it is assumed that the temporal dependence of the phenomenon is to be determined exogenously. A *Temporal Model* considers time as an essential element of the entire modeling process. For such models a set of data over a considerable time period is required.

Aggregate or Disaggregate Models: At an *Aggregate Model* the collective behavior and properties of a phenomenon (group of people, stream of vehicles etc.) are modeled. At a *Disaggregate* level the actual behavior of each separate element of the model population is considered.

Unidirectional or Multidirectional Models: A *Unidirectional* model considers a single cause and effect process that acts in one consistent direction. A *Multidirectional* model allows interactions to occur in any direction throughout the system.

Analogue, Homomorphic or Isomorphic Models: In an *Analogue* model mathematical techniques are employed to define a precise relationship between an existing phenomenon and the particular system or phenomenon being modeled. A *Homomorphic* model behaves like the process that is being considered but not necessarily for the same reason. An *Isomorphic* form models the process exactly by finding the causes and effects and simulating the interactions between them.

Forward or Backward - Seeking Models: A *Forward-seeking* model is a goal-seeking model that moves forward to find what alternatives may exist as a result of present actions. It allows the planner to seek the options that will result in the

process of achieving desired goals. A *Backward-seeking* model starts with goals and attempts to determine the methods that can be used to achieve these desired goals.

Software Package Classification

The software packages that have been selected for the purpose of this research may be broadly classified under the following application areas:

- Transportation Planning.
- Traffic Simulation.
- Mobile Emissions Modeling.
- Under Development Software Packages.

Furthermore, they have been selected such as to cover a wide spectrum of the above-mentioned criteria.

Table 1 presents a list of the software packages that have been considered in this research classified under broad categories based on their application area.

Although the application areas are not completely distinct and many software packages often fall under more than one category, an effort was made to classify the selected software packages based on their primary use.

Table 1: List of Software Packages

Transportation Planning	Traffic Simulation	Emissions Modeling	Under Development	Common Features
CUBE	INTEGRATION	MOBILE 6	DynaMIT	- Developer
EMME/2	CORSIM	PPSUITE	Dynasmart-P	- Brief Description
ESTRAUS	PARAMICS	CMEM	Dynasmart-X	- Application Areas
MEPLAN	VISSIM	MEASURE	VISTA	- Product History
METROPILUS	ROUTESIM	CAL3QHC		- Current Version / Release
METROSIM	WATSIM			- Documentation
MINUTP	SYNCHRO			- Availability and License Cost
NODUS	SATURN			- Modeling Approach
OMNITRANS				- Input Requirements
QRS II				- Outputs
STAN				- Pre Processors
TMODEL				- Post Processors
TP+				- Maximum Dimension Limits
TRANPLAN				- Strengths
TRANSCAD				- Limitations
TRANUS				- Minimum Computer and Hardware Requirements
TRIPS				- Recommended Hardware Specifications
UFOSNET				- Operating System and Environment Requirement and Compatibility
URBANSIM				- Program Languages
VIPER				
VISUM				

List of Features

A set of features was selected to better organize the review of the software packages and to assist in their comparative evaluation. Features that are common for all software packages are listed in Table 1. Additional features, which depend on the software package category, are shown in Table 2.

Table 2: List of Unique Features of Software Packages

UNIQUE FEATURES	
TRANSPORTATION PLANNING	TRAFFIC SIMULATION
Network planning	Traffic Signals
O-D matrix estimation	Ramp Metering
Trip generation	Incident Management
Trip distribution	Traffic Modeling/info
Mode choice	Parking
Trip assignment	Toll plaza modeling
Land use	Congestion Pricing
Freight applications	Pedestrians/cyclists
Vehicle routing/logistics	Emissions modeling
Commercial vehicles	Measures of effectiveness
Public transit	
Carpooling	
Roundabouts	
Ramps	
Intersections	
Intermodal transportation	

A comprehensive review of the selected software packages based on these features has been performed and the information collected has been summarized in a matrix format, as described in the following section.

SOFTWARE MATRIX

A matrix has been developed, to organize and present the information for each software package and for each feature that was considered. This matrix, developed in Excel, initially listed software packages in the columns and their features in the rows of a worksheet. Because of the content and the amount of information summarized under each feature, a workbook format was used instead.

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Figure 3 shows an excerpt from this matrix, a screen shot of the Excel worksheet. As shown in the figure, the workbook contains several worksheets, each worksheet dedicated to one software package. Information on each software package was sent to the software developer or vendor for review and commenting on accuracy and completeness. Text shown in the matrix in *italics* represents information and comments that were given by the software developers. Bold lettering represents comments that were provided by the advisory board and the users, as a result of the survey, which is described in the following section.

Figure 3: Screen Shot of Software Matrix

The matrix can be found in Appendix B. The Appendix summarizes information on each software package, including history, application areas, availability and cost, modeling approach, input, output, pre- and postprocessors, strengths, limitations, and computer requirements.

To present this important information in a user-friendly manner and to facilitate comparative evaluation of the software packages, an interactive tool was developed using Visual Basic 6.0. Using this tool, user-selected data is extracted from a Microsoft Access database and is presented in a concise form. The Visual Basic interface serves as front end to the MS Access database. This application is part of a Transportation Modeling Needs Assessment Tool, which is presented at a later section in this report.

TRANSPORTATION SOFTWARE PACKAGE USER SURVEY

Introduction and Purpose of the Survey

As part of this project a survey was conducted to determine the current usage and state-of-the-art tools in transportation modeling software. This survey intends to determine the user's perspective, emphasizing the strengths and limitations of various software packages and predicting the future trends and directions of transportation modeling. The survey analysis establishes the current use of software packages, compares the traditional modeling processes and programs with next generation alternatives and makes recommendations on which ones are likely to become the next industry standard.

Survey Design

Seven questions were asked in the survey along with the name and address of the contact person. Based upon respondents' request, detailed contact information is not presented in the survey analysis. The type of responding organization, such as private consulting firms or public agencies is used instead. Any questions in the survey that the responses of which tended to point out the name of the responding organization were not considered in the analysis.

In general, questions included in the survey instrument intended to gather information on the following aspects:

- Names of software packages used by the responding organizations according to the categories Transportation Planning, Traffic Simulation, Land Use, Integrated Traffic Simulation and Planning Models, Integrated Transportation Planning and Land Use Models, Vehicle Emissions Modeling, ITS Planning, Facilities Design Data, and Transportation Facility / Plan Evaluations: Highway Capacity Manual Software.

- Models developed in-house by the organization including primary use and application area, year of development, commercial and educational availability and license cost if commercially available.

- Additional information on the packages listed in Question 2, such as duration of usage, latest version used and scale of use.

- Reasons for purchasing the software packages used by the respondent. The respondent was asked if the program was selected because it is:

- Approved/Recommended by Local/National transportation body

- Used by the respondent's collaborators.

- Widely used or is considered to be an industry standard.

- Respondents' experience with the software packages they are currently using. This includes the strengths and limitations of each package, problems encountered in its usage, familiarity with alternative packages and willingness to use alternative packages and which ones.

- Respondents' awareness of any software packages that are currently under development and their willingness to adopt them. Specifically, this question sought to determine the respondents' view of TRANSIMS, a new product with a very different modeling philosophy when compared to the existing ones.

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The survey instrument is attached in Appendix C.

Survey Distribution and Collection

The survey instrument was sent to professionals in consulting firms and government agencies such as state DOTs, MPOs, and transit agencies. A population of 234 contacts was initially considered. The questionnaire was sent via email and follow up phone calls were placed.

Table 3 shows the number of contacts per agency type:

Table 3: Contacts for the Survey

Type of Contact	Total Listed	Total not doing Transport. Modeling
Consulting Firm	74	23
State DOT/public agencies	160	NA
Total	234	

Of the 234 contacts, 74 are consulting firms and 160 are public agencies. Of the 74 consulting firms, 23 indicated that they do not do any transportation modeling and were subsequently dropped from the contact list. Hence the size of the survey population was reduced to 211. Out of the 211 contacts, 28 participated and completed the survey questionnaire.

Table 4 shows the percentage distribution of respondents per type of organization:

Table 4: Response Rate and Distribution per Type of Organization

Type of Contact	Number of Participants	% Distribution of Participants
Consulting Firms	23	82
Public Agencies	5	18
Total	28	100%

The total response rate is 13.2 percent. Eighty-two percent of the respondents (23 participants) are from consulting firms while 18 percent (5 participants) are from public agencies. Based on the above distribution, one should expect that the survey results reflect primarily the view of private consulting firm professionals. Furthermore, it should be noted that the vast majority of the respondents are based in New Jersey or have activities in the state, thus, the survey reflects primarily the views of New Jersey based professionals. Overall, because of the small number of responses and the focus on New Jersey firms, one should not consider the survey results to be conclusive. However, as shown from the following analysis, the survey produced some interesting findings in terms of general trends in transportation modeling.

Survey Analysis

Of the 28 questionnaires that were returned, two were sent by fax, one via regular mail, and the rest via email. Response data was entered into Microsoft Excel. Every fifth response entered was checked for data-entry accuracy. If a respondent marked more than one choice in a survey question that asked for one choice only, the respondent was called back to identify the single most applicable choice. The lack of response was counted and reported as *did not respond.*

The small sample size should be kept in mind when using the survey results. However, the respondents are representative of who is using the transportation software packages in New Jersey, and the results are useful when making decisions regarding the future of transportation modeling in New Jersey.

<u>**Level of Operation of Respondent's Organization**</u>

The majority of the respondents operate at the national and statewide level. This is logical as most of the respondents represent consulting firms that work at this level. State DOT's operate at the statewide level, while transit authorities reported operations at the local or regional level. Finally, MPO's operate at the regional level.

Use of Transportation Planning Software Packages

The most commonly used transportation planning software packages are TRANSCAD and TP+ with eleven users each. TRANPLAN and MINUTP also ranked high in popularity with ten and seven users respectively. There were five respondents who reported using EMME2, four using CUBE/Voyager, three using TMODEL2, and two respondents using QRSII. Finally, there was one respondent using SATURN or no model. everal respondents reported using models that are not traditionally used or not widely known for planning purposes. These models are FTA SUMMIT, FHWA TDM, EPA COMMUTER, TRAFFIC NOISE MODEL, TRUCK TP, SYSTEM 2, SAS, ARCINFO, CORSIM, and HCM related software. Figure 4 shows the number of respondents reporting usage of each transportation planning software program.
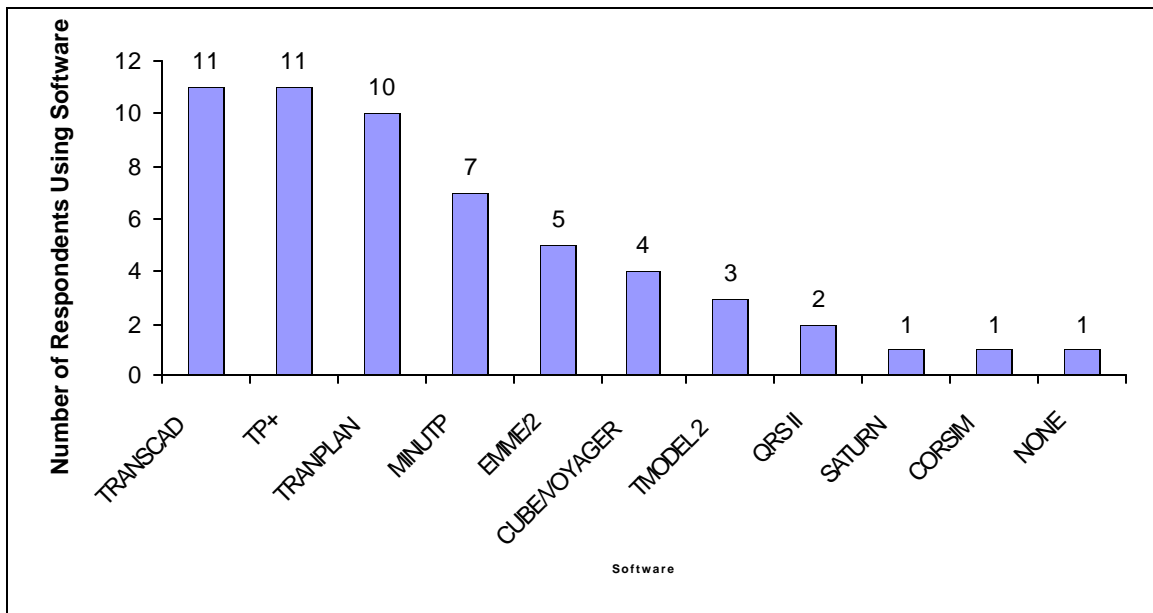
Figure 4: Use of Transportation Planning Packages

Use of Traffic Simulation Software Packages

Similarly, figure 5 illustrates the number of respondents that reported using a particular traffic simulation software program. SYNCHRO and CORSIM were the most popular traffic simulation models, with nine and seven users respectively.

Four respondents reported using PARAMICS, while three users reported using VISSIM. Two respondents use INTEGRATION and one reported using each of the following software packages: TRANSYT-7F, DYNASMART-P, CORFLO, MICROTRIPS, and HCM software. Additionally, four of the respondents did not report using any traffic simulation software. RAILSIM and TEAPAC were mentioned by one respondent each, but were not included in the statistical analysis as they are not tolls for general traffic simulation applications.
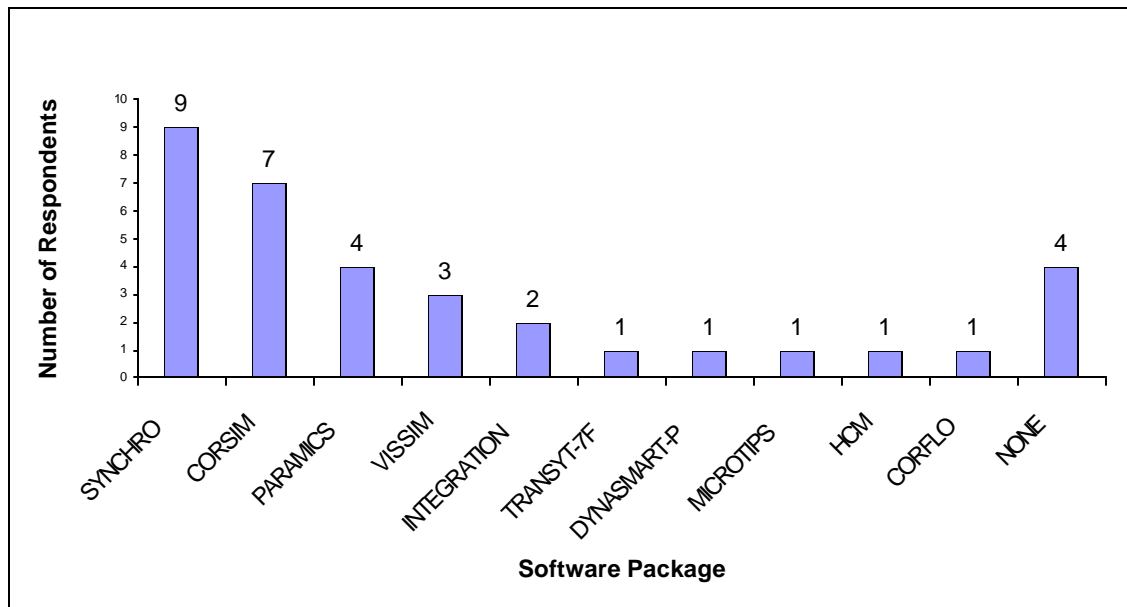
Figure 5: Use of Traffic Simulation Software Packages

Use of Land Use Software Packages

The responses for land use software package usage are summarized in figure 6, three respondents reported using ArcView while 2 respondents named ArcGIS as a land use software package that they use. One respondent each reported using ArcInfo, MapInfo, DRAM/EMPAL, and MetroSIM. Two respondents reported using excel based models that were developed in-house.
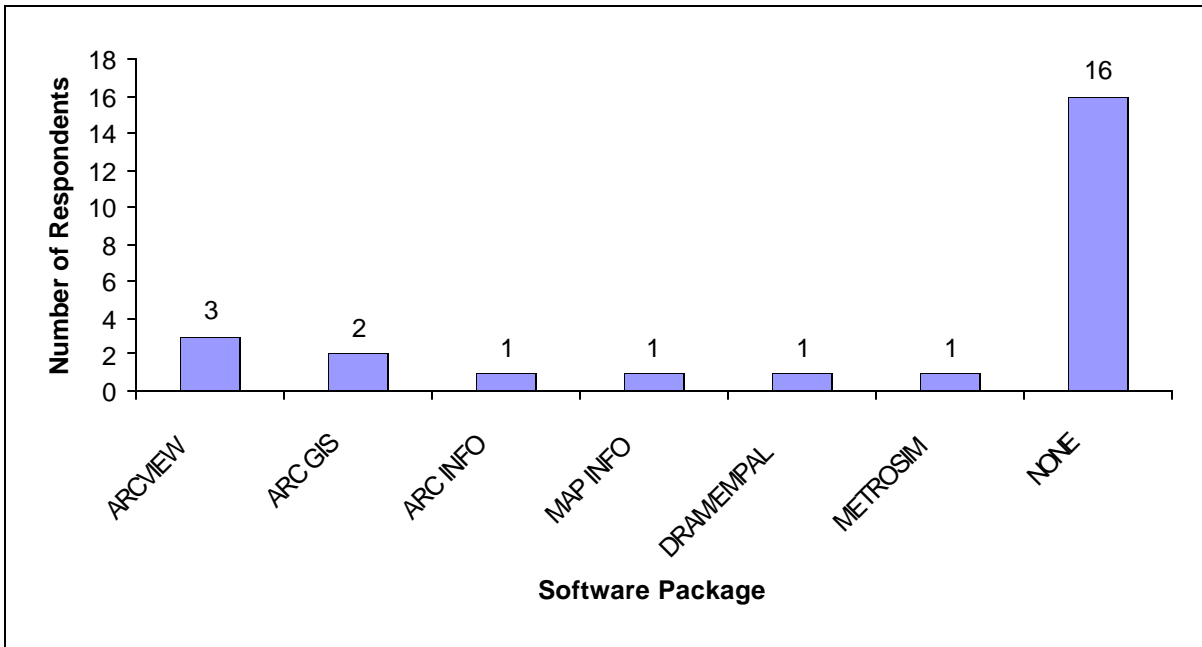
Figure 6: Use of Land Use Software Packages

Use of Integrated Transportation Planning and Traffic Simulation Packages

EMME/2, combination of VISSIM/VISSUM, TRAFFIX, TRIP GENGERATION, and SYNCHRO are also used for integrated transportation planning and traffic simulation modeling. Two of the respondents indicated that they use a combination of the transportation planning and traffic simulation software packages that they mentioned in previous categories. The majority of the respondents (fifteen) indicated that they do not use any integrated transportation planning and traffic simulation packages. Of course, the use of individual packages for either transportation planning or traffic simulation has been indicated in the previous questions.

Use of Integrated Traffic Simulation and Land Use Software Packages

Respondents mentioned UrbanSIM and GIS related programs to model integrated traffic simulation and land use. Additionally, CUBE was mentioned as a software used for this purpose. A respondent also said that they use a

combination of the traffic simulation and land use software packages mentioned under previous categories for this purpose. Finally, TP+, TRANSCAD, CORSIM, and HCM software packages were mentioned.

Use of Emissions Modeling Software Packages

Figure 7 shows the use of emissions modeling software packages. The most highly used package is MOBILE, with ten users, followed by PPSUITE with four, and CAL3QHC with three. Seven respondents did not use any emissions modeling packages. Several consulting companies mentioned tools that they have developed. Some of these include CALINE, CMAQ methodologies, and NJAQ.
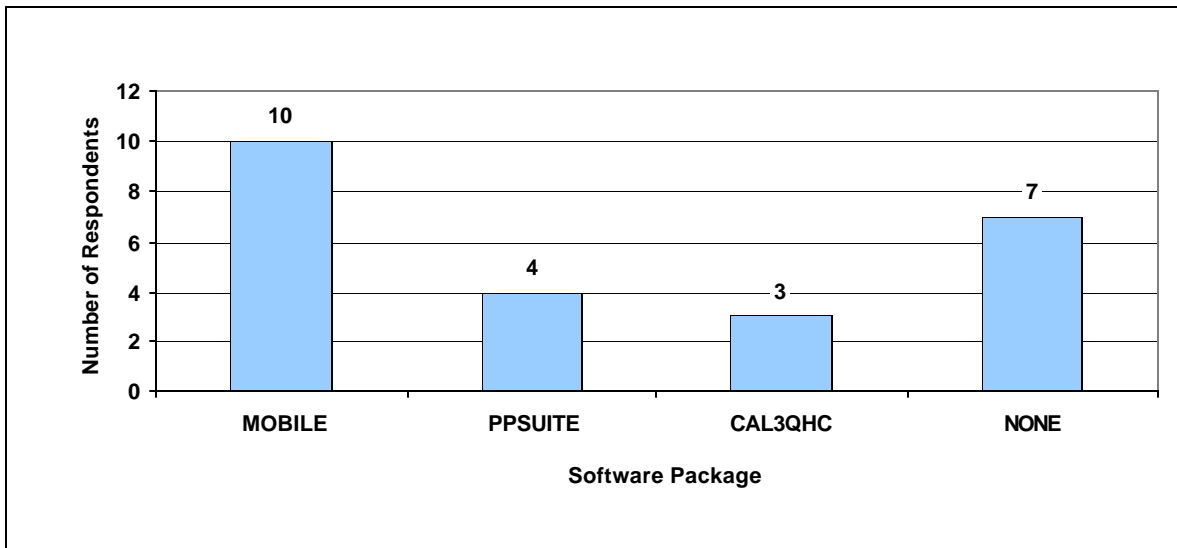
Figure 7: Percentage Use of Emissions Modeling Software Packages

Use of ITS Modeling Software Packages

Two respondents each use VISSIM and IDAS, while one respondent each uses ITOP, FHWA ITAN and Turbo Architecture for ITS Modeling. The majority of respondents did not report using any ITS modeling packages.

Use of Supporting Applications

Several additional software programs were listed as supporting applications. Many of these listed were computer-programming languages such as C++ or FORTRAN that could be used to develop interfaces between software packages. Others were statistical analysis packages such as SAS and SPSS. Additionally, specialized programs to model highway lighting and noise were mentioned under this category.

Use of Software Packages in Years

Four intervals have been used to summarize the survey results on use of software packages in years: 0 to 5 years, 6 to 10 years, 11 to 15 years, and over 15 years. Table 5 shows the number of responses indicating use of a particular software package over a certain period of time. It should be noted that not all software packages listed by respondents in Question 1 of the survey questionnaire have been included in the responses related to the use of software packages in years. If a software package is listed in those used by an organization but the use in years has not been indicated, a NO RESPONSE mark is assigned. In the following table, the interval with the highest response rate is highlighted. It should also be noted that not all software packages have been available for the over 15-year period considered in this analysis, as some of them are newer products.

Table 5: Scale of Use of Software Packages by Number of Respondents

#	NAME OF SOFTWARE	USE IN YEARS				
		0-5 YEARS	6-10 YEARS	11-15 YEARS	>/= 16YEARS	NO RESPONSE
1	TRANSCAD	7	8	0	0	3
2	MINUTP	1	0	1	5	0
3	TP+	9	2	0	0	1
4	CUBE/VOYAGER	4	0	0	0	1
5	TRANPLAN 1985	2	1	3	4	0
6	EMME/2	1	3	4	0	0
7	QRS II 1987	1	1	0	0	0
8	TMODEL 2	0	1	2	0	0
9	SATURN	1	0	0	0	0
10	CORSIM	4	4	2	0	3
11	ARCINFO	1	1	0	0	0
12	HCM	1	1	1	8	1
13	SYNCHRO	7	2	1	0	2
14	VISSIM	5	0	0	0	1
15	SIM TRAFFIC	0	0	1	0	0
16	TEAPAC	1	0	0	0	0
17	TRANSYT-7F	0	0	1	0	0
18	INTEGRATION	0	2	0	0	0
19	DYNASMART-P	1	0	0	0	0
20	PARAMICS	4	0	0	0	2
21	MICROTIPS	1	0	0	0	0
22	CORFLO	1	0	0	0	0
23	ARCVIEW	0	0	1	2	1
24	ARC GIS	0	0	1	2	1
25	ARC INFO	0	0	0	1	0
26	MAP INFO	0	0	0	1	0
27	DRAM/EMPAL	0	1	0	0	0
28	METROSIM	1	0	0	0	0
29	VISSIM/VISSUM	1	0	0	0	0
30	TRAFFIX	1	0	0	0	0
31	TRIP GENERATION	1	0	0	0	0
32	URBANSIM	1	0	0	0	0
33	MOBILE	1	1	3	2	3
34	CAL3QHC	1	1	1	0	0
35	PPSUITE	2	1	0	0	1
36	IDAS	1	0	0	0	1
37	Combination of Land use, Planning and Simulation Packages	1	2	1	0	0

The above analysis indicates that although new, more advanced products have entered the market, older ones are still used by professionals, some of them industry standards. Furthermore, older products, in general tend to have a higher usage rate, while newer ones are used by a fewer number of respondents.

Version of Software Used

Table 6 shows information regarding the versions of transportation modeling software packages used by the respondents. The latest version is highlighted. The latest version used was the latest version of each software package available at the time of the survey. Results in table 6 indicate that most of the respondents use one of the latest versions of each software package, indicating that the industry is, in general, keeping up with software updates.

Table 6: Latest Version of Software Packages Used

NAME OF SOFTWARE	LATEST VERSION USED				
	1	2	3	4	5
TRANSCAD	4.5	-	-	-	-
MINUTP	1997	2000	2002	-	-
TP+	V.2.1	V.3.0	V.3.1	V.3.1.1	V.5.1
CUBE/VOYAGER	V.3.1.1	-	-	-	-
TRANPLAN	8.0	9.0	9.1	9.2	-
EMME/2	6.0	7.0	8.0	9.2	-
QRS II	V.5.1	-	-	-	-
SATURN	V.5.3	-	-	-	-
CORSIM	V.4.1	V.5.0	V.5.1	-	-
ARCINFO	8.0	-	-	-	-
HCS	HCS 2000	-	-	-	-
SYNCHRO	V.5	V.6	-	-	-
VISSIM	V.3.0	-	-	-	-
TRANSYT-7F	RELEASE 9.7	-	-	-	-
INTEGRATION	1.5	2.0	-	-	-
PARAMICS	V.4.0	V.4.1	-	-	-
MICROTIPS	V.2.1	-	-	-	-
TRIP GENERATION	V.6	-	-	-	-
MOBILE	5A-2.0.6	V.6	V.6.2	-	-
CAL3QHC	V.1.0	-	-	-	-
PPSUITE	4/15/03 RELEASE	-	-	-	-

Scale of Use of Software Packages by Region

Table 7 indicates the scale of use of each software package, meaning that it determines whether the program is used for Single Road (SR), Regional (R), Corridor (CO), Project Board (PB), Intersection (I), City (CI), State Wide (SW), or other level of analysis. The maximum number of responses in each category is highlighted.

The results below indicate which packages are most commonly used for what level of analysis. This information may be used in combination with the description of the features of the software packages when selecting a set of tools to cover a company's or an organization's modeling needs.

Table 7: Scale of Use of Software Packages

#	NAME OF SOFTWARE	SCALE OF USE							
		SR	R	CO	PB	I	CI	SW	NO RESPONSE
1	TRANSCAD	0	15	5	0	0	4	0	0
2	MINUTP	0	7	3	0	0	1	1	0
3	TP+	1	10	4	0	0	2	2	0
4	CUBE/VOYAGER	1	3	1	0	0	2	1	0
5	TRANPLAN	1	9	4	0	0	2	3	0
6	EMME/2	0	4	2	0	0	1	0	0
7	QRS II	0	1	1	0	0	1	0	0
8	TMODEL 2	0	2	1	0	0	1	0	0
9	SATURN	0	0	0	0	1	1	0	0
10	CORSIM	4	0	6	0	4	0	0	0
11	ARCINFO	0	2	0	0	0	0	0	0
12	HCM	3	0	4	0	7	0	0	0
13	SYNCHRO	4	0	7	1	8	1	0	0
14	VISSIM	2	0	1	0	3	0	0	0
15	SIM TRAFFIC	1	0	1	0	1	0	0	0
16	TEAPAC	1	0	1	0	1	0	0	0
17	TRANSYT-7F	1	0	1	0	1	0	0	0
18	INTEGRATION	0	0	2	0	0	0	0	0
19	PARAMICS	2	1	1	0	1	2	0	0
20	MICROTIPS	0	0	0	0	1	0	0	0
21	NETSIM	1	0	1	0	1	0	0	0
22	FRESIM	1	0	1	0	1	0	0	0
23	CORFLO	0	0	0	0	0	0	0	1
24	ARCVIEW	0	2	2	0	0	1	0	0
25	ARC GIS	0	0	0	0	0	0	0	1
26	ARC INFO	0	1	1	0	0	1	0	0
27	MAP INFO	0	1	1	0	0	1	0	0
28	DRAM/EMPAL	0	0	0	0	0	0	0	1
29	METROSIM	0	0	0	0	0	0	0	1
30	VISSIM/VISSUM	0	0	1	0	1	0	0	0
31	TRAFFIX	1	0	1	0	0	0	0	0
32	TRIP GENERATION	1	0	1	0	0	0	0	0
33	ARCVIEW GIS	0	0	0	0	0	2	0	0
34	URBANSIM	0	1	0	0	0	0	0	0
35	MOBILE	1	7	0	0	2	2	0	0
36	CAL3QHC	0	0	2	0	2	0	0	0
37	PPSUITE	0	2	1	0	0	1	1	0
38	IDAS	1	1	1	0	0	0	1	0
39	Combination of Land use, Planning and Simulation Packages	0	2	2	0	0	0	2	0

Reason to Choose / Purchase a Software Package

Table 8 provides information on the reasons for using any particular software package. The table shows the number of respondents who identified specific packages as widely used / industry standards and lists the agencies recommending the package. It also lists collaborators of the respondents using any particular software package.

Table 8 provides useful information on how transportation experts view several software packages. Depending on their collaborators and based on their needs, individuals or agencies may use this information to select the appropriate packages to cover certain needs and requirements.

Table 8: Reasons for Purchasing a Software Package

NAME OF SOFTWARE PACKAGE	PURCHASE REASON			
	WIDELY USED/INDUSTRY STANDARD	RECOMMENDED BY LOCAL/NATIONAL TRANSPORTATION BODY	NAME OF COLLABORATORS	OTHER (INCLUDES RESPONDENTS' COMMENTS)
TP+	7 / 2	NJDOT, PennDOT, NJTransit, Washington and Baltimore MPO's, VDOT, FHWA	NJDOT, PennDOT, FHWA, FTA, Several MPO's and Transit Agencies, City and County engineering and planning, Consultants	Advance package for transportation planning, Compatible with older TRANPLAN and MINUTP applications and other existing systems
TRANPLAN	6 / 4	NJDOT, PennDOT, DVRPC, Florida DOT, VDOT, FHWA	NJDOT, PennDOT, FHWA, FTA, DVRPC, Several MPO's, Transit Agencies, Consultants, City and County engineering and planning, Toll Authorities	Very widespread use, Compatible with existing systems
MINUTP	6 / 1	NJDOT, PennDOT, MTA/NEW YORK. VDOT, FHWA	Several MPO's and Transit Agencies, NJDOT,	Several city and county engineering and planning, Very widespread use

Table 9: Reasons for Purchasing a Software Package (cont)

NAME OF SOFTWARE PACKAGE	WIDELY USED/INDUSTRY STANDARD	RECOMMENDED BY LOCAL/NATIONAL TRANSPORTATION BODY	NAME OF COLLABORATORS	OTHER (INCLUDES RESPONDENTS' COMMENTS)
TRANSCAD	15 / 2	NJDOT, PennDOT, NYMTC, NY Metropolitan Transportation Authority	Several MPO's and Transit Agencies, NYSDOT, NY Metropolitan Transportation Council (NYMTC), Toll Authorities, MTA NYC Transit	Strong GIS linkage, Advance package for regional transportation planning
QRS II	-	NJDOT, PennDOT	Several Universities	-
EMME2	6 / 0	PSRC	Several MPO's and Transit Agencies. PSRC, International clients, Consultants	-
CUBE	-	No response	Consultants, MPO's, Toll Authorities	Most powerful, capable travel modeling package available
TMODEL2	-	No response	No response	Consultant
SYNCHRO	8 / 0	STATE/FEDERAL AGENCIES, NYCDOT	NJDOT, NYCDOT	-
CORSIM	7 / 5	STATE/FEDERAL AGENCIES, FHWA, NYSDOT	NYSDOT, NYCDOT	Inexpensive, Integrated platform of NETSIM and FRESIM
VISSIM	1 / 0	Other DOT's	Other DOT's	-
MOBILE	0 / 8	STATE/FEDERAL AGENCIES, EPA, FHWA	EPA, FHWA, NJDEP	Federal Standard
INTEGRATION	-	No response	Universities, NJDOT	Capability to evaluate ITS/ATIS
DYNASMART-P	-	No response	Univ. of Maryland	Capability to evaluate ITS/ATIS
CMEM	-	FHWA (Office of Planning), USDOT ITS JPO	No response available	ITS sensitivities for emissions modeling
IDAS	1 / 0	USDOT ITS JPO, FHWA	Consultants	-
HCS	4 / 4	TRB, Counties and Municipalities	Several Universities and Consultants	-
TRANSYT 7F	-	No response	NJDOT	-
PARAMICS	5 / 0	NYSDOT	NJDOT, NYSDOT	Advance package for traffic simulation
PPSUITE	0 / 1	NJDOT	NJDOT, MDOT	

Strengths of Transportation Planning and Simulation Software Packages

Tables 9 and 10 provide information on what the survey participants view as strengths of several transportation planning and simulation software packages respectively. Several features identified as strengths of a software package are listed in the tables. A feature is checked under any particular software package if the respondents have identified it as strength of that particular package. Only software packages that have been listed by the respondents in Question 6 of the survey have been included in this table. Because of the small sample size, sometimes a strength (or limitation) of a specific software package was only listed by one respondent. It should be kept in mind that a "**ö**" (or in the limitations sections, an "**X"**) is assigned even if only one respondent listed a feature as strength (or limitation).

Table 10: Strengths of Transportation Planning Software Packages

Transportation Planning Packages								
Features	**TRANPLAN**	**MINUTP**	**TP+**	**QRSII**	**EMME/2**	**TMODEL**	**TRANSCAD**	**CUBE/ VOYAGER**
Flexible	ö		ö		ö		ö	ö
Easy to Use			ö	ö		ö		ö
Graphical Interface			ö			ö	ö	ö
Compatible with older versions			ö	ö	ö			
Industry Standard	ö	ö						
GIS Interface			ö				ö	ö
Easy to train				ö				
Import-Export	ö		ö				ö	ö
O-D Matrices	ö	ö			ö		ö	
Transit Forecasting		ö	ö		ö		ö	ö
PC compatible	ö		ö	ö			ö	
Programming Language		ö	ö				ö	
Processing Speed	ö							ö
Toll Facilities					ö			
Support & User Manual							ö	ö
Emissions Modeling					ö	ö		
Interface with Other Software Packages	ö	ö	ö				ö	ö

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Table 11: Strengths of Traffic Simulation Software Packages

Feature	INTEGRATION	CORSIM	PARAMICS	VISSIM	SYNCHRO	HCS	TRANSYT 7F
Traffic Simulation Packages							
Flexible			ö	ö		ö	ö
Ease of Use	ö			ö		ö	
Widely Used			ö		ö	ö	
Graphical Interface			ö	ö	ö		
Import-Export Functions	ö		ö	ö	ö		
Vehicle Tracking and Routing Capabilities	ö		ö				
ITS Capabilities	ö		ö	ö			
Support and User Manual		ö	ö	ö	ö	ö	
Rail Simulation				ö			
Transit				ö		ö	
Traffic Signal Optimization	ö		ö		ö	ö	ö
HCS Based		ö			ö		
Roundabouts		ö	ö				
Pedestrians				ö			
Bicycles / Motorbikes				ö			
Toll Facilities			ö	ö			
Parking		ö					
Commercial Vehicles / HOV		ö	ö	ö			

Limitations of Transportation Planning and Simulation Software Packages

Similar to the way that strengths were listed in Tables 9 and 10, Tables 11 and 12 present the limitations of various software packages as those that were identified by the survey respondents. This time, an **x** is used to denote a limitation.

Table 12: Limitations of Transportation Planning Software Packages

Transportation Planning Packages								
Feature	TRANPLAN	MINUTP	TP+	QRSII	EMME/2	TMODEL	TRANSCAD	CUBE/VOYAGER
Poor Support and Documentation	X					X		X
Difficult Programming Language	X			X				
Poor Graphical Interface	X	X	X		X			
Incompatible with older versions							X	
Not an Industry Standard				X		X		X
Limited GIS Interface	X	X	X	X		X		
Difficult to train	X						X	
Poor Import-Export Functions				X				
Weak Transit Modeling	X							
Not User Friendly	X							
Operating System	X	X	X					
Occasional Bugs	X	X		X			X	X
Poor Memory Management		X						

Table 13: Limitations of Traffic Simulation Software Packages

Traffic Simulation Packages							
Feature	INTEGRATION	CORSIM	PARAMICS	VISSIM	SYNCHRO	HCS	TRANSYT 7F
Inflexible	X	X			X	X	
Cumbersome Programming		X			X		
Not an Industry Standard	X	X					X
Poor Graphical Interface	X	X					
Operating Platform	X		X				
Poor Support and User Manual	X						
Unable to Model Curved links	X				X		
Inability to Model Roundabouts	X					X	
Limited ITS Modeling Capabilities		X					
Inability to Model Pedestrians	X		X				
Inability to Model Bicycles / Motorbikes	X	X					
Inability to Model Toll Facilities	X				X		
Emissions Modeling		X			X		
Limited Transit Modeling Capabilities		X			X		
Inability to Model Parking	X				X		
Inability to Model Commercial Vehicles	X						

Strengths and Limitations of Land Use Modeling Software Packages

Table 13 presents the features of land use modeling software packages, which are marked by a **C** if they represent a limitation or by a **Ö** if they represent strength. The table includes only the software packages for which strength and limitation information was provided by the survey respondents in the categories of land use or integrated land use and transportation planning software. This information is limited because of the very few responses received regarding land use packages. One respondent described a cautiousness that should be

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exercised by professionals when using software packages to predict land use patterns. He implied that generating future land use trends is too difficult to leave to computers.

Table 14: Strengths and Limitations of Land Use Modeling Software Packages

Land Use Modeling – Benefits and Limitations			
Features	Index	TP+	Trip Generation
User Friendly			**ö**
Ability to Use with Regional MPO		**ö**	
Weak or No Transit Capabilities	X	X	
Hard to Model Elasticity Functions	X		
Inability to Use Local Inputs	X		

Strengths and Limitations of Emissions Modeling Software Packages

Table 14 presents the features of emissions modeling software packages, which are marked as **C** if they represent a limitation or as **ö** if they represent strength. The table includes only the software packages for which strength and limitation information was provided by the survey respondents.

Table 15: Strengths and Limitations of Emissions Modeling Software Packages

Emissions Modeling - Benefits and Limitations		
Feature	MOBILE	CAL3QHC
Widely Used	**ö**	
User Friendly	**C**	**ö**
Input data	**C**	
Transition from older versions	**C**	**ö**
Model PM and Toxics	**ö**	**ö**
Compatibility with Post Processors	**ö**	
Compatibility with Pre Processors		**ö**
Operating Platform	**ö**	**ö**
Programming Language		**C**
Queuing Effect		**ö**
Outputs	**ö**	**ö**
Calculate Idle Emissions	**C**	**ö**

Summary of Strengths and Limitations

The previous tables list strengths and limitations of the various software packages as those that were identified by the users. The respondents were asked to indicate the features of each software package that they were mostly satisfied with and those that could be considered as limitations. As it was expected, the most commonly used packages received the larger number of comments (as either strengths or limitations). Evaluating the software packages based on the number of items in their list of strengths and limitations would not be appropriate. One, however, should look into the individual comments provided by the respondents and determine the significance of a stated strength or limitation for their individual applications or intended use of software packages.

Familiarity with Alternative Software Packages

Table 15 records the respondent's familiarity with alternative software packages in reference to the ones they are currently using. The first column lists a software package that is currently used by the respondents. For each such package, familiarity with alternatives and willingness to use them are listed in the next columns. The last two columns of the table list the number of respondents, and for those who indicated they are willing to use alternative packages, the name of the package they would prefer to use. Under each question and for each package, the answer with the highest number of responses is highlighted.

The following analysis indicates that the respondents are in general familiar with alternative software packages. TransCAD, CUBE, and TP+ and VISSIM stand out as the packages that respondents would like to use in place of other packages they are currently using.

Table 16: Familiarity with Alternative Software Packages

| NAME OF SOFTWARE | FAMILIARITY WITH ALTERNATIVE PACKAGES | | | WILLINGNESS TO USE ALTERNATIVE PACKAGES | | TOTAL # OF RESPONS | PREFERRED PACKAGE |
	YES	NO	SOME WHAT	YES	NO	YES	
TP+	7	1	4	4	8	12	TRANSCAD
TRANPLAN	9	0	1	8	2	10	TRANSCAD, CUBE, TP+
MINUTP	7	0	0	5	2	7	TRANSCAD, CUBE, TP+
TRANSCAD	11	0	5	9	7	16	CUBE
QRS II	2	0	0	2	0	2	NONE
EMME2	5	0	1	0	6	6	NONE
CUBE	5	0	0	0	5	5	NONE
TMODEL2	3	0	0	2	1	3	TRANSCAD, CUBE
SYNCHRO	8	0	4	3	9	12	VISSIM
CORSIM	9	1	2	6	7	13	VISSIM
VISSIM	0	0	5	0	5	5	NONE
MOBILE	0	10	0	0	10	10	NONE
CALQ3HC	0	3	0	0	3	3	NONE
INDEX	1	1	0	1	1	2	NONE
INTEGRATION	2	0	0	2	0	2	VISSIM, DYNASMART-P
DYNASMART-P	1	0	0	0	1	1	NONE
HCS	2	3	7	2	10	12	SYNCHRO, PARAMICS
TRANSYT 7F	1	0	0	0	1	1	NONE
PARAMICS	1	4	1	3	3	6	DYNASIM, VISSIM
PPSUITE	0	4	0	0	4	4	NONE

Willingness to Adopt Commercially Unavailable or Under Development

Models

To address the changing needs of the transportation professionals, new models
have being developed. These models may be implemented in existing software
packages that have the flexibility to include user specified models, may be coded
in new versions of existing software packages, or may be included in new
software packages, especially if the models are significantly different compared

to the current practice. Of the 28 respondents, 15 indicated that they would be willing to adopt such packages, while 18 indicated that they are not willing to adopt software packages that are not commercially available.

Given that most of the respondents are from private consulting firms, the fact that the majority of users are not willing to adopt models that are still at a development stage is not surprising. Industry professionals often prefer tools that have been tested, have known strengths and limitations, and have good technical support.

Willingness to Adopt TRANSIMS

TRANSIMS is being developed by the Los Alamos National Laboratory. TRANSIMS has a very different modeling philosophy when compared to any alternative software package and has been developed with the intent to overcome several deficiencies which have been identified in existing software packages and address the increasing needs for transportation modeling. For this reason, special consideration was given in this survey on whether transportation professionals are willing to use TRANSIMS or not. As shown in figure 8, of the 28 respondents, ten indicated that they are willing to adopt TRANSIMS, while 23 indicated that they are not willing to adopt it. Again, as indicated in the previous section, transportation professionals are reluctant to use tools that have not been tested and do not have known strengths and limitation. This is more so in the case of TRANSIMS, which is very different compared to existing software packages in terms of data requirements, modeling approach, and hardware requirements.
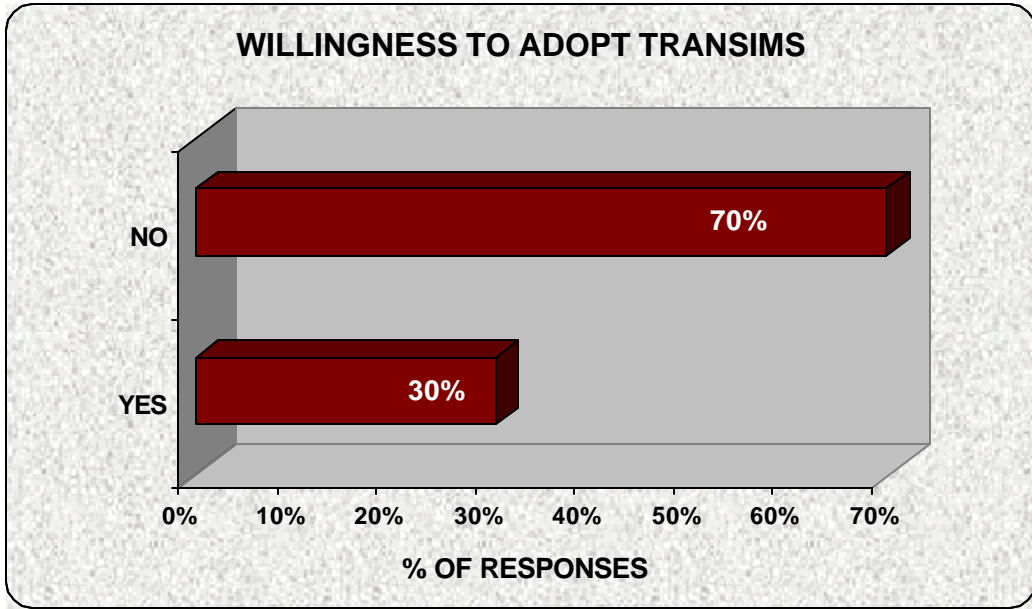
Figure 8: Willingness to Adopt TRANSIMS

This section presented the results of a survey intended to determine the current use of transportation software packages. Summary of the survey results provided information on the level of use of various software packages, the type and scale of their applications and their strengths and limitations. The users' perspective was also determined in terms of reasons for selecting the tools they are currently using, how these tools compare with alternative packages, and their willingness to adopt tools that are not widely tested and used.

TRANSPORTATION MODELING NEEDS ASSESSMENT TOOL

The findings of the survey, along with the information on the software packages that has been presented in the previous sections of the report are used to develop an approach to be followed by the NJDOT as they update their tools to cover their modeling needs. For this purpose, an interactive tool, the Transportation Software Selection System (TSSS), has been developed which allows the user to review various features of any software package that is included in the software matrix, compare selected features of any two software

packages, and determine interconnectivity of software packages based on a set of pre-specified criteria. As new versions of software packages become available and the features and capabilities change, this tool may become obsolete. For this purpose, the tool has a built-in functionality, which allows the user to update information included in the software database. Finally, a quick search tool has been added, to allow the user to easily find and review a particular feature of any software package. The functionality and use of this tool are described in more detail in the following sections.

Data Base Development

The software database includes information on Planning_Packages, Simulation_Packages, Emissions_Packages, Developing_Packages, Transit_Packages, Land_Use_Packages, Freight _Packages and IntegAppData tables. The Planning, Simulation and Emissions_Packages tables contain information on software packages used primarily for planning, simulation or emissions estimation applications. The Developing_Packages table contains information on software packages that are still under development and may not be commercially available yet, as these were described in the Literature Review section of this report. The Transit_Packages table contains information about software packages that have transit analysis and modeling capabilities. The Land_Use_Packages table contains information about software packages that have land use analysis capabilities. The Freight_Packages table contains information about software packages that have freight analysis and modeling capabilities. The IntegAppData table is a special table, which contains information about software packages' integration capabilities, their single license cost, their usage in the New Jersey transportation planning industry and the evaluation of their capabilities.

Functions

The four functions, Description, Comparison, Integration of Application and Database, listed in the main menu of the application, as shown in Figure 9, are

the main functions of the TSSS. In addition, a click on any transportation area of interest in the initial window gives the user access to a quick software review.
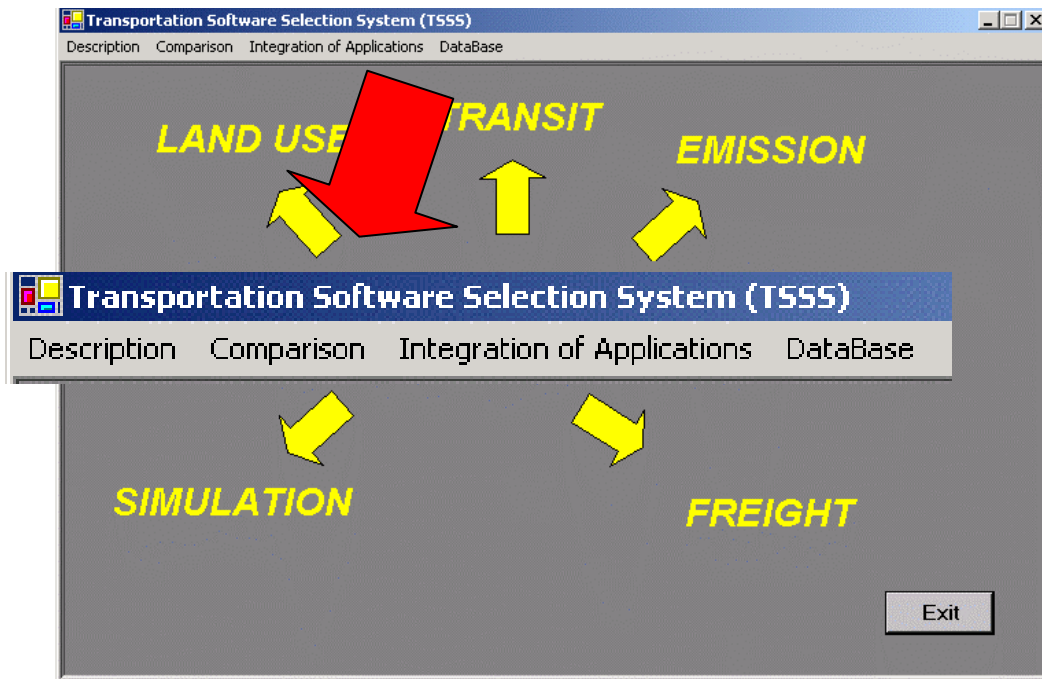

Figure 9: Main Screen

Description

This function displays information on five user-selected features of any software package. By clicking on the Description menu (figure 10) the user is allowed to select a category of software packages (figure 11). Then a new window pops up, which allows user to select a specific software package within a selected category (figure 12).
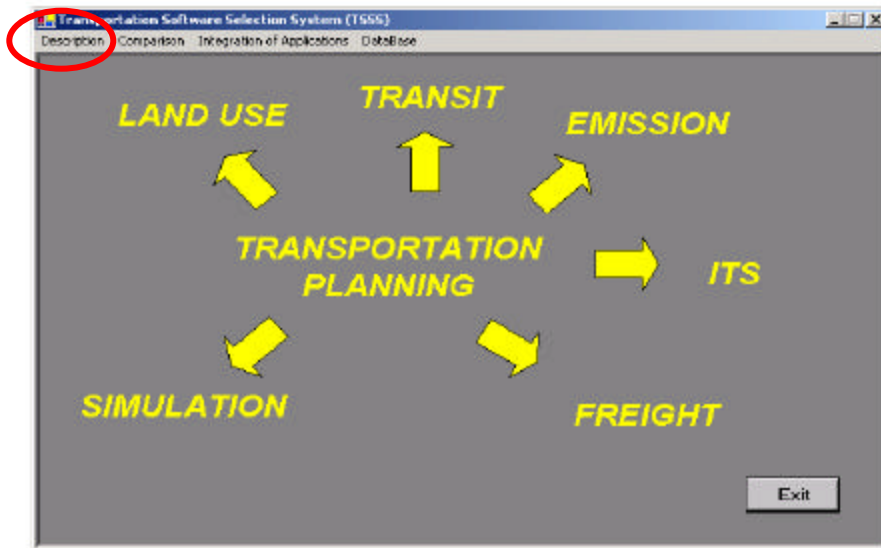
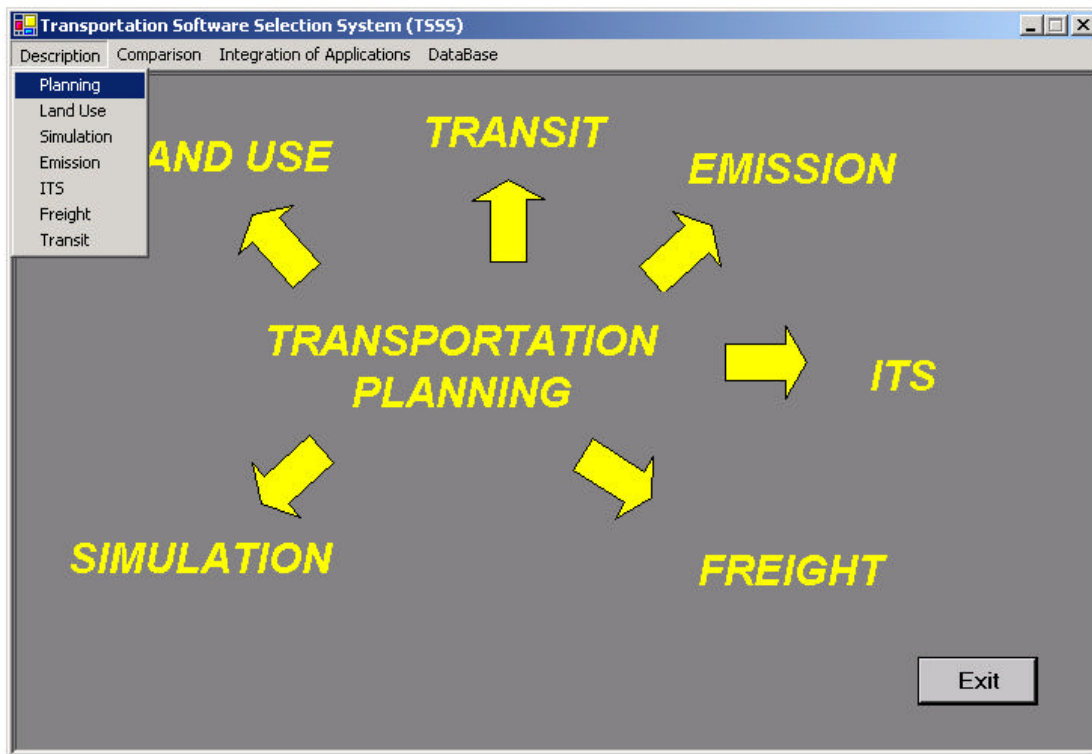Figure 10: Description Selection in the Main Menu
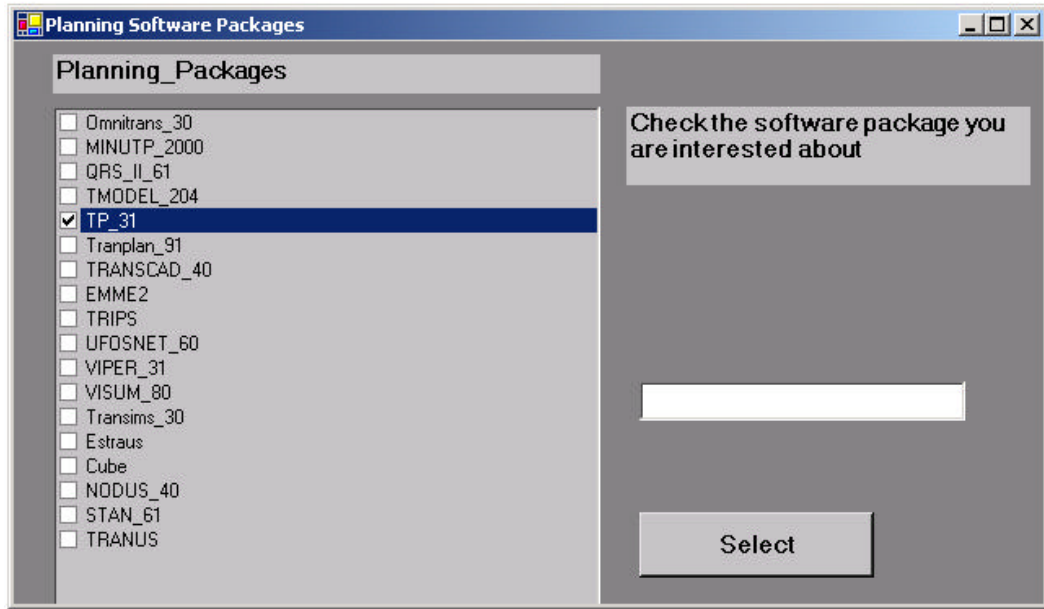

Figure 11: Menu selections within Description

Figure 12: Software Selection

After a particular software package has been selected a new window pops up (figure 13) in which the user selects the types of information s/he is interested in viewing.
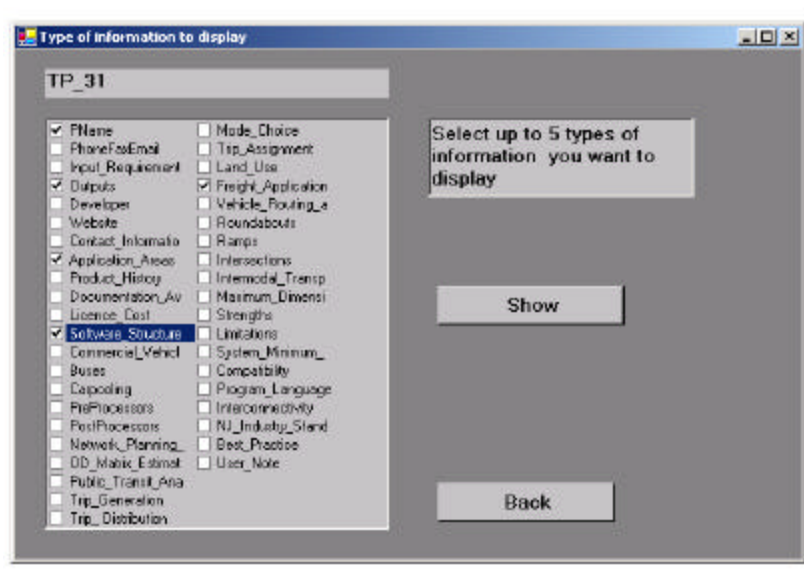

Figure 13: Feature Selection

The user may select up to five features from the list and click the SHOW button. A new window displaying the information on the selected features is displayed (figure 14).
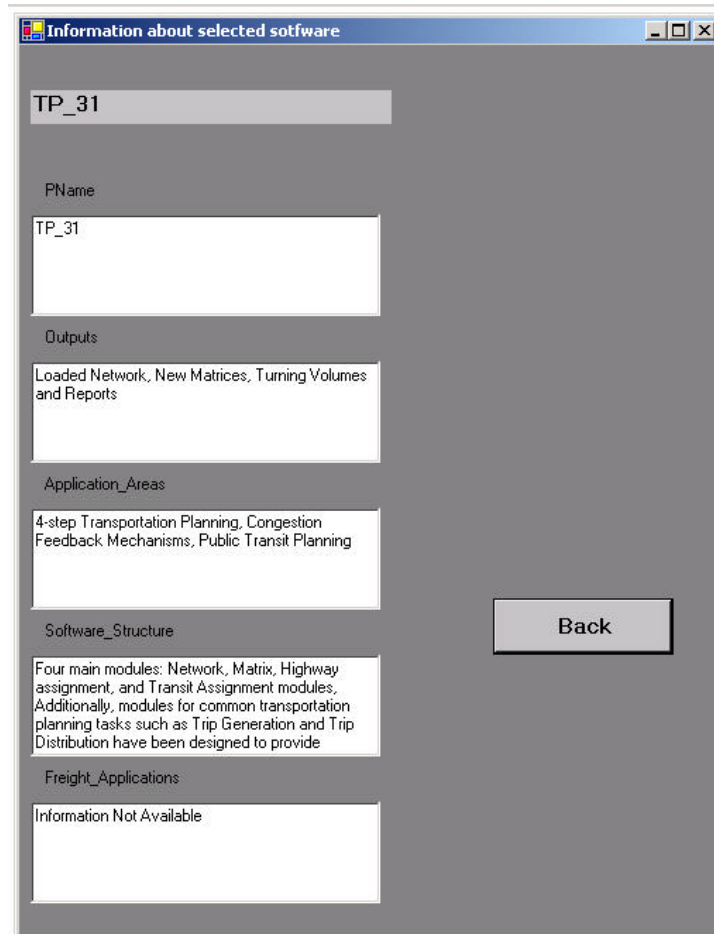

Figure 14: Selected Feature Information

By clicking on BACK at any step, the user may return to the previous window.

Comparison

The Comparison function (figure 15) allows the user to compare any two features of any two software packages from within a selected group.
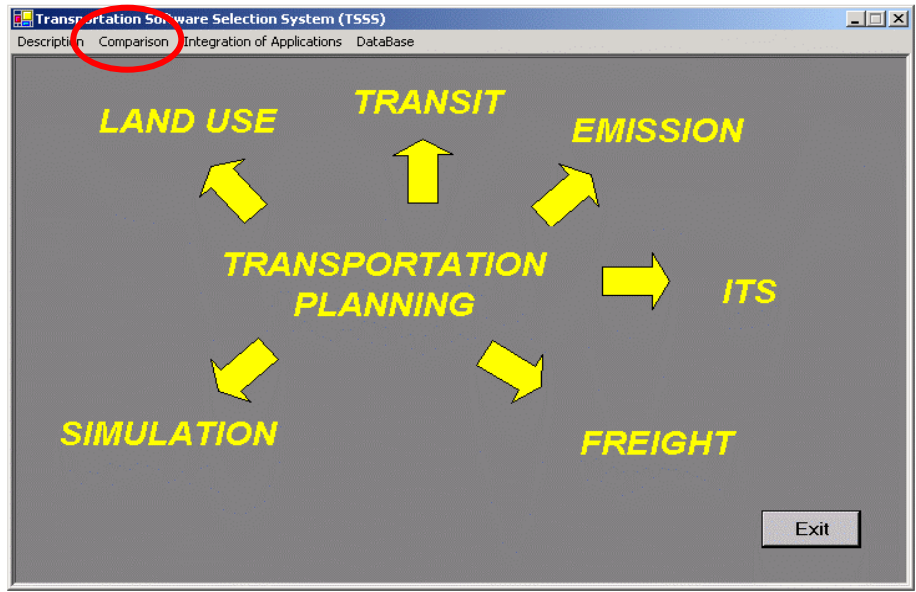
Figure 15: Comparison Function in the Main Menu

By clicking on the Comparison item on the main menu bar, the software package categories are being displayed (figure 16). The user may choose any one of these categories.
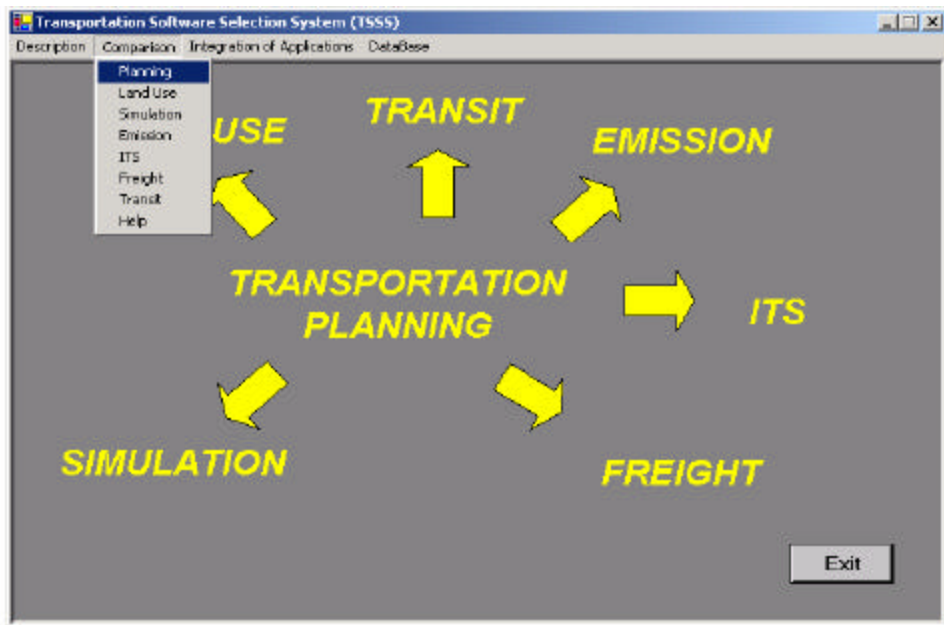

Figure 16: Software Package Categories

After the category has been chosen the user may select two software packages the features of which s/he wishes to compare and then click on the SELECT button (figure 17).

Figure 17: List of Packages within a Category
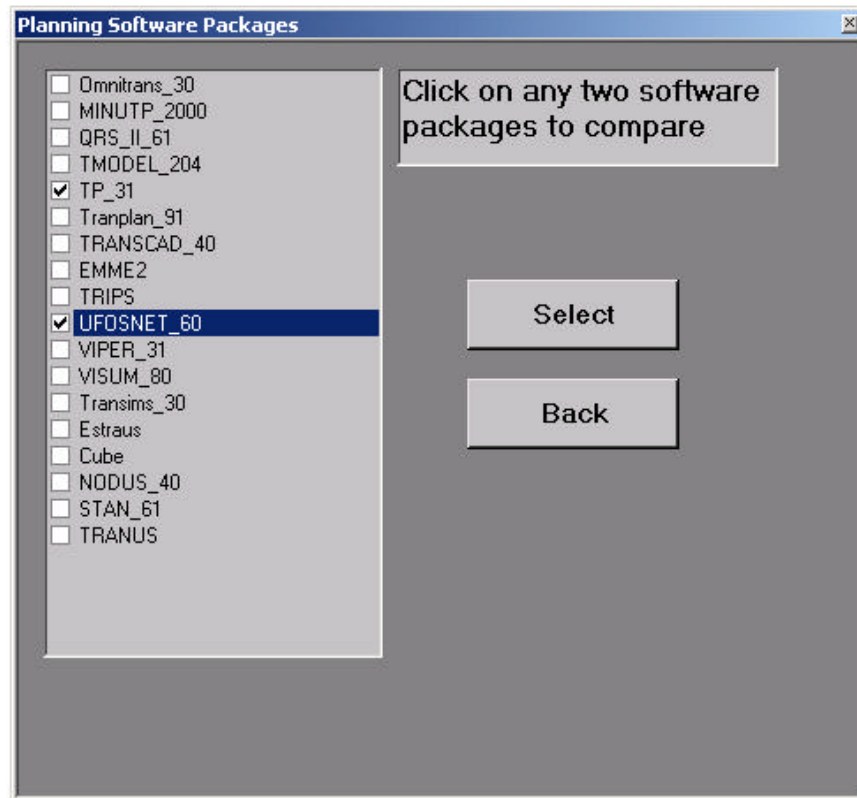
Next, a list of features to be compared is shown in a new window (figure 18). The user may select two of these features and then click on the COMPARE button. The results are shown in a new window (figure 19), which displays the two selected software packages and the features being compared.
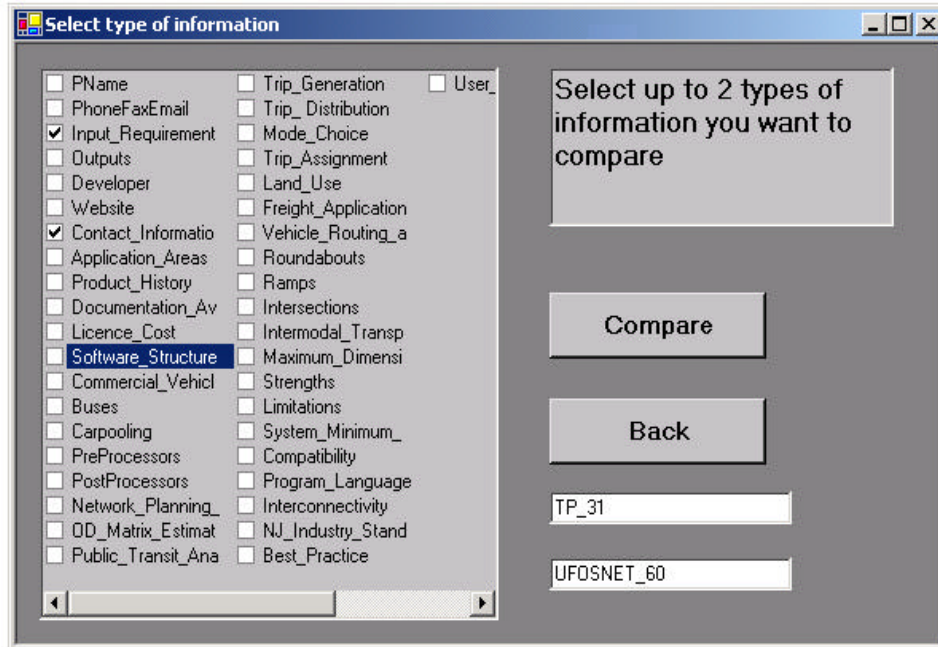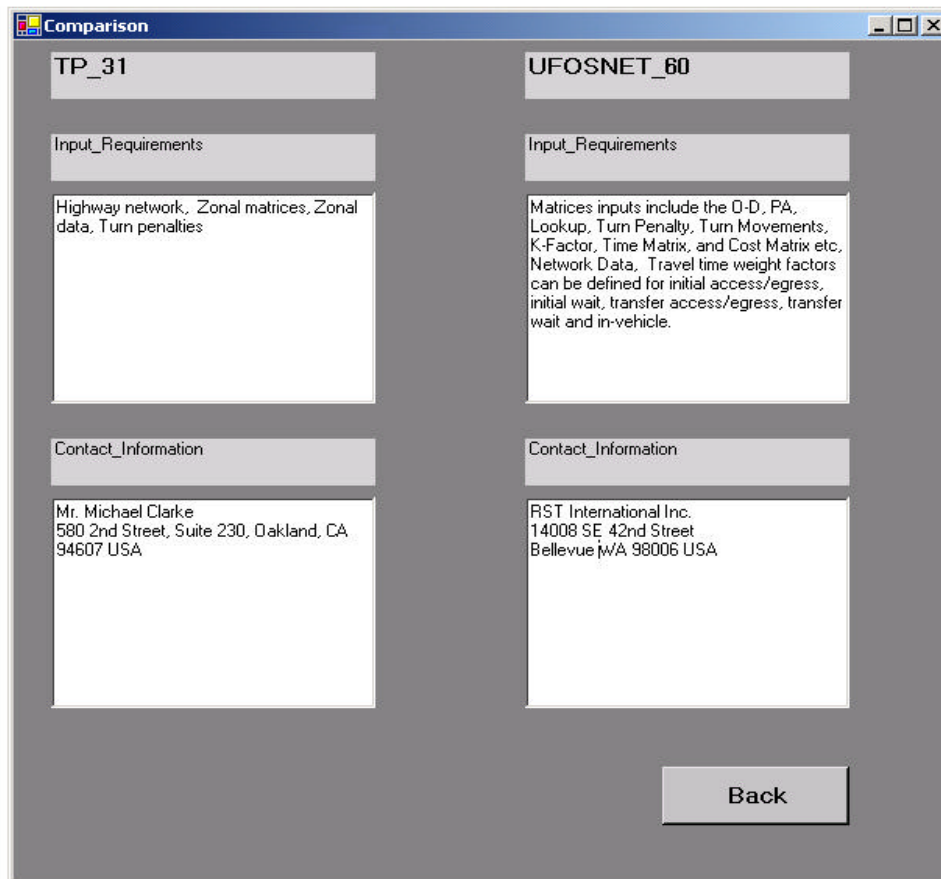
Figure 18: List of Features

Figure 19: Software Package Comparison base on Selected Features

Integration of Applications

The NJDOT Bureau of System Development and Analysis recently purchased CUBE Voyager as a tool for transportation planning applications. As a result, one of the focus areas of the TSSS tool was to provide the NJDOT the capability to determine the interconnectivity and easiness of integration of various software packages with CUBE Voyager.

The Integration of Applications function of TSSS allows the user to sort software packages according to their interconnectivity with Cube Voyager, their usage in the New Jersey industry, their single license cost and the evaluation of their strengths/limitations by transportation professionals.
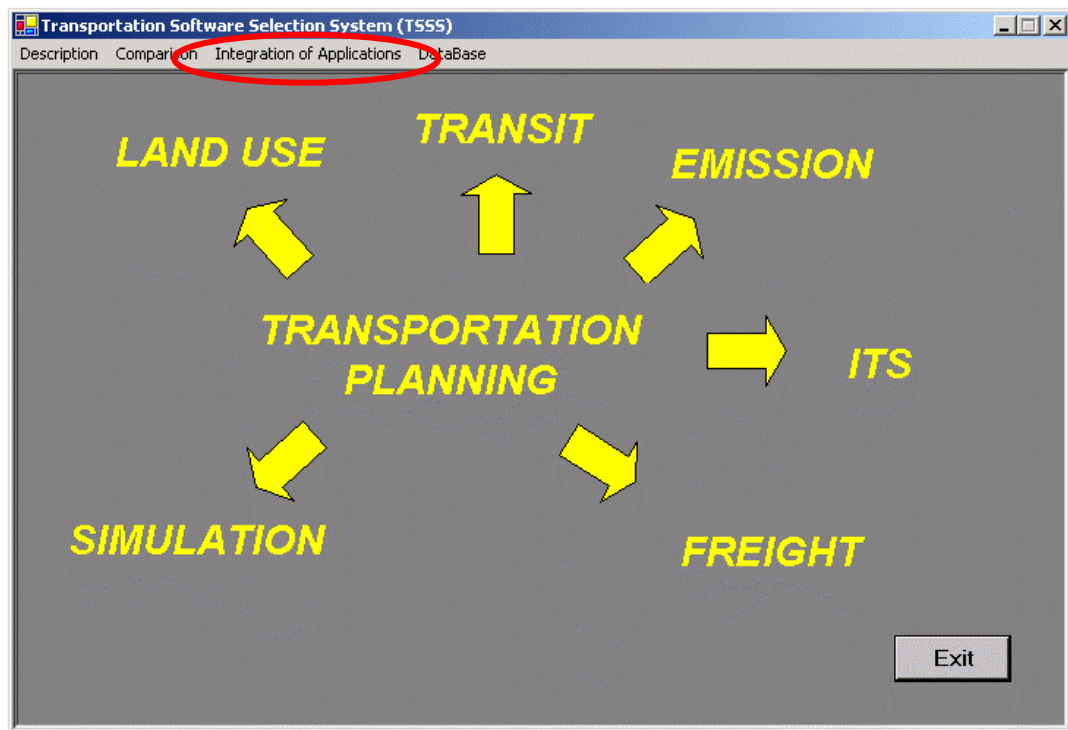

Figure 20: Integration of Applications Selection from the Main Menu

Clicking on the Integration of Applications selection in the main menu (figure 20) opens the list of transportation planning software packages. As Cube Voyager is the main application currently used by the NJDOT Bureau of Systems

Development and Analysis, this function has been fully developed only for this application. In the future, the tool may be expanded and fully developed for all software packages considered in this study. By selecting the Cube/Voyager, a list of types of applications appears (figure 21). The user may select the type of interest, which in turn opens a list of criteria.

By selecting any of these criteria, a window opens, displaying software packages, sorted according to the selected criteria.
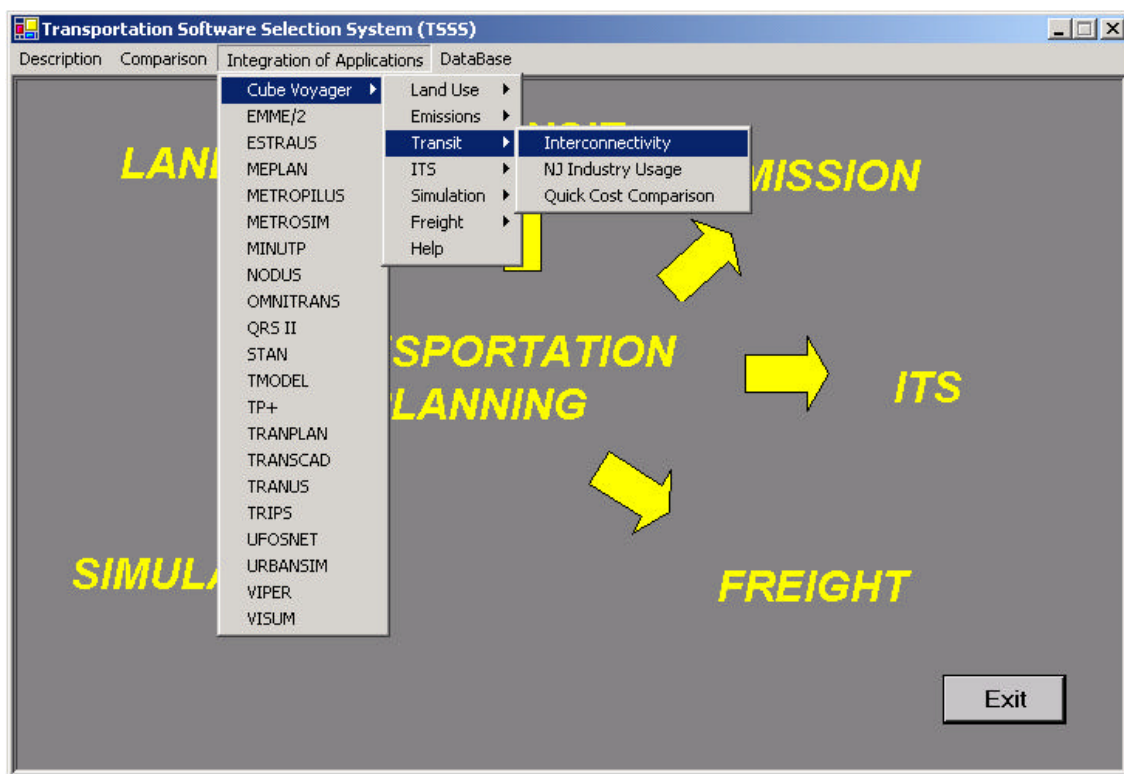
Figure 21: Integration of Applications Drop Down Menu

Interconnectivity

This criterion sorts all the available software packages into several categories (figure 22) according to the easiness with each they may be integrated with Cube Voyager.
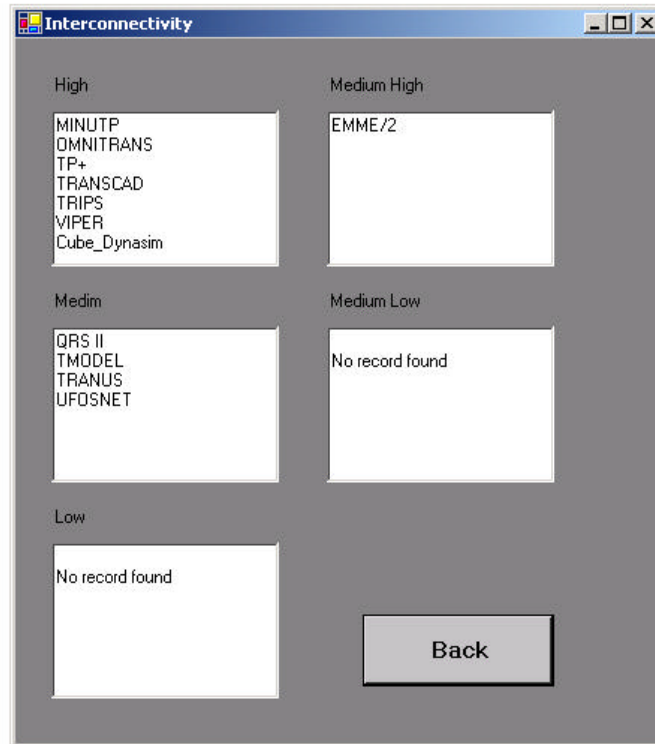
Figure 22: Interconnectivity Categories

A description of the categories is given below:

High: Direct import/export between software packages, maximum interconnectivity

Medium-high: Network data files may be read directly between software packages (TP+, Minutp, etc)
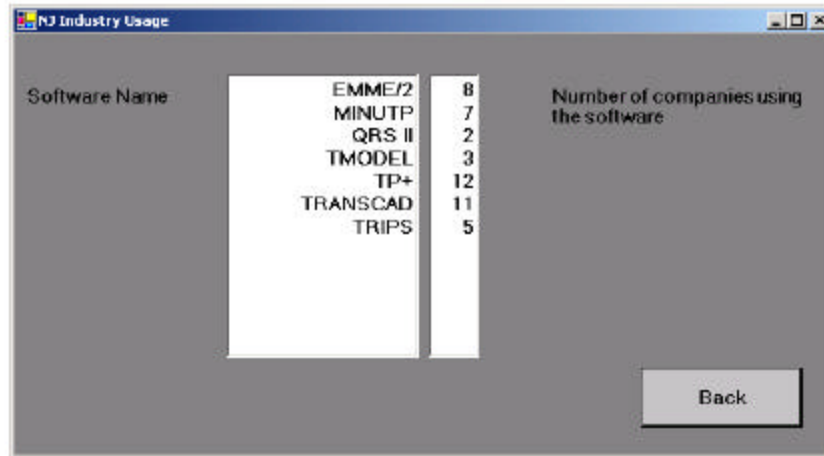
Medium: The general data files are common, like database, GIS shapefiles, etc.

Low-medium: Transferring of data between software packages is possible, but it requires significant effort (spreadsheet outputs)

Low: There is a possibility to transfer data between software packages but this task requires programming expertise

Level of Usage by the NJ Transportation Industry

This criterion sorts all the available software packages from within a selected category according to their degree of usage in the NJ Industry (figure 233).
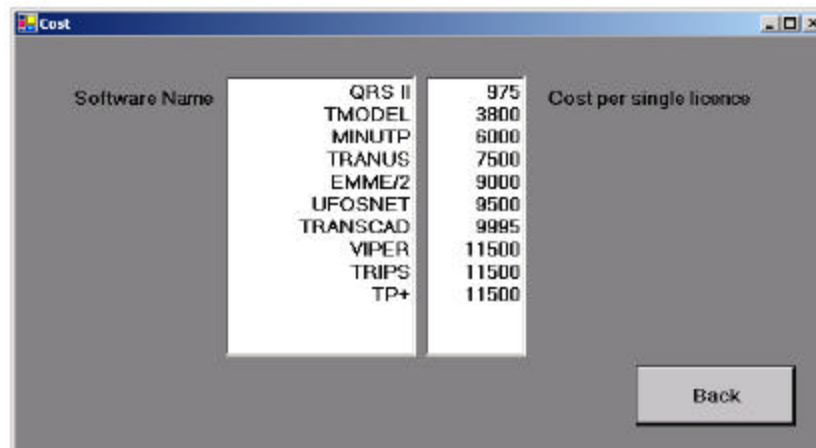
Figure 23: Classification based on Industry Usage

Data related to software usage has been obtained from the survey and is stored in the software database. The software packages are listed based on that data.

Cost

This criterion sorts the software packages according to their single license costs (figure 24).

Figure 24: Classification Based on Single License Cost

DataBase

This feature allows a user to easily add new software packages, update information contained in the database and delete records about software packages. Clicking on *Database* in the main menu bar opens a drop-down list containing Add, Edit/Update and Delete item (figure 25).
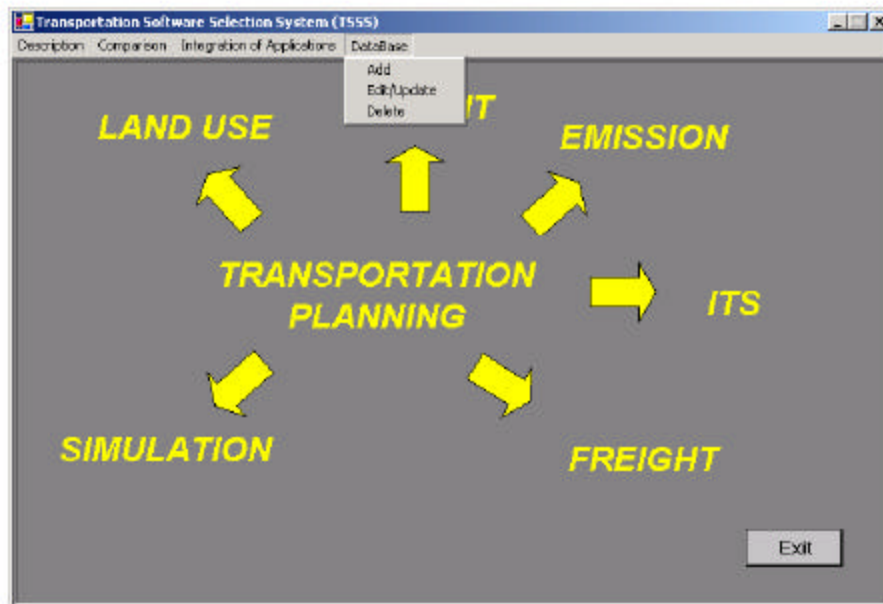
Figure 25: DataBase Drop Down Menu

Clicking on any item opens a new window where the user selects a software group that contains his/her software of interest. This part is common to all three options.

Add

After the software group, where we want to add new software package, was selected and the name of new software package was typed into textbox, the user press ADD button and the software package was added into the database (figure 26).
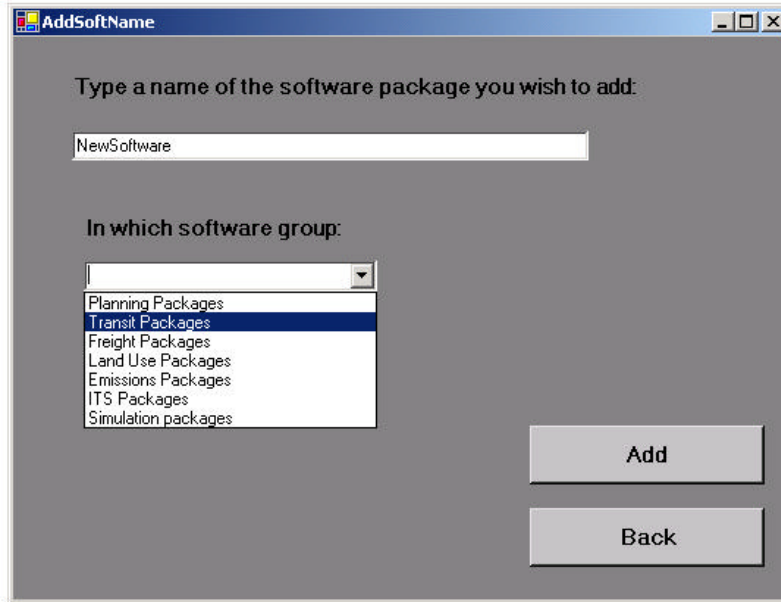
Figure 26: Adding New Software Package to the Database

Edit/Update

After the selection of the software group and a click on the SELECT button (figure 27), a new window, opens up (figure 28).
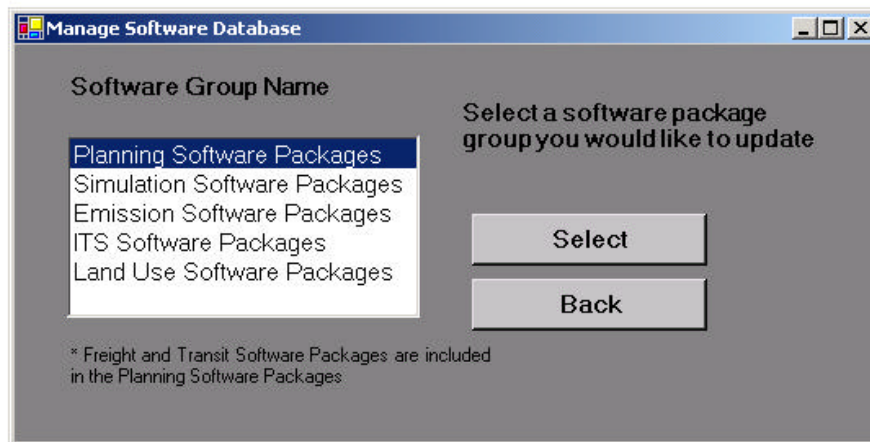
Figure 27: Software Group selection
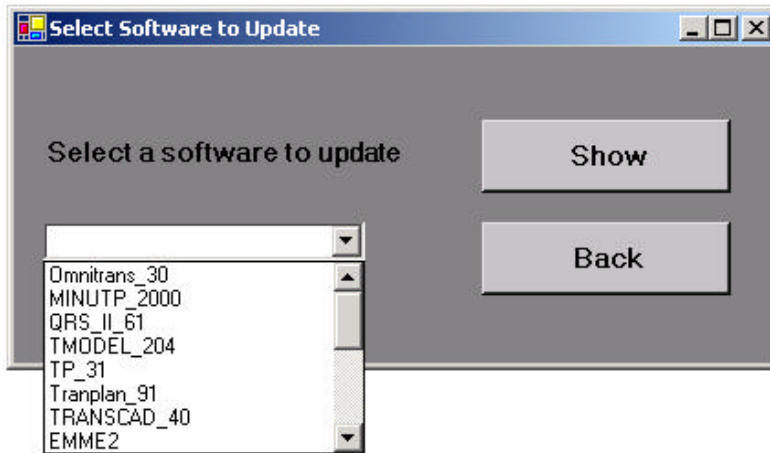
Figure 28: Software Package selection

From the list, the user selects a software package of interest, clicks on SHOW button and another window pops up.
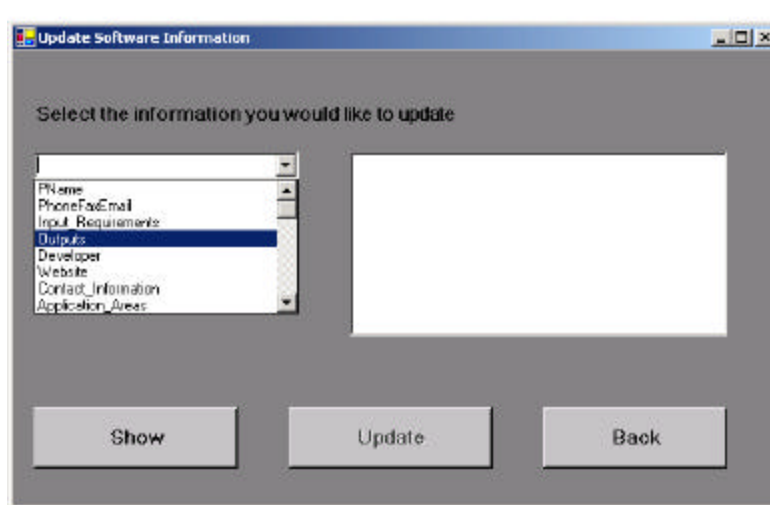
Figure 29: Type of Information selection

Now, the user selects the information he/she wants to edit/update and clicks on SHOW button. The information is displayed in the small window. The user can include changes and after that is done, he/she clicks on UPDATE button and the database is update.

Delete

After the software group was selected and SELECT button was pressed (figure 30),
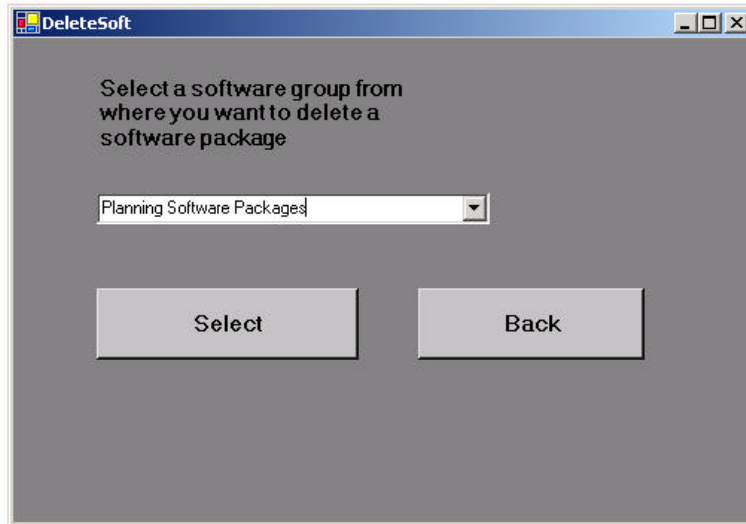
Figure 30: Software Group selection

a new window, containing the list of software packages in that group, pops up. The user selects the software package s/he wants to remove from the database and clicks delete. The software package is then removed from the database (figure 31).
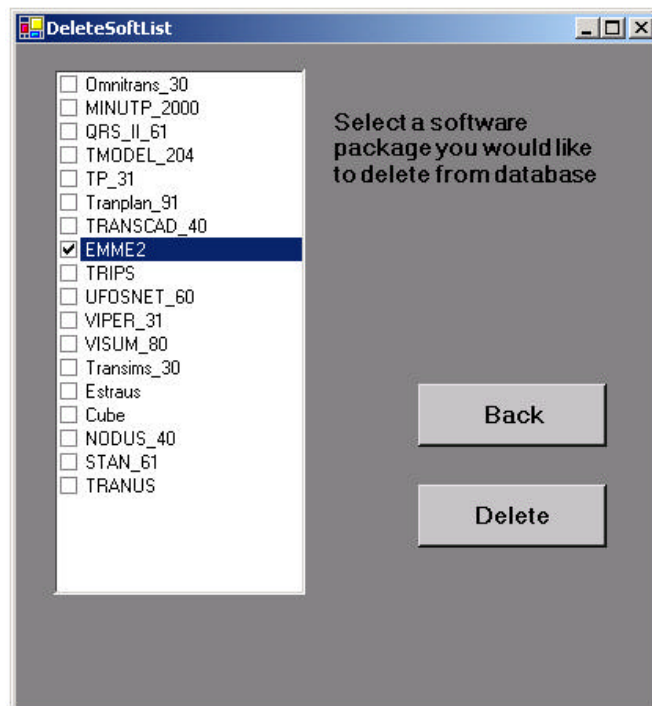
Figure 31: Select Software Package for deletion

Quick Review Function

This allows the user to quickly find information about any software package of interest from any transportation field. A click on the transportation field of interest on the initial window of the application opens a new window (figure 32). In this window the user may choose a software package from the selected field, and the type of information s/he is interested in.
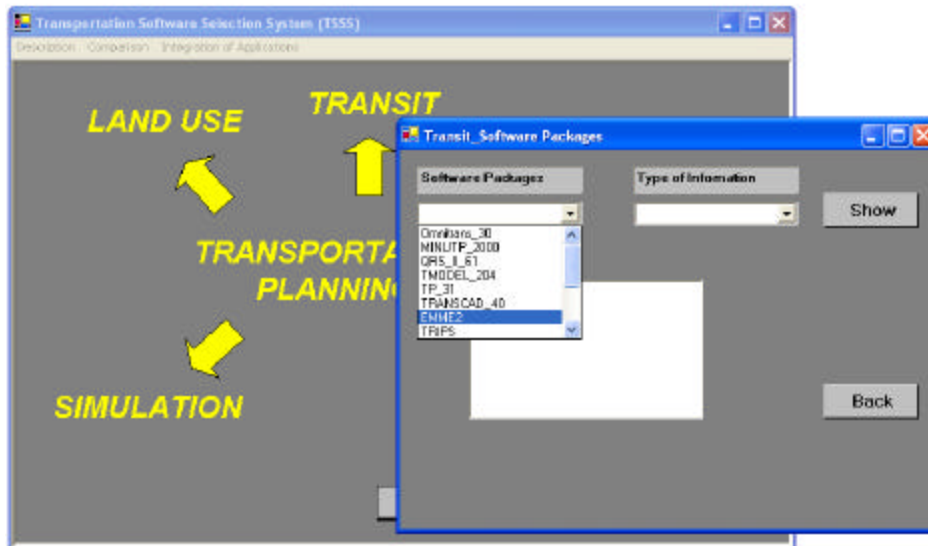
Figure 32: Quick Information Search

Clicking on the SHOW button displays the selected information (figure 33), as a result of the query.
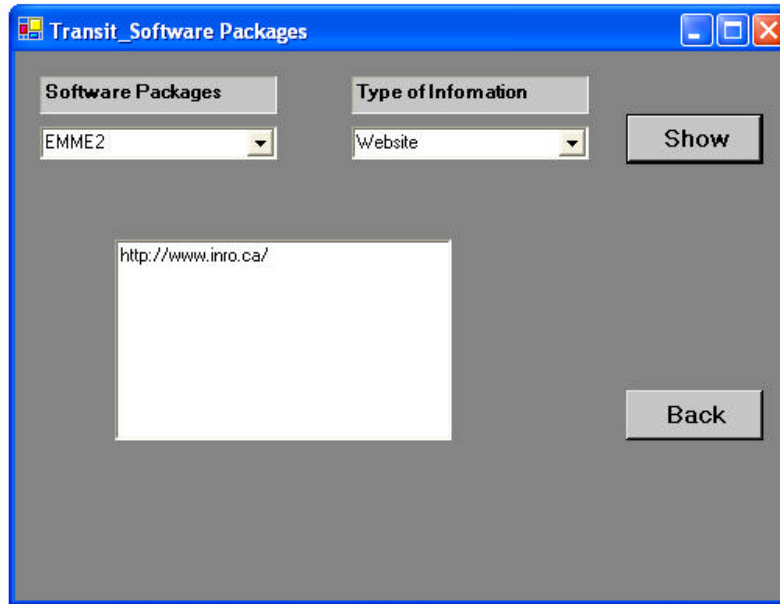
Figure 33: Query Results from the Quick Review Function

Use of this tool may support the software selection effort, given that CUBE Voyager has been selected by the NJDOT as the transportation planning application tool. If the Bureau of System Development and Analysis wishes to upgrade their tools in other application areas, the TSSS may be used to provide useful information on the features and costs of the available packages, perform a comparative analysis between packages and determine the level of effort required to integrate an application with CUBE Voyager.

SUMMARY OF FINDINGS AND FUTURE DIRECTION

This section provides a summary of the project findings and recommendations. A summary of the survey findings is presented first, followed by the comparison between private and public organization responses. Finally, future trends in transportation modeling and some concluding remarks are presented.

Summary of Survey Findings

The objective of the survey performed as part of this project was to determine the users' perspective on the overall use as well as on specific features of

transportation software packages. The survey produced several significant findings, including the following:

The majority of respondents rely on widely used transportation planning packages like Tranplan, MINUTP and TP+. Long time tradition in using these tools seems to be an important factor for the continued use of these packages, even when alternatives that seem to have increased capabilities are commercially available. Additionally, these tools are widely used, and transportation professionals may easily relate their analyses and results to their sponsors and collaborators who are also using the same modeling tools.

There is an increasing demand for sound graphical interface, GIS capabilities, integration with land-use packages, sound import-export functions, modeling of emissions, transit-forecasting capabilities and modeling of toll facilities. These capabilities are incorporated in software packages like TransCAD, EMME/2 and CUBE.

The majority of respondents use traffic simulation software packages like Integration, Corsim, and Paramics. There is an increasing demand for simulation packages with sound graphical interface, ability to model ITS facilities, roundabouts, pedestrians, toll facilities, emissions and parking. Also, there is a stated need to add capabilities to model commercial vehicles and Highway Capacity Manual requirements.

Software packages like VISSIM, Synchro, Paramics, UrbanSIM and HCS 2000 are viewed as future trends in simulation modeling packages.

Since there are an abundance of available transportation planning and traffic simulation packages the criteria to select a proper package should be project based. However one should look for tools with a friendly user interface, network modification and creation structure, traffic generation / distribution, vehicle / driver classification, route selection / traffic assignment, ITS modeling capabilities, incident simulation / traffic control and measure of effectiveness.

Land use modeling is mainly done using software packages like DRAM/EMPAL, METROSIM, TransCAD, ARCVIEW GIS and UrbanSIM. New packages that can be integrated with transportation demand modeling packages are still under development. However packages like TransCAD, CUBE and EMME/2 are viewed and used as integrated transportation planning and land use software packages.

Emissions modeling packages like MOBILE, PPSUITE and CAL3QHC are among the most widely used emissions modeling software packages. MOBILE is the industry standard in emissions modeling.

ITS modeling is mainly done using VISSIM, IDAS and INTEGRATION. There is a need to develop simulation packages that are capable of doing ITS modeling.

The Highway Capacity Software (HCS) is the industry standard for signalized intersections since it is the implementation of the Highway Capacity Manual. HCS only performs the procedures in the manual. Developers have sensed the need for other functionality such as additional performance measures, usual geometry and design features. Recent additions to the suite of intersection analysis tools have tended to combine this expanded functionality with either the HCM procedures by imbedding them directly or by linking to the HCS.

The main concern of the industry to accept any under-development software package like TRANSIMS is that it is not yet fully tested and proved, and of course it is not an industry standard. The selection of any software package is still dependent on client requirements and decisions. All 28 respondents believe that a new package can only be used if a client is ready to accept it. Twelve of the respondents believed that any new software should be validated with real world data before it is accepted by the industry. Requirement of proper documentation and support to accept TRANSIMS was voted by sixteen of the respondents. The fact that TRANSIMS cannot run on a single PC was identified as one of its deficiencies by 11 of the respondents. All 28 respondents believe that it is not

very cost effective. Fourteen of the respondents believe that TRANSIMS requires cumbersome data input and six respondents believe that outputs of TRANSIMS are not interpretable. Eleven respondents would require TRANSIMS to have easy integration with database and GIS capabilities. From the views of respondents on TRANSIMS it seems that more research, testing and documentation is still required on the development of TRANSIMS for the industry to consider adopting it.

Private vs. Public Organization Needs

The limited number of responses from public agencies limited the comparison to private agencies to only transportation planning software programs and emissions models. Because there were only few public agency responses that were analyzed, first, the general trend among private agencies was looked at. Then, it was examined to see if the software programs used by public agencies matched that of private agencies.

The most popular transportation planning software programs among private consultants were CUBE (7), TRANSCAD (6), TRANPLAN (6), MINUTP (4), EMME2 (2), TMODEL (2) and QRSII (2). Of these, three public agencies reported using CUBE, three reported using TRANPLAN, one reported using EMME2, and one reported using TMODEL for transportation planning. The software programs used by public agencies were among the most popular programs used by private agencies.

Similarly, private users named various versions of MOBILE as the most popular tool for modeling emissions. It was also the most popular among public agencies.

Regarding their willingness to use new and developing software programs, private consulting agencies were hesitant to use new software programs, dependent mostly on the cost and the desires of their clients. One respondent from a public agency reported that he would consider using a new software

program under certain circumstances, while another respondent said that he would not.

Regarding their willingness to use TRANSIMS, private consulting agencies seemed rather cautious, depending mostly on the cost compared to the improved benefits. Of the small number of public responses, two respondents indicated they would not be interested in using TRANSIMS.

Future Trends

One of the objectives of this research was to identify current and future trends in the use of transportation modeling tools. As a result of the survey and the literature review, the following observations can be made.

Although the general tendency is towards "traditional" type of planning tools, there is a need for supporting capabilities such as microsimulation analysis and GIS based visual support. In addition to the industry preferences and tendencies, there are federal directions and requirements such as those for inclusion of freight considerations in the planning process and integration of land use and transportation modeling.

Overall, there is a need for tools that are capable of covering a wide range of applications. Traditional package capabilities need to be complemented by other tools or upgraded to include additional capabilities. Integrated tools seem to be preferred by the users.

In transitioning from a current application to a new one, the level of integration and interoperability as well as the ease of transition are major factors being considered.

There is a strong push from the research community for tools with dynamic network analysis capabilities. These tools seem to be more accurate in terms of traffic flow estimations, impacts, and emissions modeling. Although an increasing number of agencies are supporting the testing of these tools, it is not likely that

they will be widely adopted by the industry within the five-year time horizon of this project.

As a next generation tool TRANSIMS has the potential to revolutionize transportation and land use planning and modeling. TRANSIMS has the capability to model the transportation system and the individuals who use it with greater detail than ever before. However, such complexity comes at the price of much greater data collection and computer resources. TRANSIMS requires highly detailed data and road network information, and it is not as forgiving as less complex software packages. This problem was discussed in a conversation with a representative from the FHWA in October 2002 as it related to the Portland Case Study. Potential TRANSIMS users need to decide if they have the capabilities to provide such detailed data inputs, and if expending their resources to provide such detailed input is worth the benefits of detailed microsimulation. Still, TRANSIMS may become the best available option to accommodate increased pressure from federal legislation such as ISTEA and the Clean Air Act Amendments. TRANSIMS needs to be a user-friendly software program if it is to be successful. This is expected to happen as demand for this program increases.

CONCLUSIONS

The NJDOT Bureau of Systems Development and Analysis has selected the software package Cube Voyager as their main modeling platform. The results of the survey that was performed as part of this study support the Bureau's selection of Cube Voyager. Cube Voyager, although relatively new compared to other software packages listed in the survey is widely used by the New Jersey Industry. Furthermore, Cube was among the software packages that survey respondents indicated that are familiar with and which they would like to use in place of other packages that they are currently using.

Additional tools or modeling software will be required for several applications, which may not be performed using Cube Voyager. For these types of applications, the Bureau of Systems Development and Analysis and other

Bureaus within the NJDOT would need to select the appropriate tools. In selecting additional tools and modeling software, one should consider several factors, including, the suitability of the software package for the particular application and its capabilities, along with cost, and interconnectivity with other software packages and tools currently available within the organization. The TSSS tool that has been developed as part of this project may be used to review the features and capabilities of various software packages, perform a comparative evaluation of any two software packages and assist the NJDOT personnel in selecting the additional modules and modeling software needed to complement the capabilities of Cube Voyager and cover the Department's modeling needs.

APPENDICES

APPENDIX A.

TRANSIMS

One of the requirements of this study was to take a closer look into the newly developed program, TRANSIMS. This appendix presents a comprehensive review of TRANSIMS, including experiences from its applications. The modeling philosophy of TRANSIMS is unique as compared to the other software packages that are reviewed in previous sections. For this purpose, TRANSIMS has not been included in the software review and summary matrix sections.

Introduction

Amendments to existing and other recent legislation created requirements that could not be fully met with the current transportation modeling tools available. The U.S. Department of Transportation, under TEA 21, funded the University of California at Los Alamos National Laboratory (LANL) to design TRANSIMS to address the requirements of the new legislation. Development of TRANSIMS has been funded mainly by the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA), with some additional funding through the Environmental Protection Agency (EPA).

TRANSIMS uses a disaggregate approach to traffic modeling, providing more accurate and comprehensive information on traffic, congestion, and pollution. Populations are analyzed on an individual basis rather than a Travel Analysis Zone (TAZ) as in traditional 4-step models. In addition, the entire transportation network, including local streets, highway ramps, and transit routes are modeled. Using survey data, a virtual population is created, representing the actual community to be studied. Individual households and travelers with their own activities patterns are used to create a set of travel plans, which are then simulated in the transportation network.

TRANSIMS has the ability to model multiple modes of transportation, including private auto, public transit, freight, and bicyclists and pedestrians, which interact with each other on a second-by-second basis. Using a feedback mechanism, travelers may change route or mode based on trip length, time, and perceived level of service (LOS). By tracking individuals with various demographic characteristics, TRANSIMS can also model the effect of a project on sub-populations such as low-income or minority groups. [50]

Federal Legislation and the Need for TRANSIMS

The Intermodal Surface Transportation Efficiency Act (ISTEA) and the Clean Air Act Amendments (CAAA) are the two most influential pieces of legislation when it comes to TRANSIMS. Their analytical requirements exceed the capabilities of the models that are currently being used. In their paper "TRANSIMS Model Design Criteria as Derived from Federal Legislation", Morrison and Loose point the importance of addressing infrastructure, congestion, and air quality more precisely to meet the demands of ISTEA and CAAA. [51]

<u>**ISTEA and CAAA requirements and TRANSIMS**</u>

The demands addressed by TRANSIMS are mentioned in this chapter. Title I of ISTEA provides funding for projects that improve air quality as a result of decreased congestion, improved safety, improved public transportation, intermodal transportation projects, and traffic monitoring[51]. Title III of ISTEA requires the planning and management of transit programs, as well as a means of analyzing proposed projects. ISTEA also requires that each state develops and implements a state planning process. State Transportation Improvement Program (STIP, created by ISTEA) requires that State Planning Organizations and Metropolitan Planning Organizations (MPO's) must submit plans that include intermodal planning, a 20-year planning horizon, and coordinated state and local plans that include congestion management strategies. A State Public Transportation Management system is to be created to identify needs so that cost effective strategies can be developed to maintain and improve public

transportation. A State Intermodal Management System is required to analyze linkages between one or more modes of transportation. CAAA requires that transportation planners must prepare long-range transportation demand forecast and model air quality as a function of increased travel demand and changes in transportation network. It also requires the development of a model that recognizes differences in engineering design between vehicles and also requires capabilities to model alternative fuel sources. Most of current models are not able to fulfill these requirements to the extent that TRANSIMS is expected to.

Functional Requirements for TRANSIMS

The legislation described about requires that TRANSIMS is different from current planning models, providing more accurate and detailed analysis. TRANSIMS must be flexible and functional to transportation planners in numerous types of applications, including those that necessitate intermodal applications. Other modeling requirements according to Morrison and Loose[51] include:

- Land use and demographic characteristics of different regional transportation domains.
- The Natural environment, including topography, meteorology, and background pollution.
- A transportation network including minor arterials and all potential nodes.
- Representative populations for residential, commercial, and industrial entities.
- Unique travel decisions of individuals with a wide range of socioeconomic characteristics.
- Detailed automobile and commercial transportation systems to analyze the effects of different engines and fuels on air quality emissions.
- The consequences of traffic on congestion and air quality. [51]

The individual level analysis associated with microsimulation will require the representation of complicated behavior as well as choice/utility modeling that is dependent on travel time, travel behavior, cost, and perceived quality of service. The TRANSIMS model must consider the demographics of each individual modeled to accurately portray their effect on fuel consumption and congestion. Individual vehicle characteristics are also needed to model fuel consumption and emissions. It is also necessary for TRANSIMS to accurately model land use patterns. This is necessary to create activity zones and linking origins and destinations.

TRANSIMS needs to accurately represent the transportation infrastructure, including "intersection and roadway widths and lanes, grade, parking freight, mode transfer facilities, HOV lane miles, node characteristics, roadway functional class, and type and location of construction". [51] Also modeled needs to be:

- Operational characteristics – channelization, traffic control, ramp metering;
- HOV lanes;
- Public transit rights-of-way;
- Park and ride; and
- Travel cost data including tolls and congestion pricing.

Measures of Effectiveness and outputs that should be reported by TRANSIMS include:

- Level of Service (LOS);
- Vehicle miles of travel and average daily traffic by vehicle class;
- Number of vehicles using HOV lanes;
- Proportion of vehicles congested or delayed;
- Proportion of travel time under congestion or delay;
- Nature and location of congestion and incidents;
- Average travel time per trip;

- Vehicle speed and acceleration;
- Vehicle, fuel, and engine characteristics; and
- Startup and idling.

Computer Requirements

A parallel computer system will decrease the time required to run the TRANSIMS modules. A Linux cluster running RedHat Linux 6.2 with a 100-gigabyte disk accessible from all 64 dual-processor nodes with Intel Pentium II 500 processors was used in the Portland study. There was 1 gigabyte of memory per node and a 100 megabit/sec Ethernet connection between the nodes. A shared memory multi-processor system by Sun Microsystems was used for code development, data analysis, network construction, and computations that required less than 14 processors. The system had 6 gigabytes of memory, 300 gigabytes of disk, and a Solaris 7 operating system. [50]

The Six Modules of TRANSIMS

TRANSIMS is composed of 6 integrated modules: a Population Synthesizer, an Activity Generator, a Router, a Microsimulator, a Selector and Iteration Database, and an Emissions Estimator. The Population Synthesizer is based on a synthetic population based on demographics obtained from census data and demographic forecasts. The Activity Generator assigns activities to the synthetic travelers. Each individual is assigned a daily list of activities including work, school, and shopping. The Router provides travel plans for each individual by determining the shortest route. The Microsimulator executes the travel plans created by the Router and produces detailed information about individual vehicles and the transportation network. Finally, the Emissions Estimator models the emissions of nitrogen oxides, hydrocarbons, carbon monoxide, and carbon dioxide. Each module is further described below.

Data Tables

A series of interconnected data tables are used in TRANSIMS. Each module depends on the data found in some or all of these data tables. [53] These tables include nodes, links, pocket lanes, parking locations, activity locations, process links, transit stops and schedules, connectivity, signs, and signals and signal phases.

The node table identifies each node as a point with X (Easting), Y (Northing), and Z (Elevation) coordinates. Nodes do not represent intersections, but provide the locations of all features and the anchors of link segments. The Portland Network described in further detail later on in this report has approximately 101,000 nodes. [54]

The link table identifies all links, which connect two nodes. Links represent roadways, walkways, and all connections between nodes by any mode of transportation. Link tables identify the number of lanes on a link, the type of vehicles and travel modes allowed (can be multimodal), and the speed. The length of a link, link grade, capacity, and function class are also identified. The Portland Network contains approximately 126,000 links. [54]

The pocket lane table identifies on which link each pocket lane lines, the starting position, the length, the lane number, and the type of pocket lanes (turn, pull-out, merge). The Portland Network contained approximately 4,400 pocket lanes.

Parking locations are places where vehicles may enter and exit links. This table identifies the location of a parking entrance from the link, the capacity, the types of vehicles permitted to park, and the type of parking place (parallel, driveway, lot, park and ride, etc…) The Portland Network has approximately 123,000 parking locations (Henson, 2001).

Activity locations identify places from which household members travel and are associated with the particular layer with which they are accessed from (i.e. auto,

walk, light rail, etc…). The link ID number that the activity is located is identified in this table, as well as the X, Y and Z coordinates of node on which the activity lies (Henson, 2001).

Process links are represented by process links that allow for travel between parking, activities, and transit. These links are designated as walk links, and have their own delays and costs. The process link table identifies the type of locations that the link joins. The Portland Network had over 500,000 process links. [54]

Transit stops can be used by more than one transit route and can be connected to other stops, parking, and activities with process links. The transit stop table identifies the type of vehicles that stop at the location, the type of stop (stop or station), the capacity of vehicles that can stop, and the node and link on which the stop occurs. The Portland Network has approximately 8,000 transit stops. [54]

Transit routes and schedules are identified by a route ID with a departure time and a transit stop ID. A schedule files identifies a list of stops and the time a transit vehicle leaves the stop. [54]

A connectivity table identifies which movements are allowed at a node. The node, incoming and outgoing links, and incoming and outgoing lanes are identified in these tables. The traffic signal and phase's table can be created based on actual data. Additional tables can be created for detectors and signal coordinators. Unsignalized nodes (stop sign, yield sign, or nothing) can also be represented. [54]

Population Synthesizer

The Population Synthesizer creates a population identical in the number of people and the number of households to the actual population modeled using census summary data and Public Use Microdata Samples (PUMS) detailed census sample. These sources provide sufficient information to assign demographic characteristics to each household as well as determining the

locations of the individual households and vehicles in the transportation network. Population characteristics taken into consideration include gender, age, education, employment, income and preferred vehicle choice. Vehicles are assigned to households using DMV records. [55] Figure 34 summarizes the inputs and outputs of the Population Synthesizer. It was found through validations that synthetic populations generated this way have desirable characteristics and match true populations. [55]

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│                        ┌──────────┐                         │
│                        │   DMV    │                         │
│      ┌──────────────┐  │ Records  │   ┌──────────────┐      │
│      │ Census Data  │  └──────────┘   │    PUMS      │      │
│      └──────────────┘                 └──────────────┘      │
│                                                             │
│                    ┌──────────────────┐                     │
│                    │   Population      │                     │
│                    │   Synthesizer     │                     │
│                    └──────────────────┘                     │
│                             │                               │
│      ┌──────────────────────────────────────────────┐      │
│      │     Synthetic Households and Vehicles         │      │
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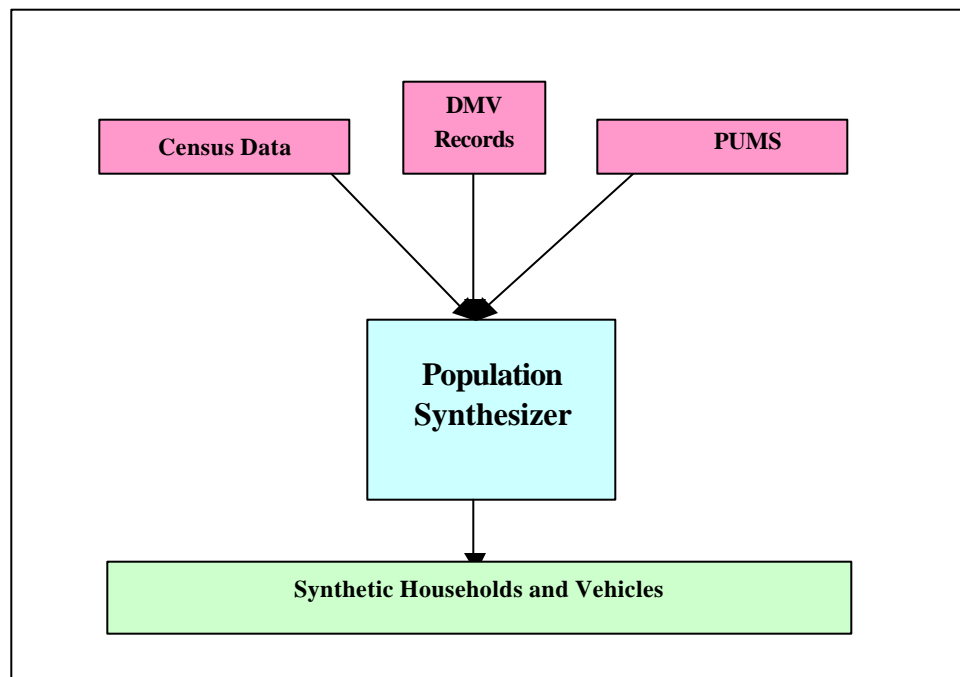
Figure 34: Inputs and Outputs of the Populations Synthesizer

More detailed information on the algorithms used to create a synthetic population in TRANSIMS can be found at the Los Alamos National Lab's TRANSIMS documentation repository in TRANSIMS 2.1 Documents, Volume 3, Chapter 2.[55]

Activity Generator

The Activity Generator uses household travel activities surveys for the area to assign activities to the individual households. Each individual is given a list of

daily activities, whose locations are specified by the user. Itinerant travelers, such as truck drivers, are given activities based on origin-destination tables. Activities are located based on land use and employment data for an area.

The purpose of the Activity Generator is to illustrate household behavior, not just travel patterns for an individual. In addition, the Activity Generator receives feedback from the Traffic Microsimulator and Router to improve activity locations. Figure 35 illustrates the inputs and outputs of the Activity Generator.

Input for the Activity Generator is from the synthetic population created in the Population Synthesizer, as well as household activity surveys that provide detailed information on travel and activity participation of all household members. Network data including nodes, links, activity locations, and travel times are also inputs. Outputs are a list of activities including the participants, activity type, activity priority, starting time, ending time, duration, mode preference, vehicle preference, and possible locations. Decision trees are used in the algorithm to create the set of activities that best meet each individual.
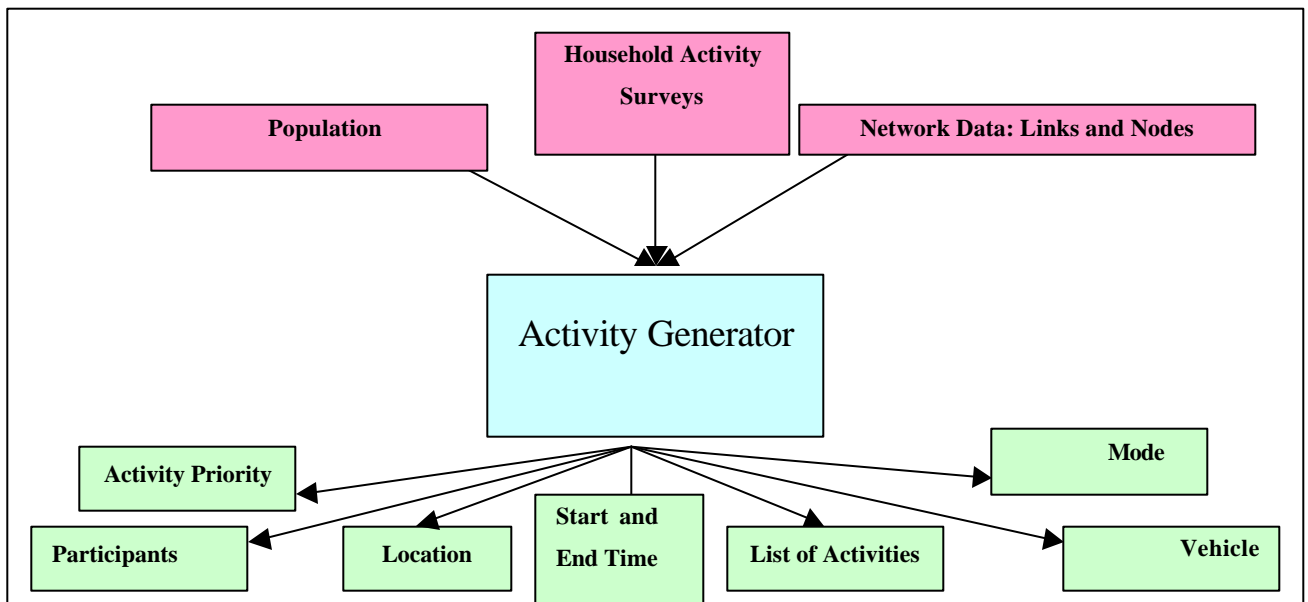

Figure 35: Parallel computation can be used in the module to accelerate processing time

Feedback from the Router and Microsimulator can result in Activity Regeneration. This may result in changes in activity mode preferences, times, and locations. Feedback allows users to begin with a rough base activity list. More research needs to be done to determine whether national survey data and the feedback mechanism is enough to not necessitate local surveys. Feedback may determine that the household's activity list needs to be regenerated. Other possibilities are a change in setting for the activity, change in mode, change in activity type, change in activity times, change in activity location, and change in activity priority.

More information on the Activity Generator can be found in the Los Alamos National Lab's TRANSIMS repository. [56]

<u>Router</u>

The Router finds the shortest path for each individual in the model to complete his respective activities, and provides an individual detailed set of travel plans. The Router uses either free-flow speeds or simulation travel times from the Microsimulator to determine the best path. Routes are constrained by the transportation network and the preferences of individual travelers. The origin, destination, starting and ending times, duration, and mode choice are decided for each trip. Inputs necessary for the Router Module are transit routes and schedules, activity lists for each individual, the multimodal network, vehicle files, and link travel times. Outputs include vehicle start and finish locations, parking locations, the vehicle route through the network, expected arrival times along the route, individuals present in the vehicle, and traveler mode changes. The Router can be run on several machines or processors. Running the Router in parallel increases the processing speed. Figure 36 illustrates the inputs and outputs of the Router.

The Router views the network as several interconnected layers, where each mode receives its own layer and is linked at nodes to other layers, allowing intermodal transportation to be modeled. A traveler that moves over certain layer

is considered to be traveling by the mode corresponding to that layer. An example might be a network with separate layers for walking, driving, and transit.
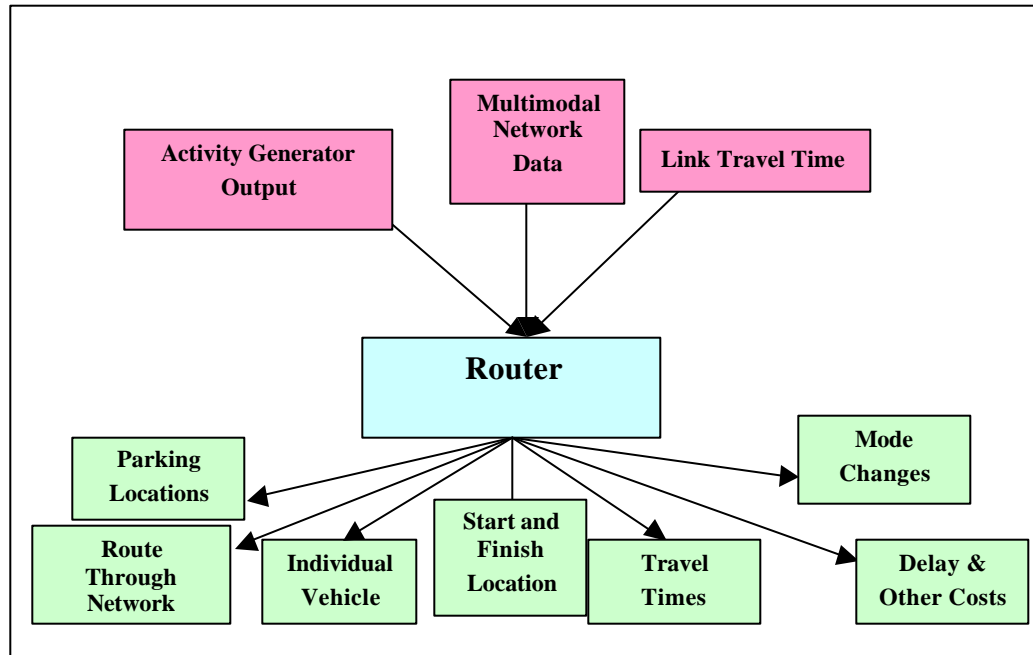
Figure 36: Inputs and Outputs of the Router

Transit stops are modeled in TRANSIMS as nodes in the transit layer. Each route has its own layer. Process links connect each transit stop to route nodes. It is important that each transit stop is connected to the walk layer.

Cost can be calculated as time, monetary cost, and distance. Each link is assigned a delay. Delay can be constant (as in walking time) or dependent on the time of day (congestion). Delay for a street link is ordinarily the free speed delay, represented as an average delay over a 15-minute period. Delay on a walking or biking link is dependent on walking speed and the length of the link. For transit, delays are associated for waiting to the transit vehicle, as well as time requirements to exit and enter the vehicle. A delay associated with parking can be represented by a delay on the process link between the parking location and the activity location. Monetary costs are associated with transit fares, parking fees, and tolls.

Further information on the Router such as algorithms that are used and file formats can be found at the Los Alamos National Lab's TRANSIMS documentation repository. [56]

Microsimulator

The Microsimulator runs the travel plans produced by the Router using cellular-automata simulation. Travelers interact with each other, resulting in phenomena such as congestion. Also simulated are intermodal travel plans, multi-occupancy vehicles, multiple trips per traveler, and variations between vehicles. Driver behavior such as accelerating, turning, changing lanes, passing, and responding to other vehicles and signals is also modeled. The Microsimulator can help model the effects of proposed projects such as building a highway, changing transit schedules, and changing traffic signal timings. Other important factors can be modeled such as the effect of a project on a specific demographic group, identifying projects that may have inequitable results.
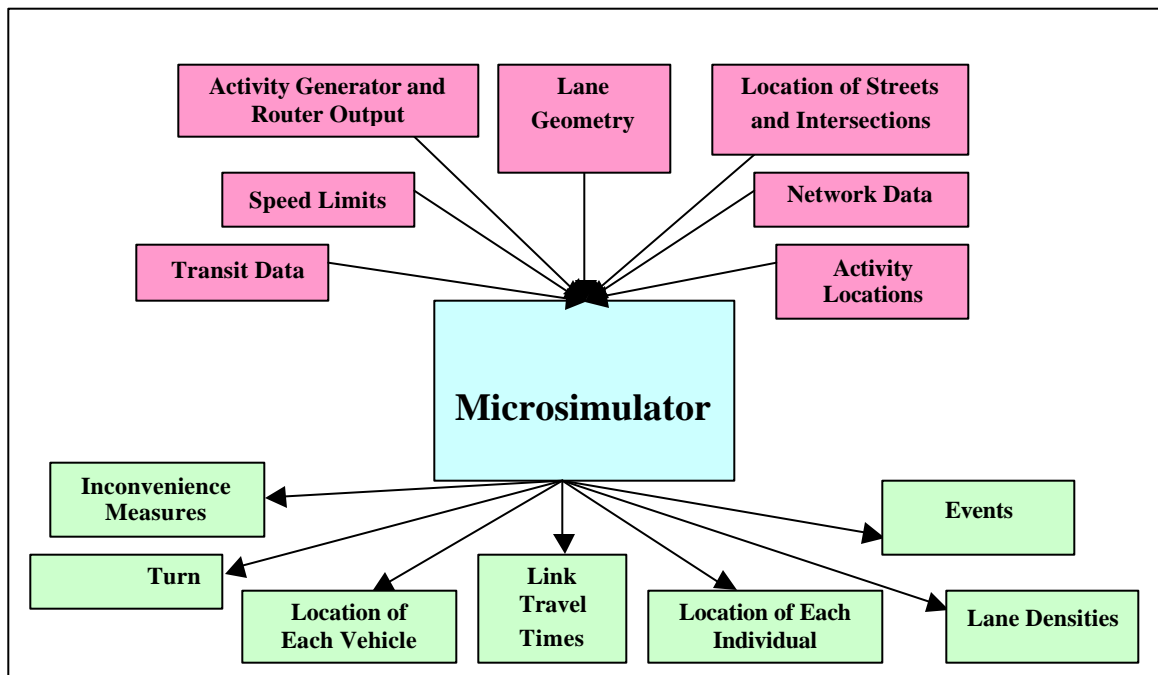
Figure 37: Inputs and Outputs of the Microsimulator

Figure 37 shows the inputs and outputs of the Microsimulator.

The cellular automata (CA) approach allows the Microsimulator to work at an efficient speed while modeling individual travelers, allowing a large number of travelers at a fast processing speed. CA divides each link in the network into a finite number of cells, each of which can hold one vehicle occupant. If a vehicle is occupying a cell, it can proceed to another cell following a set of rules. A smaller cell size increases reliability at the expense of slower computational speed. Because there are so many travelers modeled in great detail with microsimulation, it is recommended that multiple CPUs are used in parallel when possible.

Required inputs for the Microsimulator are the location of streets and intersections, the number of lanes on each street, lane connections, parking locations, and activity locations. Network data including nodes, links, land use, intersections, activity locations, and transit stops should also be included. Relevant transit data includes routes, a schedule of stops, driver plans, and vehicle properties such as a starting location. Finally, traveler plans from the Activity Generator and Router are important inputs for the Microsimulator. Additional information that is optional but beneficial is more detailed information such as turn pockets, HOV lanes, and speed limits.

The outputs of the Microsimulator are the location of each individual at all times, inconvenience measures, anomalies, events, location of vehicles on links and intersections, traffic controls, vehicle sub-populations, link travel times, lane densities, and turn counts.

Vehicle interactions such as movement and lane changes are governed by a simple rule set that allows for fast computational speed. Interactions are modeled so that collisions do not occur. Lane changes are allowed for a vehicle trying to pass a slower vehicle or to make a turn at an intersection. Lane changes are not allowed if it violates lane use or HOV restrictions. Passing lane

changes calculate gaps in the current and new lanes. If the gaps satisfy constraints, a lane change is attempted. A similar method is used to model merging lanes.

Mass transit vehicles are given priority in lane changes. A mass transit vehicle will enter a transit stop if it is not full and people are waiting, if a passenger wishes to get off, or if the driver has a scheduled departure time for the stop.

Further information on the Microsimulator, including greater detail on cellular automata theory, can be found at the Los Alamos National Lab's TRANSIMS documentation repository. [56]

Selector and Iteration Database

As mentioned earlier, TRANSIMS uses iterative feedback, interconnecting all modules to each other. This feedback mechanism accounts for learned behavior among the travelers. An important feedback example is the loop between the Router and the Microsimulator. The Router plans routes based on free speed travel times on the network. The Microsimulator model actual travel times which are sent back to the router for correction for traveler interactions. The Selector/Iteration Database chooses which travelers are to be redirected through the Router with new travel time information.

The Iteration Database can be considered the input for the selector. It provides information regarding the travelers, their planned activities, routes, and location at all times, as well as experiences as derived from Microsimulation output. The output is a list of travelers that will be reassigned activities. Figure 38 illustrates the flow of in formation in the Selector/Iteration Module.
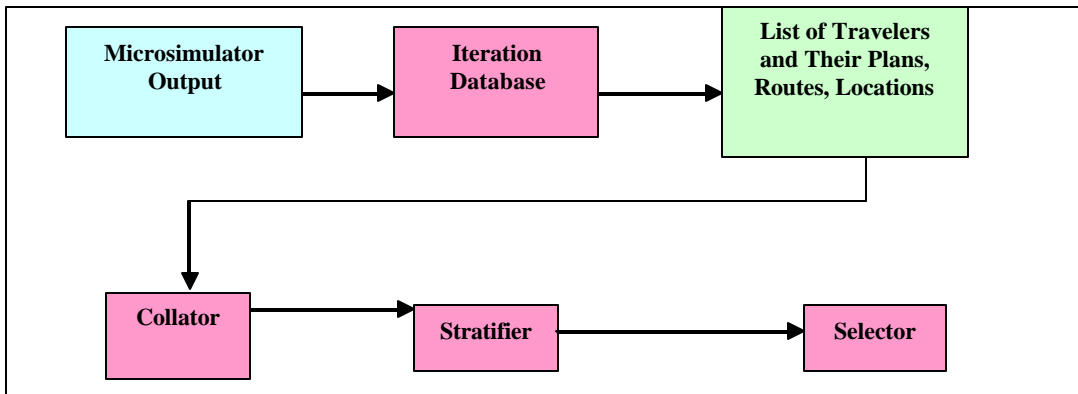
Figure 38: Selector/Iteration Module

There are three different parts to the selective feedback of TRANSIMS: the Collator, the Stratifier, and the Selector. These tools choose the set of activities or households to be acted on.

The Collator creates a database of input and output data for each trip. This information can be stored as a large ASCII database. The Stratifier allows the user to sort through the database and create tables of binned values from the trip data. Finally, the Selector chooses a subset of travelers or trips from a cell in the Stratifier for feedback.

The Los Alamos National Lab's TRANSIMS documentation repository provides a detailed description of the Selector/Iteration Database and the Feedback Mechanism, including examples of the Collator, Stratifier, and Selector. [56]

Emissions Estimator - Environmental Module

The environmental module of TRANSIMS is designed to model air quality, energy consumption, and carbon dioxide emissions that result from traveler behavior. Current emissions models use aggregate representations of behavior and estimate emissions on typical driving cycles, resulting in significant inaccuracies. [57] TRANSIMS models air quality by using information from the planning and microsimulation modules.

According to Williams et al[57], TRANSIMS must accomplish four tasks to translate driver behavior into environmental consequences: estimate emissions; describe the atmospheric conditions into which the contaminants are emitted; describe the local transport and dispersion; and describe any chemical reactions that occur during transport and dispersion. The required input for the emissions module includes surface characteristics, large-scale meteorology, terrain, and traveler behavior and vehicle characteristics, in the form of inputs from the TRANSIMS planner and traffic microsimulation.

Disaggregate modeling allows TRANSIMS to account for cold-starts, malfunctioning vehicles, evaporative emissions, variations in engine and fuel-types among various vehicles, as well as variation in the type of driving being done. Because cold-starting vehicles release considerably higher emissions that one at normal temperature, a case where many vehicles are making frequent short trips may significantly increase emissions. Similarly, it has been found that 10% of vehicles can account for most of the emissions, emphasizing the importance of modeling malfunctioning vehicles. TRANSIMS can analyze individual vehicles and determine if they are idle or running, leading to effective modeling of evaporative emissions. TRANSIMS also can model the effects of topography (steep grades) and meteorological effects (temperature and winds).

Atmospheric conditions are modeled using a meteorological module called HOTMAC (Higher Order Turbulence Model for Atmospheric Circulation). HOTMAC combines data for horizontal wind components, temperature, moisture, and turbulent kinetic energy, HOTMAC models wind, heat transfer, and solar and terrestrial radiation effects of forest and urban canopies. Using the above, differences in urban and non-urban surfaces are modeled. Similarly, the effect of air pollution caused by vehicle emissions becoming trapped between buildings in urban areas, an "urban canyon", is also demonstrated. [57]

The Transportation and Dispersion Module for the emissions module of TRANSIMS is based on RAPTAD (Random Particle Transport and Dispersion)

Model. This turbulence based model shows how pseudo-particles are transported and takes into account wind speed differences. The Air Chemistry Module used is the Urban Airshed Model. [57]

The TRANSIMS Visualizer

The Visualizer requires Sun Solaris and Linux operating systems. Hardware requirements are a three-dimensional capable graphics board (Sun workstations) or an OpenGL-compatible graphics board (Linux). A three button mouse is required for Sun Solaris systems and recommended for Linux systems. Required software includes OpenGL or Mesa3D-graphics library and GLUT, a multi-platform windowing system library. The Visualizer allows users to view and manipulate 3-D objects. [56]

Dallas-Ft. Worth Case Study

Background

The purpose of the Dallas-Ft. Worth study was to demonstrate a working traffic microsimulation. This study was meant to test features of the Interim Operational Capacity (IOC). This IOC focuses primarily on microsimulation. Subsequent IOC's were to focus on activity generation, planning and routing, and the environmental modules of TRANSIMS. Los Alamos National Laboratory and the North Central Texas Council of Governments developed the case study. The study investigated further areas of research necessary for future TRANSIMS development. Also, the network detail necessary and data requirements for TRANSIMS were studied.

A 25-square–mile microsimulation study region was selected for its mix of residences and work places, range of roadway types, recurring and non-recurring peak period traffic congestion, minimal transit and pedestrian activities, and a multi-use activity center at the center of the region.

The Dallas-Fort Worth Network

The network coding structure consists of tables maintained in an Oracle database. Separate tables for nodes, links, pocket lanes, parking, lane connectivity, traffic signal phasing, and traffic signal timings are used. Several steps needed to be taken to modify the initial 1990 travel model network. Network geometries needed to be reviewed so that actual geometries were depicted. Local streets needed to be added. Intersection and signal details were also added to the network. Twenty-four hour production-attraction person trip tables also needed to be modified for TRANSIMS.

Populations and Activities

Populations were generated using data from the National Personal Transportation Survey (NPTS) and the PUMS data from the U.S. Census Bureau. This information was used to create traveler demographics. Activities were created according to production-attraction matrices from NCTCOG. NCTOG provided production-attraction pairs for over 10 million trips for a 24-hour period. The trip types are home-based work, home-nonwork, nonhome-based, and other. A separate traveler was created for each activity.

Router

Individual route plans are assigned to each individual to meet their daily list of activities. At the time of the Dallas-Fort Worth Study, TRANSIMS ran on fixed route plans, not allowing a traveler to changed the sequence of links once simulation has started. Microsimulation is run on an initial plan set. A certain percentage of trips are then rerouted using travel times from the microsimulation in an iterative fashion.

Microsimulation

Microsimulation for the Dallas-Fort Worth was run on five networked SUN workstations. This allowed a five-hour microsimulation between 5:00 and 10:00 A.M. to run in real time.

Calibration

The microsimulation was calibrated with simple network such as a traffic circle, an on-ramp, a left turn, and a signalized intersection.

Results

This study tested the results of three infrastructure projects on populations of travelers. The three scenarios were a 1990 base case, an addition of lanes to the LBJ Freeway, and increased capacity on the arterial roads of the local network. Information on individual travelers allowed new analysis methods. Measures of effectiveness for the study included total vehicle miles, total vehicle hours, travel time, and average speed.

Dallas-Fort Worth Case Study Source

The information pertaining to the Dallas-Fort Worth Case Study was based primarily on the 1996 Los Alamos National Laboratory document, "The Dallas-Ft. Worth Case Study," Barrett et al. Information needs in greater detail should be referred to this document.[58]

Portland, Oregon Case Study

According to the Portland Study reports provided by LANL, the purpose of the Portland study is to see how TRANSIMS works in a regional setting on "available computers in a reasonable amount of time." [54] In addition, the study is to show how TRANSIMS responds to variables and conditions important to planning organizations, such as parking costs and transit availability and further review the IOC of activity generation, planning and routing, and the environmental modules of TRANSIMS.

Purposes of the Portland Study

Pendyala, of Florida Department of Transportation, states, "the purpose of the Portland Study is not to develop a complete calibrated model of 1996 Portland.

Rather, it allowed the developers of the system to understand transportation planning methods and the models and data that support these methods."[54]

Pendyala also gives three other purposes of the study. The first is to run the software for a regional problem in a reasonable about of time (under 24 hours for each module). Secondly, the study was to show that TRANSIMS could be calibrated to use in forecasting and respond to changes in variables important to planning organizations such as parking costs and household income. Finally, TRANSIMS output needed to match traffic and transit counts for a base year.[54]

The Portland Network

No new data was collected for the Portland Study, although much work was required to make existing data compatible with TRANSIMS. The most difficult task associated with preparing data for TRANSIMS was developing the roadway network to include all local streets, land-use characteristics on a block face, land connectivity at intersections, intersection signalizations, and transit schedules, routes, and stops. Automated procedures were used to generate lane connectivity. Also, generic traffic signals were used in the study. The commercial version will have a network editor to simplify network construction.

There are 475,246 nodes and 650,994 links in the TRANSIMS network. There are 506,138 nodes, 1,104,177 links, and 3,287,972 edges in the internal Route Planner network.

Errors associated with the network occurred because of human mistakes and inaccuracies in network data. Some human errors included reverse lane connectivity and inconsistent link attributes (speed limit, number of lanes). In addition, the Portland network was based on the TIGER street data, digitized from the U.S. Geological Survey topographic maps. These maps contain many topological errors. Other problems are listed below.

Ramps and other road segments beginning and ending at the same node were interpreted by the microsimulator to be only a point.

Because the original data was two-dimensional, intersecting overpasses and underpasses were connected by nodes, allowing a simulated vehicle to drive off an overpass onto an underpass. Such nodes were divided into two or more nodes existing at different elevations. Some links that were not joined together and needed to manually joined. Links with short lengths caused traffic problems and needed to be merged with longer links.

All nodes in the network were given an ID and X (Easting), Y (Northing), and Z (Elevation) coordinates from ArcView. The entire node table was approximately 3.5 MB, containing nearly 100,500 records.

Activity locations are represented as generic points for residential and work locations. All links have activity locations except for bridges, ramps, and freeways. Required data for activity locations includes an ID, node, link, offset, and layer (default walk). Optional data was up to the user to define. In this case, geographic data was used such as Traffic Analysis Zones. Other activity locations were households, schools, colleges, number of employees, park area, number of households per acres, distance to the nearest transit stop, Origin/Destination data, river zones, urban zones, and parking zones. The final activity table contained 243,400 records and was 35.6 MB.

Transit tables included information from two agencies: Tri-Met and C-Tran. Transit stops were provided in ArcView and text format. Some transit stops were originally placed on the wrong side of the street, which needed to be corrected by moving the stop. Transit schedules were provided and converted into an acceptable format for TRANSIMS. Transit routes were created by a custom ArcView Network Analyst tool written by Metro. There were sometimes problems with connectivity problems that frequently had to be checked.

Traffic control tables for Phasing Plan, Timing Plan, Signal Coordinator, and Detector tables were generated using the Create Traffic Controls Program. Modifications to the automatically generated controls included the removal of signals that were generated on freeway links.

Other tables available in TRANSIMS that were not used in this study are Speed Table, Lane Use Table, Barrier Table, and Turn Prohibition Table.

Population

Portland Metro provided a 1996 forecast to represent household size, age of head of household, and annual household income. The 1990 STF-3A and PUMS data for Oregon and Washington were obtained from the U.S. Census Bureau. This provided household and demographic information.

Portland Metro forecasted 636,533 households, compared to the actual 636,389 households in the greater Portland area. Size, age, and income demographics match closely to actual. Spatial distribution and the number of vehicles for households also statistically match. Detailed demographic information on households and individuals is available.

Activities

Activities were generated for each individual, as well as itinerant travelers and freight trips. Activities are chosen based on a simple location choice model, and mode and final location choices are made through feedback loops. Portland Metro conducted a two-day activity survey of 5863 households.

Router

Activity input for the Router was divided into population, trucks, and itinerants. The Router creates a plan files for each trip containing starting and ending locations, start time, expected duration, distance traveled, and mode. Nine transportation modes were used: auto, walk, bike, transit, light rail, school bus, inter-household shared ride, and park and ride.

Microsimulation

The Microsimulator realistically modeled traffic jams, difficulty in left turns and lane changes, delayed mass transit, full mass transit, and waiting through multiple cycles of traffic signals.

Emissions Estimator

The Emissions Estimator requires output from the Traffic Microsimulator for input. Fleet distribution was additional input that was required, divided into 23 subcategories of Light-Duty Vehicles and Heavy-Duty Vehicles.

A 24-hour TRANSIMS Microsimulation was run, providing the input for the emissions estimator. Eight output files were collected as follows: 3 velocity data files for auto, truck and bus velocities; 4 energy summary output files; and a traveler even file.

The initial Emissions Estimator for autos took 34.5 hours to run. Velocity files were divided to 24 files (one per timestep output), resulting in a run time of 4 hours.

Portland Study Source

The information pertaining to the Portland Case-Study was based primarily on the 2002 Los Alamos National Laboratory document, "Portland Study Reports," Barrett et al. Informational needs in greater detail should be referred to this document. [54]

Diamond Drive Local Engineering Study

Unlike the above TRANSIMS case studies that were regional planning studies, the Los Alamos National Laboratory used TRANSIMS to perform a local engineering study on the conversion of a local road, Diamond Drive, from four lanes to three lanes due to safety concerns.

Four cases were analyzed in the study: 1) a four-lane versus a three-lane road; 2) the morning and evening peak traffic conditions; 3) the location of the merge relative to a large intersection; and 4) potential traffic flux uncertainties up to 20% in the morning peak.

The cellular automata were set for a speed limit of 35 mph. The Diamond Drive Network was based on overlaying roads and parking lots on a satellite photo. Lanes, turning movements, and signal timings were specified for each intersection. Parking lots were created as places for vehicles to begin and end trips, taking the place of activity locations for this study. Also modeled were turn pockets and merges. Traveler origin-destination tables were created based on turn counts. Start times were generated randomly. Travel time was used as a measure of effectiveness for this study. The model was not calibrated to real traffic data. It was determined that TRANSIMS provided reasonable results to what was expected.

The conclusion of this study was that reducing Diamond Drive from four lanes to three lanes would not be a problem during normal operation except for slightly longer travel times. The morning peak hour, however, would be operating near capacity and could experience traffic delays. [59]

APPENDIX B.   SOFTWARE MATRIX

Attachment: Software Matrix.xls
Included in the enclosed CD ROM. Also available through:
http://www.cait.rutgers.edu/faculty/boile/index.html

APPENDIX C.   USER SURVEY INSTRUMENT

The survey instrument is shown below. It can be also accessed at:
Attachment: Survey Instrument.pdf
http://www.cait.rutgers.edu/faculty/boile/index.html

CAIT

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Survey of Transportation, Land Use and Simulation Software Packages

NJDOT Project #2001-19

THE FUTURE OF TRANSPORTATION MODELING

Dear Transportation Professional:

Through project #2001-19 "The future of Transportation Modeling", NJDOT wishes to evaluate the future trends and directions of transportation modeling with an emphasis on the practical side. Traditional modeling processes and programs will be compared with next generation alternatives and recommendations will be made on which ones are likely to become the next standard.

A fundamental part of this project is a survey of various organizations to determine the current use of software packages and anticipated future trends.

To help us achieve the objectives of this project, we ask you to please complete the following survey and return it to us. Upon completion of the project, we will be glad to send you a copy of the survey results and a document containing a comparative review of various transportation software packages.
Thank you in advance for your help.

Please complete and return this survey by September 27

You may send your response electronically to: tejal14@eden.rutgers.edu or tpatel@schoordepalma.com or to the address above, attention Ms. Tejal Patel.

Name and address of a contact person in your organization:

_____
_____
_____
_____

1. At what level does your organization operate? (Check those that apply)

_____ a. National
_____ b. State
_____ c. County
_____ d. City

2. Please List all software packages used by your organization, by category:

a. Transportation Planning _____

b. Traffic Simulation _____

c. Land Use _____
d. Integrated Traffic Simulation
   and Planning Models _____
e. Integrated Transportation Planning
   and Land Use Models _____

f. Vehicle Emissions Modeling_____

g. ITS Planning_____

h. Facility Design Data_____
i. Transportation Facility /
   Plan Evaluations_____

j. Others_____

3. For all models developed within your organization:

Please briefly describe the application and its primary use(s) and application area(s)	When was it developed?	Available for Commercial / Educational Use?	If yes, what is the license cost?

4. Please Provide some additional information on the software packages listed in question 3

5. Did you purchase it/choose to use it because it is:

Please List Software Packages	Year Purchased	Dates of Any Updates/ Upgrades	How long have you been using it?*	Scale of Use**	Approved / Recommended by local/national transportation body - which one?	Used by your collaborators? (list type of organizations you collaborate with)	Widely Used/ Industry Standard	Other (please explain)

*   **F: Planning to use in the near future (specify date)**
  A: Already in use (Specify date and for how long)
  N: Not planning to use in near future (specify reason)

****Single Road (SR)**
  Intersection (I)
  Regional (R)

  City (CI)
  Corridor (CO)
  State Wide (SW)
  Project Board (PB)
  Others (specify)

6. Strengths and Limitations: **7.** New and Underdevelopment Software Models:

Features of this software package you are most satisfied with?***	Please Identify Software Deficiencies***	List any problems you encountered using this software package for certain applications***	Would you consider this software package as the tool that will be widely used in the future for relevant applications?***	Are you familiar with alternative packages?	Would you rather use another package instead? Which one?	Please list new softwares or softwares under development with which you are familiar. Who is the developer?	Would you consider adopting modles which are not currently commercially available or standardly used? Which ones?	Would you consider adopting a completely new type of model such as TRANSIMS?
				Yes No Somewhat	Yes No		Yes No	Yes No
				Yes No Somewhat	Yes No		Yes No	Yes No
				Yes No Somewhat	Yes No		Yes No	Yes No
				Yes No Somewhat	Yes No		Yes No	Yes No
				Yes No Somewhat	Yes No		Yes No	Yes No
				Yes No Somewhat	Yes No		Yes No	Yes No
				Yes No Somewhat	Yes No		Yes No	Yes No
				Yes No Somewhat	Yes No		Yes No	Yes No

***As Your comments to these questions are very important to our
survey, please use an extra sheet if you need to provide more detailed information

APPENDIX D.   TRANSPORTATION SOFTWARE SELECTION TOOL (TSSS)

Included in the enclosed CD ROM.

Also available through: http://www.cait.rutgers.edu/faculty/boile/index.html

Installation directly from CD

Insert CD that came with the report into CD drive.

Go to My Computer and click on the CD drive icon (Usually D:\).

Enter *Future of transportation Modeling-final submission*. Click on TSSS file.

Follow the instructions and DO NOT change destination folder.

After the installation is done, go to C:\Program Files\CAIT_Rutgers\TSSS and run *init4.exe*. That should start the applications.

Installation from your PC

Copy folder Final Report from CD or download it from

http://www.cait.rutgers.edu/faculty/boile/index.html

Go into Final Report folder and click on TSSS file.

The rest is the same as the Installation directly from CD.

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