The National Center for Transportation and Industrial Productivity (NCTIP) at New Jersey Institute of Technology (NJIT) is one of four national centers designated under the landmark 1991 Intermodal Surface Transportation Efficiency Act (ISTEA), which the U.S. Congress reauthorized in 1998 as the Transportation Equity Act for the 21st century (TEA-21).

Chartered under the U.S. Department of Transportation's (USDOT) University Transportation Centers Program, NCTIP supports USDOT's strategic goals of mobility and economic growth, as well as National Transportation Science and Technology strategies of enhancing goods and freight movement at domestic and international gateways; increasing global competitiveness; optimizing intermodal passenger and freight transportation systems; and modeling tools for transportation planning, design and operations. NCTIP is the main research resource for the N.J. Department of Transportation, which provides funding for mutually acceptable state-of-the-art research.

An academic and research entity of NJIT, NCTIP's mission is to increase efficiency and productivity in private and public sector entities and industries through transportation improvements by undertaking high-quality, multidisciplinary, innovative education; peer-reviewed research activities; and technology transfer.

All economic sectors that use transportation as part of their production processes or services come within NCTIP's scope, including manufacturing and service sector areas, such as retailing, electronic commerce, logistics and public transit. NCTIP fosters applications of new technologies and innovative changes in the operating practices of enterprises involved in the provision of transportation functions and services, and strives for efficiency in transportation fleet and system operations, as well as in personal productivity by reducing travel time.

NCTIP research focuses on:
Freight Movement Efficiency - The movement of goods over complex networks of shippers, terminal facilities, carriers, distributors and receivers. The movement is increasingly inter-modal and involves the transfer of containers between modes. The Center maximizes productivity gains in the management of cargo flows and related information flows by introducing new processes, information technology and simulation tools.

Passenger Movement Efficiency - Operations planning solutions for highway and transit properties designed to stimulate productivity through improvements, such as unimpeded access to jobs and services. Much of NCTIP's public transportation research is conducted in this area.

Facility, Institutional and Regulatory Efficiency - The physical and regulatory environments in which transportation vehicles operate. The inefficiencies in this area affect all modes. For example, a congested roadway renders trucks, automobiles and transit buses unproductive at the same time. Rail transit and freight railroads that have dedicated rights of way or specialized regulations and institutional arrangements under which they operate also are investigated.

NCTIP's flagship academic program, the Interdisciplinary Program in Transportation, leads toward a designated M.S. and Ph.D. in Transportation. The program meets the needs of students with engineering and science backgrounds who choose to study the planning, design and operation of highway and public transit systems. Students also can pursue a M.S. in Logistics Engineering and a M.B.A. in Management. In addition to designated transportation faculty, some 30 additional faculty with diverse backgrounds and academic appointments from various departments and schools throughout the university are involved in the Center's educational and research activities. These departments include civil and environmental engineering, computer and information science, electrical and computer engineering, industrial and manufacturing engineering, management and mathematical sciences.

Please visit our Web site: http://transportation.njit.edu/nctip/ for information about the many activities of NCTIP.

Lazar N. Spasovic, Director
Research Projects
Freight Movement Efficiency

Active Projects

Container Port Operations - Phase II Optimization Algorithm Refinements
The efficiency and Maximum Practical Capacity (MPC) of a marine terminal depend on the size and shape of the land; the processes and systems used to control operations; the size and skill of the labor force; the terminal manager's philosophy and will; and the number and type of equipment used. Phase I of this research (see Completed Projects) concentrated on the first two determinants of the terminal's MPC, primarily on the straddle carrier operations. The research showed that significant efficiency improvements could be achieved in terms of straddle travel distance reductions, and demonstrated how the operator could substantially reduce its fleet ownership and maintenance costs while maintaining a desired level of truck wait time.

In addition to improving and refining the earlier algorithms, Phase II has taken into consideration the terminal's change from one to three lines of slotted waiting trucks with straddle carriers exclusively allocated to each of the three lines, and has included model modifications to accommodate this three sub-yard operation. Straddle downtime, container pickup time as a function of storage location, and changing the number of available straddles during the day will be considered in this phase. Four optimization algorithms for scheduling the straddle carriers to minimize the distance traveled and truck waiting time that were developed in Phase I will be further tested. The nominal algorithm represented current practice; a second was an easy analytical improvement on the first. Both of these algorithms look at one straddle at a time.

The third and fourth, new heuristic algorithms that use the Hungarian assignment method, look at several straddle assignments simultaneously. Management and scheduling algorithms and the system animation should be programmed using Visual Basic 5.0. Operating data and system characteristics will be stored in a Microsoft Access database. The user will interact with the program through a series of well-defined graphical user interfaces, which reduce the chance of error and are highly efficient in terms of usage. A key feature of the program is the ability to record all operating data that will be used to generate a variety of statistical reports which can improve productivity and reduce costs.
Sanchoy Das, Xiuli Chao, Athanassios K. Bladikas, Lazar N. Spasovic

Estimation of Freight Flow: Data Analysis and Gravity Modeling
The U.S. Department of Transportation (USDOT) constructed transportation regions to facilitate the collection and analysis of public information on the inter-regional movements of freight. Transportation regions were developed by carefully analyzing the geography and economic activity of the Bureau of Economic Analysis (BEA) Economic Areas, and choosing among various schemes to aggregate these areas into 90 or less. As these areas were not originally designed to accommodate the needs of transportation analysis, commodity flow data was needed to construct regions based on functional geography.
Often in freight movement modeling, only one or two of the various existing data sources are utilized. Unlike planning for mass transit and passenger vehicles, truck freight movement planning is not directly based on the profiling of area residents, but by a combination of profiling and several additional factors such as the area's economic level of activity. The ability to access and utilize key truck freight movement data is essential for statewide transportation modeling and subsequent planning.

To create a model capable of predicting commodity flow information via trucking to assist the appropriate agencies in understanding when and where new transportation facilities are needed, this research has developed an integrated database containing commodity flow and BEA data for New Jersey and other states. An extended gravity model for freight flows between BEA regions and an integrated database that incorporates county business pattern data are also being developed, along with non-detailed disaggregated 'breakdowns' of freight flows within New Jersey. The various databases will use forecast economic activity for the years 2000-2015. These will include freight flows to, from and within New Jersey; within New Jersey and 100 miles of the state's borders; and from New Jersey to all other states on state and county levels.

This project will enable the New Jersey Department of Transportation to better predict truck traffic patterns within New Jersey and other areas of the country.

KENNETH LAWRENCE, GARY KLEINMAN

Multi-Modal Freight Transportation: Regional Data Development and Analysis, Tasks 5-7

Information on freight movement is critical for comprehensive transportation planning. Commodity flow data and related analytical and modeling tools are needed to make capital program improvements and assess their impact.

This continuation of previous research has attempted to make the New Jersey Department of Transportation (NJDOT) database available to planners throughout the metropolitan region. The project has three major tasks: design and development of a management information system (MIS), introduction of hypertext capability to the MIS, and development of a methodology for assessing the impact of infrastructure investments and transportation policies.

The MIS will enable county, Metropolitan Planning Organizations and state planners to analyze emerging trends in freight traffic at the county, regional and state levels; address certain planning questions on the magnitude of freight activity in an area of concern; and answer various capital improvement questions. The MIS will have the capability of generating reports and presentations to elected officials and the public. The hypertext functionality will provide users direct, automated access to data and analysis routines, thus providing the MIS with a high level of automated documentation.

A World Wide Web interface is being created to give NJDOT analysts local and remote access from any kind of workstation. The central part of the methodology that can assess and evaluate the impact of infrastructure improvements and policy decisions on the regional network commodity flows
will be a model to assign the commodity origin-destination (O-D) trip tables and trip interchanges that have an origin and destination both in and outside the state over the regional multi-modal transportation network. The applicability of the methodology will be demonstrated with a case study to be selected by NJDOT.

Lazar N. Spasovic, Michael Bieber, Athanassios K. Bladikas, John Powers (NJDOT)

**COMPLETED PROJECTS**

**Assignment of Commodity Flows over New Jersey Highway Network**

The project developed a methodology for assigning commodity flows over the truck-route network for New Jersey. This methodology could be used by the New Jersey Department of Transportation, the metropolitan planning organizations (MPOs) and county transportation planners as a sketch planning tool for identifying the most heavily traveled links of the network and determining the direction of flow for major commodity groups. The insights provided by the assignment may be used to estimate exposure to the state's population in case of an incident along the major routes for hazardous materials. They can also ascertain the impact of the flows on pavement maintenance.

The overall analysis showed that the most heavily utilized routes throughout the state of New Jersey are Interstate 80, the New Jersey Turnpike, and Route 202. Heavy volumes are shown to travel in, out, and through Union, Essex, Morris, Middlesex, and Bergen counties.

Maria P. Boilé, Sara Benson, Jakub Rowinski

**Container Port Land Side Operations - Phase I: Optimization of the Straddle Carrier Operations**

This research evaluated the potential for improving productivity and quality of service for a straddle carrier operation at an intermodal container port terminal. A straddle carrier is a specialized vehicle for removing the container from a truck-tractor chassis by straddling the chassis and lifting the container, using an overhead crane, up to four times the container's height. The straddle carrier then drives away with the container in its belly. In this study, a methodology was developed to quantify possible savings from redesigning the straddle operation. The main effort was to develop and evaluate a series of algorithms for straddle assignment and control. These differ in the manner in which the straddles are given assignments to move containers.

The algorithms were applied to a case study representing the operation of a major terminal in the port of New York and New Jersey. Results indicated that the use of the proposed algorithms would result in a substantial reduction of 17-23 percent in straddle distance over the current operation. This reduction was accompanied by a slight increase of 1-2 percent in the average truck service time, although a particular algorithm was able to simultaneously reduce both the distance and truck service time. The model shows that the operator can substantially reduce its fleet ownership and maintenance costs by using fewer straddles while maintaining a desired level of truck wait time. Annual cost savings were conservatively estimated to be in the $997,000-$1,970,000 range. Savings could increase to $3,370,000-$6,740,000 if the operator...
were to invest proceeds from the sale of straddles.
Sanchoy Das, Xiuli Chao, Athanassios K. Bladikas, Lazar N. Spasovic

**Container Port Land Side Operations - Forecasting the Container Arrivals at a Port**

The last decade has seen a remarkable growth in the volume of containerized cargo, which increased, on average, 6 percent annually in the United States, 1.5 percent in Canada and 10 percent world wide. The U.S. Department of Transportation estimates that 90 percent of the world's liner cargo will move in containers by the year 2010. Introduction of high-speed hull designs and larger container ships capable of carrying over 3,000 TEU (twenty-foot equivalent units) containers has substantially increased the productivity of water line haul. On-dock facilities have expedited the transfer of containers between ship and rail, contributing to the increased productivity of terminal operations by decreasing the amount of container handling. Direct rail access on on-dock facilities has induced a mode shift from truck to rail in the delivery of containers, reducing congestion at terminal gates. Automation of the gates has further alleviated truck congestion by providing unimpeded truck access and equipment interchange.

This study refined the seamless interface between the land and water modes of an intermodal port. With the objective of developing a forecasting tool to assess daily service demand patterns, a set of forecasting models was introduced and implementation difficulties explored. By utilizing a continuously updated database of logistics information, the tool has the ability to formalize and accurately show the current demand patterns. A management information system (MIS) was designed to assist the terminal operator in the real-time decision-making process by reporting the expected truck arrivals for a given set of scheduled voyages. Potential gains from the improved productivity of port operations, terminal access and services are obvious, and are likely to be shared among a number of entities. Truck wait time at gates has been decreased, thus improving fleet productivity and reducing congestion from spillover truck traffic to highway, turnpike and local road networks. More efficient equipment assignment by the operator has improved productivity, and the combined impacts and use of technology may increase global competitiveness for the U.S. business entities at the port.
Alexios Sideris, Lazar N. Spasovic

**Developing a Freight Data Executive MIS for New Jersey Using Hypertext**

Hypertext is the science of interrelationships. Conceptually, hypertext ties together information structuring, representation, and user access. Hypertext functionality includes annotation, structural links among like or related objects, guided tours, domain and system overviews, etc. Technically, hypertext develops an engine to connect various databases, analysis tools, and user interfaces.

Introducing hypertext capabilities to the research products of the freight commodity data developed under the Multi-Modal Freight Transportation: Regional Data Development and Analysis project, and building a framework for an executive management information system (MIS) was the focus of this research, which was the first attempt by the New Jersey Department of Transportation to make
data pertaining to freight movements available to planners throughout the state. As this database required updating and screening with further duality checks, records of data changes had to be kept, explanations and traces of modifications provided, and the capability designed for generating reports and presentations to elected officials and the public. An infrastructure was provided for these activities, and hypertext functionality played a major conceptual and technological role. The hypertext functionality of the engine allowed users direct, automated access to data and analysis routines, and provided a level of automated documentation. The executive MIS currently assists analysts in locating, utilizing and annotating data and in preparing standard, online (though guided tours) animated reports. Thus, the engine not only provides users with an increased set of tools, but also assists them in conducting analyses more easily and effectively.

MICHAEL BIEBER

Estimation and Prediction of National and Regional Sectoral Freight Flows in the United States: An Analysis from Origin to Destination by Modality of Transportation

Investigating interstate traffic flows has a long history. National and state governments need to know freight transportation flows for the maintenance and de novo establishment of transportation infrastructure projects. This information is relevant for optimal budgetary appropriations for such projects, and is intricately linked to relative national and regional competitiveness vis-à-vis other nations and regions.

The research generated forecasts of the flows of commodity freight shipments from origin to destination by modality of transportation by industry. Approximately 100 industry groupings, 50 state origin-destination combinations and four modes of transportation provided the general structure for this study.

Comprehensive in nature, this research encompassed analyses of all freight flows from origin to destination by mode of transportation. Demand modeling techniques for freight transportation were studied and available sources of data for freight transport demand modeling were investigated. These were then merged into an analysis of requirements of state departments of transportation and metropolitan planning organizations (MPOs) for freight planning purposes. A review of literature dealing with forecasting and general modeling of freight transportation flows was conducted, and instrumental to this was the exploration and expansion of appropriate data sources on freight transportation flows.

T. HOMER BONITSIS, KENNETH D. LAWRENCE

Multi-Modal Freight Transportation: Regional Data Development and Analysis, Tasks 1-4

In New Jersey, and all states and regions of the United States, information on freight movements lagged significantly in terms of availability and quality of data compared with information available about personal trips. Critical to comprehensive transportation planning, commodity flow data and related analytical and modeling tools were needed for informed decisions on which facilities capital improvement funds should be expended. As the state evaluated its position in the regional, national and global economies, and designed actions to improve its economic competitiveness, this input was essential.
At the outset of this project, separate databases containing information on commodity trip tables were in use at the New Jersey Department of Transportation (NJDOT), including Reebie Associates' TRANSEARCH for 1982, and DRI/McGraw Hill's DRI database for 1993 flows. Trips were given on a county-to-county scale, and between each county and points outside the state. This research used the DRI database to generate reports for each of New Jersey's 21 counties, showing commodities broken down by Standard Transportation Commodity Code and mode of transport. The project was the first attempt to use the NJDOT freight database to generate a product that would be made available to county and municipal planners throughout the state and the North Jersey Transportation Planning Authority.

The multiple objectives of this research included performing a comparative analysis involving the current database and independent data sources (e.g., U.S. Census 1993 Commodity Flow Survey) for the purpose of validation; suggesting ways of supplementing the DRI database with data from other sources and efforts; developing descriptions of commodity flows in and out of New Jersey; and developing indicators to ascertain New Jersey's competitive position in the regional and national transportation market. The study created various analytical tools to support comparative analyses of the freight data to analyze the changes in traffic patterns from TRANSEARCH 1982 to DRI 1993 commodity flows and to address the causes of these changes and the potential shifts in modes of transport. The project also organized the existing data in user-friendly reports and databases; interfaced the existing databases and analytical tools within an executive management information system (MIS) capable of providing analytical answers to a myriad of critical planning questions; developed a hypertext capability for the executive MIS; and studied selected topics in intermodal freight transportation.

LAZAR N. SPASOVIC, MICHAEL BIEBER, ATHANASSIOS K. BLADIKAS, JAKUB ROWINSKI

Rail-Truck Intermodal Service Planning

Despite its relative short distance compared to rail movement, drayage, the trucking portion of rail-truck intermodal freight service, accounts for a large percentage of intermodal origin-to-destination costs. Drayage is a major factor in service quality as perceived by the shipper. High drayage cost seriously affects the profitability of intermodal service and limits the markets in which it can compete with inter-city trucking. This research examined the potential for improving service quality and reducing the cost of drayage. Detailed current costs and potential for improvement at one intermodal terminal were examined. The limitation to one terminal was dictated by the extreme difficulty and cost of obtaining reasonably good data on actual trailer movements and demands - the result of fragmented responsibility for current drayage operations which involved numerous intermodal retailers and drayage companies. These costs were estimated using existing drayage prices and discount practices.

An optimized drayage operation in which tractor and trailer movements are centrally planned was developed using an integer programming model for scheduling, with time windows for pickup and delivery. An alternative system design that included various payment options for drayage was also developed for the centralized drayage operation.
The model was then used to compute the cost of each alternative. Results revealed substantial cost savings of 43-63 percent for the centralized operation over current operation. The research addressed possible changes in intermodal organizational and operational procedures necessary to achieve the cost savings.

Lazar N. Spasovic, Edward K. Morlok

Smart Sensors for Freight Movement

The motivation for this project was a train derailment which occurred when a barge hit a bridge in Alabama. Research on a distributed sensing system, composed of a backbone optical fiber network and stress monitors as an inherent part of the tracks, was undertaken. Such an intelligent system did not exist at the time for railroad systems.

In stage one, a communication system that also serves as a monitoring system was developed. An optical system was launched through one fiber which runs along a rail. A one percent coupler provides a return signal on a fiber running along the mating rail. Any catastrophic disruption of the rail system results in an optical signal loss, and may be localized to the originating cell. This system may be expanded in the future to include other sensing systems without major overhaul.

The laser input is comprised of a set of pulses in a pre-determined sequence. The delay time of the return signal at the operator point is \( t = 2 \times m \times L / v \), where \( m \) is the \( m \)-th cell, \( L \) is the cell's length and \( v \) is the velocity of the pulse sequence. A computer control system monitors the arrival of the pulse sequence and correlates it with the transmitted pattern. The laser system was chosen to conform with existing communication patterns; the pulse sequence was determined by the signal-to-noise ratio of the system and the length of the links.

A more sensitive system destined for critical points such as bridges and overpasses was designed in the second stage. In this, a corrugated tube encapsulating the optical fiber is laid along the rails as part of the backbone system and firmly attached to the rails via bolts or cement. Stress developed in the infrastructure deforms the tube and the fiber embedded in the tube. The light power loss is correlated directly to the stress developed in the system. The periodicity of the corrugation was designed to increase the signal-to-noise ratio of the sensor system. Twenty meter segments of these extended sensors can be connected together to cover an entire bridge or other critical point.

This system gives track owners the flexibility of distributing low and high resolution sensor systems according to need, and provides low-cost, on-line monitoring to detect catastrophic failures of rail lines. The research included a thorough analysis of the cost benefit of the proposed system and risk damage assessment of the sensing device.

Haim Grebel, Kenneth Farmer
Passenger Movement Efficiency

Active Projects

Developing an Integrated Congestion Pricing and Traveler Information System - Phase I: The Individual System

Many people believe that we are quickly approaching a crisis. As two-income families have become more prevalent and suburban rings have grown in both absolute population and area, the number of commuters using private automobiles has increased dramatically. Between 1960 and 1980 the number of people driving to work nearly doubled although the workforce increased by only 50 percent. There has been a continued increase in the amount of truck transport, and miles, both inside and outside of urban areas. Indeed, 90 percent of all transported goods are carried on highways at some stage of their production or distribution. The result of this increase in highway travel is congestion. More people are trying to use the road network than it can handle at a reasonable level of service. One projection states that 65 percent of peak-hour travel on urban interstate highways and 10 percent of all daily urban travel is conducted under congested conditions. The inability of the current road network to deal with this increased demand has been called one of the most pressing infrastructure issues of the decade.

The traditional approach to alleviating congestion in the United States has been to build more and larger roads. However, for a variety of reasons, this approach is no longer viable. Instead, the focus now is on improving the management of existing infrastructure. Much attention is currently focused on traveler information and congestion pricing systems. Unfortunately, most existing research has focused on these systems in isolation. Very little is actually known about how such systems can and/or should be integrated.

The initial phase of this research has been on the individual systems. Specific attention has been given to developing the routing algorithms and route choice models required to both implement and evaluate these systems, and to collecting and delivering real-time information. Subsequent phases will focus on using what has been learned to develop and evaluate integrated traveler information and congestion pricing systems. To date, the study has shown that the existing methods of identifying alternative paths can be less than ideal, and an alternative based on the notion of $k$-similar paths has been proposed. The research also demonstrated that the inherited constraint algorithm could efficiently solve the minimum cost path problem when path costs include both time and tolls and the valuation of travel time is nonlinear.

David Bernstein, Alain Kornhauser, Mei Chen, Steven I. Chien, Kyriacos C. Moukas

Digital Map Requirements for Automatic Vehicle Location

Automated Vehicle Locator (AVL) technology enables a fleet operator to track and monitor the location of vehicles at any given time. Used mainly in transit and commercial vehicle management systems, AVL provides an operator information on the exact location of a vehicle, permitting more accu-
rate customer information and response to operation-related problems.

Most AVL systems provide information in terms of coordinates (latitude and longitude or northing and easting) which have to be unambiguously matchable with those on a map for unique identification. In order for the matching process to be successful, the coordinate systems of the map and those of the AVL system must be consistent, compatible and sufficiently accurate. Where various stops or destinations of a vehicle are spread out over a large area, this matching process can be achieved with rather moderate accuracies of the AVL and digital map systems. However, in a transit application that operates in densely built urban and suburban areas with frequent bus and traffic control stops, the accuracy requirement from these systems could be much more stringent. If based on the Global Positioning System (GPS), urban building canyons and overpasses or interference from wireless or radio communications can block satellite signals.

The actual accuracy of AVL systems under these conditions had been untested. This research performed tests on NJ Transit routes under conditions including tunnels; underground and completely enclosed areas; densely built urban areas with many obstructions and very active electromagnetic interference; densely built urban areas with only a few obstructions (4-10 story buildings); and other urban, suburban, rural, and open areas.

JOSHUA GREENFELD

Establishing Safety Driveway Grades for New Jersey State Highways

Currently the New Jersey Department of Transportation’s standards for state highway drive-

way grades are based on American Association of State Highway Officials (AASHTO) guidelines, which were established in 1959. These standards are currently unsupported by research, creating a need for reevaluation based on modern traffic and vehicle conditions and sight distance requirements.

NJDOT hopes to determine if steeper driveway profiles could be safe and provide adequate sight distance while developing more liberal driveway grade design standards for county and local roads. The design of safe driveways encompasses many elements, including spacing, volume, highway classification, use of property, angles of exit and entry, and grade of the driveway. The importance of considering these elements in the driveway design would be reflected in the safety and capacity of the roadway and the driveway.

The study will develop and apply a computer simulation model to assist an engineer in selecting a driveway profile from the main road. Its purpose is to develop new standards based on data collected throughout the United States and/or on computer simulation; and to determine the possibility of developing more liberal design standards than those in use. Cost savings for NJDOT could be projected based on reducing construction costs, needs to obtain rights of entry, and reduced right-of-way impacts and costs. Because there is no design guideline for a driveway's vertical alignment, this research will help fill transportation engineers improve design to increase both safety and capacity performance of driveways and adjacent roadways.

LOUIS J. PIGNATARO, WU SUN, SHAHID IQBAL, EUGENE REILLY
Evaluation of the Potential for Using Ramp Metering in the ATMS of the I-80 Showcase Corridor

Ramp metering has been discussed for more than four decades as a traffic management technique on many freeways. Releasing single vehicles on either a pre-timed or a demand-responsive basis generally reduces accidents because the turbulence at the ramp/freeway merge point is reduced. To achieve the full benefits of ramp metering, traffic-responsive systems are necessary.

Ramp metering can increase the capacity of the freeway, maximize throughput and speed, reduce accidents, and lower emissions resulting from stop-and-go conditions. While vehicles on metered ramps will have longer delays, increased freeway speeds may compensate for the wait time.

This research will evaluate the effects of "short ramps" on local traffic congestion (e.g., delays and accidents), develop real-time multiple-ramp metering control systems (e.g., pre-timed system control and demand-responsive system control), develop a methodology for evaluating freeways without metered ramps and alternative ramp metering control systems, and develop procedures for quantifying benefits. To achieve the ultimate benefits for the selected freeway corridor, various metering control strategies (including an integrated real-time ramp metering model) will be developed and tested by a selected simulation program. The metering model will capture dynamic traffic characteristics. For real-time implementation, an effective optimization algorithm will be developed for determining the time-varying metering rates. The entire algorithm will be integrated with the simulation program.

Steven I. Chien

Impact of Access Driveways on Accident Rates on Multi-Lane Highways

A major concern of transportation professionals is the safety impact of access points on multi-lane highways midway of the links. Vehicles traveling at high speeds in the vicinity of the access and egress points on the highway links are required to reduce their speeds to accommodate other vehicles exiting or entering the facility. Geometric configuration of the entrances and exits, the number of vehicles entering and exiting, the spacing of the access points and driver characteristics are among the principal variables which dictate traffic flow on the highway link.

NCTIP has conducted a statistical analysis of accident data on multi-lane highways in New Jersey and identified the principal variables. The research has produced preliminary analytical models based on simulation and field studies to capture the impact of these variables on the traffic flow operation of the link. In cooperation with the New Jersey Department of Transportation, different categories of links based on geometric and traffic signal characteristics have been produced, as well as a methodology for analysis of the impact of access and egress points on traffic flow operations on highway links. This will provide a tool for better access management techniques. The final product of the study will include an analysis of all the links of the state highway network, using simulation and actual traffic flow measurements, which will aid the decisions of access management. In a proposed second phase, actual traffic flow measurements will be undertaken to calibrate the simulation model developed and a more comprehensive analysis of all the links of the network will be undertaken.

Kyriacos C. Mouskos
Integrated Signals - A Cost Benefits Analysis for the New Jersey Department of Transportation

The majority of signalized intersections in the State of New Jersey are regimented locally by a single controller. Any change to the timing of a single signalized intersection requires manual intervention. The majority of arterials are interconnected through a single field controller but not through a central computer. This requires dispatch of a person for any changes in signal timing or response to a system malfunction. A problem faced by a transportation planner/engineer is the cost-effectiveness of integrated traffic signals in improving the traffic flow and safety on major arterials and multi-lane highways.

Integrated signals can change the timing of any signalized intersection through an instruction from a PC to which all traffic signals are connected. The central monitoring of the signals of several intersections also provides for efficient changes to signal progression in arterials where continuous monitoring of the system is necessary. The basic trade-off between these two approaches — integrated signalized systems and isolated signal control — is the cost of operation and maintenance, as well as the capital and installation cost and the benefits that each system provides.

The first part of this research will include a cost analysis of both controlled and isolated signalized systems, including traffic actuated control systems, for New Jersey. An overview committee will be responsible for identifying the measures of effectiveness/performance of signalized systems, establishing an appropriate cost structure for the analysis, and providing guidance throughout the study. A travel time and delay study will be conducted on a selected arterial system.

Kyriacos C. Mouskos, Wu Sun

Mobility and the Cost of Congestion

Congestion negatively affects the movement of people and goods. It translates into increased travel time and fuel consumption. People traveling longer times to and from their jobs experience higher levels of stress, which leads to decreased labor productivity. Congestion effects translate into higher costs for truck freight operation through driver wages, and have negative impacts on the manufacturing industry and the service sector. Congestion decreases the productivity of just-in-time manufacturing processes by forcing businesses to keep larger than necessary inventory in order to accommodate unreliable delivery schedules.

A recent study by Texas Transportation Institute (Urban Highway Congestion - 1982 to 1994 Volume 1: Annual Report, 1997) summarizes a 10-year research effort that quantifies urban mobility. Its primary product is the Roadway Congestion Index (RCI) that is calculated for 50 urban areas in the United States. Portions of New Jersey are included in the New York and Philadelphia urban areas. The study identified the New York City area as the eighth most congested while the Philadelphia area is the third fastest growing congested area. A secondary product of this study is the estimated congestion cost due to increased travel delay and fuel consumption. The study found that congestion costs U.S. travelers 4.6 billion hours of delay, 6.7 billion gallons of wasted fuel and $74 billion of time and fuel cost in 1996.

This study will measure quantifiable and qualitative impacts of congestion in New Jersey on mobili-
ty; cost of transportation; economic productivity; air quality and safety. The research will address the impacts of congestion on single travelers as well as area-wide (e.g., county). The cost of congestion will be ascertained on a per county basis as well as per capita for an average county resident. The cost will combine not only the direct impact of travel delay and excess fuel costs, but also the added cost due to congestion of transporting goods and services to consumers. The results of the study will inform the general public and provide information for developing a public policy.

Lazar N. Spasojevic, Janice Daniel, Jakub Rowinski, Alexios Sideris, Athanassios K. Bladikas

**COMPLETED PROJECTS**

**A Methodological Framework for Optimizing Bus Transit Service Coverage**

This research determined the optimal length of transit routes extending radially from a central business district (CBD) into low-density suburbs. Because optimal route length may not be considered independently of route location and service scheduling, the study considered an optimal combination of route length, route spacing, headway and fare, which maximized operator profit or social welfare for an urban corridor with elastic demand. The social welfare objective is optimized with both unconstrained subsidy and break-even constraints. Equations for the optimal design variables that maximize operator profit and social welfare are derived analytically for many travel patterns. These provide considerable insight into the optimality conditions and interrelations among variables. They also are incorporated within an efficient algorithm that computes the optimal values of decision variables for a more realistic model with vehicle capacity constraints. The algorithm is applied to a rectangular urban corridor with uniform passenger travel density.

Numerical results show that the optimum total operator profit and welfare functions are rather shallow, thus facilitating the tailoring of design variables to the actual street network and particular operating schedule without substantial decreases in profit and/or welfare. The social welfare function is relatively flat near the optimum for a large range of subsidies. This result implies that for a given set of input data, the break-even constraint may be an economically and politically preferable objective because of subsidy elimination and a marginal reduction in social welfare. Sensitivity of design variables to some important exogenous factors is considered. The methodology also is applicable to the problem of optimal service coverage of feeder bus systems serving rapid rail line stations.

Lazar N. Spasojevic, Maria P. Boile

**An Approach for Modeling and Analyzing the Impact of Telecommuting Strategies on Traffic Flow**

Statistics show that telecommuting represents the fastest growing workplace option, with approximately 26 million Americans engaged in job-related work at home at a given time. More than 600 large U.S. corporations have formal "work at home" programs with nearly one million employees participating.

Telecommuting has been defined as working from home, supported by appropriate hardware, software, telecommunications, and home office management and services. The employee transfers the result of
his or her workday to a central office. This way of working has made inroads for a number of reasons. Technology has advanced quickly and, because of the growing sophistication and portability, an office can be created anywhere. The availability of low-cost office equipment, such as personal computers, modems, photocopiers and fax machines, has allowed people to work at home as if they were in the office.

This project analyzed the effect of telecommuting on traffic congestion and flow patterns. Organization and simulation models were developed to assess the behavioral effect of traffic patterns when telecommuting is implemented. Control methodologies were introduced that coordinated telecommuting strategies to achieve the maximum benefit of the concept. In the short term, telecommuting was found to eliminate commute trips; largely reduce peak period trips; not increase other trips; decrease vehicle miles traveled, trip times, and freeway use; and increase the proportion of car trips. Changes in telecommuters’ travel patterns also may influence the travel patterns of non-telecommuters and their energy consumption. The role and definition of telecommuting could undergo radical modifications, which could have important implications on future planning strategies. To improve our understanding of telecommuting and the impacts on transportation, energy and air quality, empirical evaluations will need to be conducted.

Layek Abdel-Malek

**An Intermediate Run Traffic Assignment Model for Intermodal Networks**

A mathematical model to be used in intermediate run planning for intermodal highway-transit trans-

portation networks was the focus of this research. Intermediate run relates to the time period within which a transit operator can adjust route schedules and vehicle assignments to the expected volume of ridership. The intermediate run intermodal network equilibrium model was formulated as a mathematical programming problem with a non-linear objective function and linear constraints. The objective functions minimized the individual user cost (User Equilibrium) or network-wide cost (System Optimal).

The model presented an efficient approach for analyzing commuter rail within a competitive environment to improve transit service and increase attractiveness. The research calculated the cost of expanding parking capacity at the park-and-ride lots and provided important fundamental insights for understanding the impacts of a commuter's mode choice on the modal performance in terms of time and cost. The model can be extended to handle other high occupancy vehicle modes. In the final analysis, an example was presented and user equilibrium and system optimal traffic assignments and rail headway were calculated. Impact of a modal shift on average user and total network travel cost was ascertained for various levels of travel demand.

Maria P. Boile and Lazar N. Spasovic

**External Validity Test for Discrete Choice Transportation Forecasting Models based on the Stated Choice Approach**

Transportation demand forecasting had, over time, shifted from the sole use of aggregate models to a broad range of aggregate and disaggregate models. Disaggregate models incorporated a wide array of transportation system attributes and behav-
ioral characteristics of travelers unknown to aggregate models. Mode, route and departure time choices had been modeled using one of several discrete choice approaches. Stated Choice (SC) modeling techniques formed one branch of discrete choice disaggregate models, the other being Revealed Preference (RP).

RP models were based on actual decisions and SC models on individual decisions made from hypothetical choice situations. RP models were usually assumed valid and SC models possessed greater uncertainty. This may have been an appropriate conclusion, but few published studies had sufficient detail to compare the two approaches. Although studies suggested that the two complemented each other, the level of effort for the proper use of SC had not been standardized. Without standards, the SC study became a custom operation with quality control being highly subjective. This research aimed to produce tests of predictive validity for both models, as well as external validity tests comparing the SC structural model with an RP model. A guide was designed to standardize the design, administration and evaluation of SC studies.

W. Patrick Beaton

Fault-tolerant Traffic Control Systems

A fault-tolerant control system maintains system integrity (stability and vehicle flow regulation) under partial system failure due to local faults, such as sensor/actuator failure, vehicle accidents and severing of communication links. Because most urban traffic control systems utilized fixed-time control, fault-tolerant traffic control had been but an emerging area of research. As older, fixed-time controllers were being gradually phased out, reliability of traffic-reactive control systems became imperative. Vehicle and traffic control systems are highly complex. The probability of a system crash caused by local fault in an automated environment was proportionately high. Fault-tolerant capabilities needed to be incorporated into a traffic network by means of suitable feedback compensation.

A methodology for synthesizing fault-tolerant urban traffic control systems was devised based on the decentralized servomechanism approach. The control focused on the phase-split at each intersection, such as balancing the queue lengths for competing approaches or minimizing the average sum of queues in an area. In the event of fault occurrence, the fault-free subsystem continued to execute the traffic control requirements without fault detection or control reconfiguration. The type of fault considered for this work included sensor failure, actuator failure, accident, gridlock and communication dropout.

Timothy N. Chang

FHWA Sketch Planning Analysis Spread Sheet Model (SPASM)

The North Jersey Transportation Planning Authority (NJTPA), one of the three largest Metropolitan Planning Organizations in the U.S., has a significant goal in guiding transportation investments within the region. In 1997, NJTPA tested the new Federal Highway Administration's Benefit Cost Analysis Software, titled Sketch Planning Analysis Spreadsheet Model (SPASM). This effort was supported by a sensitivity analysis of the parameters of the model, including transportation-related factors, such as economic (discount rate, value of in-vehicle time, and value of walking or waiting time by mode); operational (auto,
truck and transit operating cost per vehicle-mile); accident (cost per fatality and cost per non-fatal injury); energy (consumption per vehicle mile by mode and user/agency costs per energy unit by mode); user cost (non-fuel user costs; out of pocket costs per vehicle-mile); emissions (emissions per vehicle-mile, per start, per trip by mode and society cost per gram of pollutant); noise (noise cost per vehicle-mile by mode and costs per vehicle mile and per vehicle-trip); and elasticity (travel time change by mode).

For each of the factors, the sensitivity analysis was conducted relating the decision of the choice of transportation alternative to a possible variation in the relative value of each parameter, including weight in the impact analysis. Also included in the project was the development of presentation options to the users of the analysis, including elected officials, the public, and transportation professionals and planners. This was developed using the (sensitivity) range of values under an alternative analysis of a project in the North Jersey corridor.

Harold Deutschman

Heuristic Search Strategies to Solve Discrete Transportation Network Design Problems

Network design is one of the most important components of the transportation planning process. The transportation planner needs to identify the objectives of the users of the system to provide compromising solutions to improve the transportation system. Primary objectives usually taken into consideration are the total travel time of the transportation system based on a user equilibrium traffic assignment rule, traffic safety, environmental concerns, traffic and economic impacts on the system or parts of the system, and individual user groups' specific objectives.

This study presented heuristic search strategies to solve single- (passenger cars) and two-class user (passenger cars and trucks) equilibrium transportation network design problems subject to a budget constraint. The single-class problem considered a one-lane addition for each link as the decision variable. The two-class considered adding a new lane for trucks and passenger cars; a new truck lane only and a new passenger car lane only. The methodologies were tested on small networks with the optimal solution known, and on a real transportation network. Sensitivity analyses on the different components of the search strategies (i.e., evaluation heuristic functions, knapsack type moves, number of iterations for each step) were conducted. The project developed strategies for network design to enable transportation planners to evaluate alternatives. The strategies developed, although used to solve specific problems, may be used with modifications to solve more realistic problems.

Kyriacos C. Mouskos

Improving the Capabilities of Existing Transportation Planning Packages

The Urban Transportation Modeling System (UTMS) estimates travel demand in response to changes in land use patterns, roadway characteristics, and socioeconomic factors. This demand is measured by the volume of traffic that flows through a system of streets and highways. Through the use of traffic assignment software, parts of UTMS have become automated. One of the newest automated processes is the extraction of a subarea from a larger regional model. This extraction process is important to the local planner because it maintains a linkage from the regional model to the
local model and allows the planner to extract an already distributed trip table rather than build one from scratch. This subarea extraction process, as practiced, is a one way information flow. The regional model is calibrated and information is then passed down to the subarea model. This study suggested that an "information feedback loop" should be inserted into the process. The subarea model information is "looped" back to the regional model and used in the regional calibration.

The enhanced procedure was applied to a northern New Jersey network. The new methodology improved the calibration of the regional model, particularly in the vicinity of the subarea focus model. This new methodology is the key to developing subarea focus models with properly distributed trip tables. In addition, the results are used to develop general conclusions regarding the applicability of the feedback process.

The research also formalized the initiation of ongoing experimental, but unreported activities, and generated enhancements to existing transportation planning models, (i.e., intelligent transportation systems) improvements, congestion pricing and fixed demand, and consideration of over-saturated conditions) which would gradually and sequentially be introduced to the existing packages.

ATHANASSIOS K. BLADIKAS, LAZAR N. SPASOVIC, KYLE WINSLOW, KEN HAUSMAN

Modeling Intermodal Auto-Rail Computer Networks

This study presented a methodological framework for evaluating operating and pricing policies in an intermodal auto-transit (commuter rail) network. Commuters departing from their homes access their final destination, a Central Business District (CBD), via auto, rail and intermodal auto-to-rail modes (e.g., park-and-ride). If commuters choose to begin their trip by auto, there are numerous paths by which they can reach a final destination. Once on the highway, the commuter can switch to rail at stations along the rail route. The commuter also may choose to walk to the rail station closest to the trip's origin.

The intermodal network is considered as one system. Traffic flows and travel costs have been optimized for the entire system and not for separate auto and transit networks, as was the case in most previous studies. The central part of the framework is an equilibrium demand-supply model consisting of a mode choice and a traffic assignment sub-model. The commuter's choice of using auto or rail is represented by a mode choice sub-model. The traffic assignment sub-model assigns transit (walk-to-rail and drive-to-rail) and pure auto trips to routes in the network, based on the minimization of an individual traveler's generalized (travel time and out-of-pocket) cost. The model yields modal shares, equilibrium flow pattern and resulting generalized costs of the network assignment.

The framework was then applied to an intermodal network, modeled closely after a northern New Jersey commuter corridor, and was used to analyze policies, which included increasing parking capacity on commuter rail lots, increasing tolls on highways, increasing the parking fee on a CBD parking lot, decreasing rail fares, and improving rail service quality. These policies were evaluated based on user costs and transit and highway operators' costs and revenues.

MARIA P. BOILÉ, LAZAR N. SPASOVIC
Facility, Institutional and Regulatory Efficiency

Active Projects

Air Quality Monitoring Computer Systems

The focus of this research has been to re-engineer and automate the New Jersey Department of Transportation's (NJDOT) air quality monitoring data collection and entry processes. By providing a connection between computers and the data logger, labor and entry errors can be reduced, leading to greater assurance that transportation projects will meet all institutional and regulatory efficiency requirements.

The study has endeavored to maintain and provide monitoring of the state's air quality, automate the current air quality data entry process, and generate clear and detailed air quality reports and statistical analyses. The research has interfaced the existing database and analytical tools within windows-based monitoring systems capable of supporting project planning.

After analyzing NJDOT's current systems and testing the interface program, a windows-based monitoring system was designed. This prototype system will be assessed by the users and an installation and implementation schedule will be prepared. Engineers and managers will be trained in the use of the system and a user manual will be provided.

By improving the productivity of engineers and substantially aiding management's control ability, the new systems should reduce overall costs, improve air quality controls and streamline processing procedures.

H. Joseph Wen

Moving Telecommuting Forward

Telecommuting has been useful strategy in transportation management through the reduction of traffic congestion, as well as in organization management through enhancing productivity and quality of work life. For example, in transportation management, Transportation 2020: the New Jersey Statewide Long Range Transportation Plan (March 1995) addresses the necessity of working with businesses on incentives for telecommuting as one of the options for reducing employee trips to the workplace. Interviews with directors and other personnel from New Jersey TMAs had indicated the necessity of investigating existing management barriers in firms appearing to be good candidates for telecommuting.

Management resistance or lack of employer support has been a frequent barrier to successful implementation of telecommuting programming. Apprehension about monitoring employees was one source of this resistance. And telecommuting would necessarily change managerial roles. While control, coordination and communication would continue to be keys to the successful functioning of an organization, managers would no longer have direct control of their workers, nor would they be able to engage in the many short, oral interactions that take place through the day. Research in the management area had focused primarily on telecommuters, not managers. Little was known about behavior changes in management in response to new situational demands from managing remote workers. A database built on the experiences of firms that had initiated pilot projects could yield opportunities for examining relationships among organizational vari-
ables, management practices and telecommuting program outcomes.

The project examined experiences of companies, already having implemented at least a pilot project in telecommuting, as they relate to management and organizational issues. Changes in managerial behavior were analyzed in relation to telecommuting program outcomes to identify patterns of proficiency and deficiency.

Naomi Rotter

**Project Movement Enhancement/CPM Tracking System (CAPAS)**

The structural reorganization of the New Jersey Department of Transportation (NJDOT) has resulted in a shift to the use of project managers as the new paradigm. Recognizing the need to provide this new breed of project managers with the necessary tools for effective project management, and concomitant with the structural changes, PC workstation applications have been developed to build on and supplement the cost data available through the mainframe workhorse, Financial Management Information Systems (FMIS). Of the four systems supporting EIS, the PM+ system is the most recent to come on-line. PM+, developed by a Canadian firm, provides a DOS-based, Windows-type environment for entering project budget information. The system is the backbone for integration of FMIS cost data. Users of this system, according to personnel from the department’s Program Support Services, have identified a number of shortcomings of the system, as well as a list of enhancements that would improve overall effectiveness and utility. While shortcomings are not unusual for any new system coming on-line, user comments must be addressed to encourage acceptance.

This research has been to assist NJDOT in achieving an efficient, user-friendly, project management system through enhancements known as the Capital Program Assessment System (CAPAS). CAPAS provides an MS Windows environment for data entry, analysis and reporting, including the use of graphical displays. The system addresses user needs; establishes a framework for user-defined and implemented enhancements; and expands the basic financial control features available for use. CAPAS can be based on dollars or work-hours, or both, and provides enhanced reporting flexibility. A secondary objective has been to ensure that there is adequate training, user manuals and on-line help available to NJDOT personnel.

The project maintenance and monitoring systems will permit response to inquiries regarding description and current status of problem-statement submissions and current research projects. The systems will improve the productivity of project engineers and help management control the program by providing greater product accuracy; reduce overall costs; improve management controls; and streamline processing procedures.

Louis J. Pignataro, Edward Duenhaimer, H. Joseph Wen

**Research Project Maintenance and Monitoring System**

Maintenance and monitoring systems are key components of planning and control within an agency. They are one way to increase efficiency in state departments of transportation. By facilitating monitoring, these computer-based systems permit more optimal use of organizational resources to increase efficiency. Administrators of research units can follow the status of suggestions and projects
from initiation through disposition, providing greater assurance that tasks will be completed within budget and on time. As an organization's strategies and policies change, the monitoring systems must conform to new environments. The New Jersey Department of Transportation (NJDOT) required a new computer-based project monitoring system that could monitor on-line the disposition of problem statement submissions and projects in the current research program.

This research focused on assisting NJDOT in generating clear and detailed technical reports on current projects, schedules and financial status; and enabled it to maintain, update and provide on-line monitoring of project descriptions and status of problem statement submissions. Upon completion, the project will produce a system that can permit efficient response to inquiries, descriptions, and current research projects, thereby reducing costs, improving controls and streamlining processing procedures. The system will provide greater assurance that research tasks are completed within budget and in a timely manner.

H. JOSEPH WEN, CHI TANG

Seismic Retrofitting and Design of Highway Bridges in New Jersey

Most bridges in New Jersey are multi-span simply supported (MSSS) where, under earthquake ground motions, there is high possibility of impact between adjacent spans and the end-span and abutment. Although the response in any direction of each span (or frame) in an MSSS bridge is normally dominated by the fundamental mode in that direction, detailed seismic analysis of essential bridges should employ a non-linear computer model. The analytical model should account for interaction among spans due to impact, and other important non-linear phenomenon, such as soil-structure interaction, modeling of post-failure friction at the bearings and possibility of plastic hinges in the columns. The spatial nature of ground motion also could have a significant effect on the seismic response. For MSSS bridges, small seat length at the abutments and at the top of columns may be the most critical parameter that will require retrofitting. Various procedures, such as increasing seat length, use of cable restrainers, variable dampers and lock-up devices, must be investigated to identify the most feasible retrofitting method.

In an extension of current research being performed at NJIT, this project is developing a computer program and/or simplified analytical procedure for consideration of impact at the joints; determining the spring constants to represent soil-structure interaction using non-linear finite element models; qualifying the damping effect of soil-structure interaction at the abutments; and developing a more rational procedure for analysis and design of cable restraints.

M.ALA SAADEGHVAZIRI

TELUS 2.0 (the Transportation Economic and Land Use System)

Under increasing pressure to perform more effectively and efficiently, public agencies have availed themselves of computer technologies to enhance productivity and interconnectivity. Few, however, have had access to a system that would integrate data management, descriptive modeling and computer mapping; provide information required to make decisions; and evaluate the impacts of those
decisions on critical factors. The Transportation, Economic and Land-Use System (TELUS) will enable the nation’s 340 sub-state Metropolitan Planning Organizations (MPOs) to carry out these activities.

The research has developed a computer-based information system uniquely designed to help MPOs meet legislative mandates when they annually decide which projects to include in their five-year Transportation Improvement Plans. By providing key information about each project in clear and accurate terms, TELUS strengthens the ability of local elected and appointed officials, citizens, special interest groups and others to participate knowledgeably and effectively in the MPOs transportation planning processes. By evaluating the economic and land-use impacts of each project, TELUS promotes informed decision-making by an MPO board and staff, and responds to citizens’ concerns about how projects might affect their neighborhoods and communities. TELUS includes a Geographical Information System to view the geographical relationship with other physical features of the community. By compiling information on hundreds of projects into a single database and incorporating economic modeling and mapping capabilities, TELUS demonstrates the power of technology to enhance transportation decision-making and public participation.

The initial phase of TELUS focused on providing the North Jersey Transportation Planning Authority (NJTPA) with more detailed and easily accessible information on transportation projects in the region, including their interrelationships and impacts, thus enabling NJTPA to meet organizational, ISTEA, State Plan and other mandates more effectively.

Phase II provided enhancement add-ons to the three components: a Transportation Improvement Plan, Project Pipeline and Local Scoping, and will assist NJTPA in successfully implementing and maintaining the integrity and functionality of the TELUS system.

Initially funded under the National Center for Transportation and Industrial Productivity (NCTIP), the TELUS project has been specifically named in the TEA-21 legislation to receive an additional six years of funding for further development and deployment. NCTIP expects several versions of the existing system will be developed to meet changing user needs and, within the next couple of years, a freight component may be added.

LOUIS J. PIGNATARO, ROBERT W. BURCHELL

The Uses of State DOT Research: Customer Use of Completed Project from NJDOT's Bureau of Research

Contemporary management has stressed the need for administrators to enhance relations with customers. In the public sector, this Total Quality Management imperative has become central to the reinventing government movement and other attempts at productivity improvement. Administrators have been urged to facilitate a customer-based way of doing business. Bureaus discover what their customers want; users can count on services that meet their needs and desires. State department of transportation research bureaus have many internal customers including (but not limited to) executive-level management, environmental services, design services, construction and materials, and operations management. For these customers the bureau performs many kinds of work with projects differing
on such dimensions as topics, cost, time frame, locus of research, etc. Optimal service requires that research managers obtain feedback on customer satisfaction and use of bureau work. Research Bureau staff need information on which variables facilitate and which impede use of their services.

This research focused on analyzing several state manuals and the National Cooperative Highway Research Program’s research process to learn about alternative ways of conceptualizing and communicating research proposal solicitation and prioritization. The information gained enabled Department of Transportation decision-makers to frame a process from a broader base of potential choices.

**Hindy Lauer Schachter**

**To Advance the Concept of Aesthetic Design of Noise Wall Barriers Through the Detailed Design of Models, Prototypes and Plans and Specifications of the Bhavnani Design**

Public perception of and response to noise barrier walls on highways in New Jersey has been that they are extremely unattractive and unaesthetic. The New Jersey Department of Transportation initiated a research project that would utilize computer and physical models, as well as full-scale prototypes, to examine the aesthetic qualities and cost effectiveness of a proposed innovative Type II Noise Study Wall by Bhavnani.

In Phase I, questions of noise attenuation, ease of construction, life cycle and maintenance cost, and potential environmental benefits in the use of recycled materials were addressed. An attachment system was developed for a reinforced concrete post and panel system that utilized the Bhavnani aesthetic design. An attachment system also was developed for the fin structures central to this design. A 3-D computer model was developed, as well as component attachment systems. A wood and plastic scale model was constructed.

In Phase II, a prototype reinforced concrete noise wall will be manufactured in reinforced concrete and erected. The prototype is being evaluated for comparative cost, strengths and weaknesses, transport, stockpiling, erection and operation efficiencies. Included in the specifications and testing of the prototype will be accommodations for vertical and horizontal wall alignment, design tolerances for components, potential corrosion and weathering problems, ease of construction and cost estimates. This will involve the videotaping of the manufacture and erection process of the prototype to quantify the workload and crew size required. Videotaping of the manufacture and erection process of the prototype to quantify the work load and crew size required will take place.

**Eugene Golub, Louis J. Pignataro, Edward Dauenheimer, Walter Konan**

**Water Level Prediction for Transportation Projects**

Determination of bridge clearance and proper design of cofferdams, caissons and bridge fenders over navigable rivers and waterways are important safety and transportation network management issues. An error in calculating or determining the correct bridge clearance and determining the proper elevations of cofferdams and caissons could result in safety hazards, and damage to property and the integrity of the transportation network. A minimum bridge clearance is calculated from tide observations and predictions, the expected life span of the
structure and an assessment of the size of vessels expected to travel beneath them. The water level and clearance are expressed in elevations in a particular height system. To avoid implementation errors, proper methods and procedures are exercised during the surveying and engineering design phases, prior to construction, to ensure a consistent height system.

Tidal level is a dynamic phenomenon that changes constantly. Some recent observations indicate that tidal levels are slowly increasing due to global warming and changes in weather patterns. In addition, ship sizes are increasing. These changes may require an update of current clearance values that were computed many years ago.

Implementation errors leading to problems in waterway operations and more restrictive use of the waterway can create problems with regulatory agencies and may impact on the rights of the public and adjacent owners. Also, not using the waterway to the fullest extent may have a negative impact on the local economy.

This research project will study bridge clearance over navigable rivers and waterways, and determine the various water levels required to meet the many regulations. Construction issues that may increase costs and delay completion of projects will also be addressed. A thorough survey of current practices of water level determination and prediction by agencies such as the Federal Highway Administration, Federal Emergency Management Agency, TIDE- LANDS, the New Jersey Department of Environmental Protection, the National Ocean Services and the Army Corps of Engineers will be undertaken. Other state departments of transportation will be contacted, and methods for height determination at these special construction sites will be studied.

JOSHUA GREENFELD

**COMPLETED PROJECTS**

**Analysis of Accident Reports of Trucks in Work Zones**

A work zone or workspace is identified as 'that portion of the roadway closed to traffic and set-aside for workers, equipment and material. This area may be fixed or moved as work proceeds, and while work is in progress, roadway capacity is reduced and potential hazards are increased. Work zones are as common to New Jersey as they are to other states, but New Jersey is also a major thoroughfare for truck movement in the northeast corridor.

There are about 25,000 truck-related motor vehicle accidents in New Jersey each year. Of these, approximately 1,300 happened in work zones statewide, and more than 1,100 accidents were on interstate or state highways. The Problem Identification Committee of the Safety Management System of the New Jersey Department of Transportation (NJDOT), in reviewing a full year of accident summaries to determine unusual occurrences, found truck accidents in work zones to be disproportionately high.

This research analyzed police accident reports to identify relationships, if any, between work zones and truck traffic safety. A pilot study was conducted using 28 truck/work zone accident reports. The results were used to design a research approach and estimate both the time and miscellaneous cost requirements for successful completion.
A database was developed and analyzed based on all the information provided by the NJDOT Bureau of Accident Reports and the New Jersey Turnpike Authority. Statistical analyses were carried out to identify relationships among types and severity of accidents, geometric layout of work zones and characteristics of the roadway.

Given the numerous categories used to evaluate them, the study found that the frequency and severity of truck accidents in work zones was not significantly different from those in non-work zones, though the reporting of the accidents was not as accurate as might be desired. The predominant collision type was sideswipe, followed by rear-ending. Recommendations were made for improvements to the layout of the work zones and gathering of contributory information.

LOUIS J. PIGNATARO, HONG LIN

Assessing the Benefits of Highway Traveler Information Services

This research estimated traveler benefits from an information system capable of forecasting traffic conditions on the roads of a network with variable degrees of accuracy. Unlike the cases that have already appeared in literature, where furnishing actual times eliminates all uncertainty from a driver’s behavior, here the uncertainty of a particular traffic condition may be reduced instead of being completely eliminated.

The project proposed a methodological framework that could evaluate benefits from the introduction of information services in highway networks. Given certain behavioral aspects of the traveler decision-making process, the research focused on quantifying what travelers gain by having perfect or partial information about highway traffic conditions. The framework provided a tool to evaluate the value of an Advanced Traveler Information Service compared to historical information available. A methodology to determine the optimal number of travelers to whom information on travel conditions should be provided was proposed. Given a certain target market penetration, this methodology can be used to determine the system accuracy (i.e. probabilities of detecting traffic conditions) so that an average potential user received a certain level of benefits. The framework may complement behavioral studies that determine a traveler’s attitude toward various types of information delivery technologies.

LAZAR N. SPASOVIC, MARIA P. BOILÉ, ATHANASSIOS K. BLADIKAS

Communication and Productivity

Organizations send employees important information in the form of task/job rationales, performance instructions and feedback on individual work. Effective communication, particularly among professional and staff employees, is essential. Because effective communication varies depending on a division’s aim, audience and situation in relation to the external environment (e.g. state law) and internal culture, appropriate differences exist in methods used to communicate. Agencies are likely to revise manuals and operating procedures as environments and cultures change.

Prior research indicated a positive association between performance and the degree to which organizations provide rationales, give complete job instructions, and present easily readable material. All organizational communicators should motivate
employees by explaining the purpose of their work, including all crucial job steps, and by deleting difficult jargons and "gobbledygook."

The 1991 Intermodal Surface Transportation Efficiency Act (ISTEA) led the Federal Highway Administration (FHWA) to institute rulemaking changes to increase state research program autonomy and accountability. State departments of transportation were required to develop a process to identify research, development and technology transfer activities. A manual would enable each state to plan a research management system and communicate it in a clear way to enhance productivity. The research was aimed at linking improved communications and productivity by analyzing diverse approaches state transportation department research divisions used in written communication. The study identified potential problem areas and provided suggestions for strengthening communication to increase productivity.

Following the FHWA's requirement, this project analyzed research division manuals for transportation departments of selected states and the National Cooperative Highway Research Program's research process to seek alternative methods of conceptualizing and communicating research proposal solicitation and prioritization. The project also demonstrated how entities, responding to change, alter their communication strategies. Emphasis was placed on the extent to which the materials incorporate rationales for action, give complete instructions and are readable.

Hindy Lauer Schachter

Developing a Market Sensitive ITS Educational Program

This research evaluated the educational needs of the emerging field of Intelligent Transportation Systems (ITS) and ascertained how these needs are met by course offerings in academic programs. A survey was conducted to determine needs for ITS education among public and private sector entities and assess the perception of the academic sector on the type and level of ITS education to be offered. Results indicated that ITS academic programs should consider the educational needs of the private and public sectors, and that a traditional civil engineering curriculum is inadequate to educate engineers in ITS. The ITS educational program must be inter or cross disciplinary with a focus on areas that are not traditionally part of civil engineering education, such as communications, traffic surveillance, systems analysis, and social and institutional issues. The results provide a guideline to universities for developing the content of an ITS program by identifying the type of program structure, as well as topics to be covered in courses. A case study of how an ITS program was implemented at the graduate level at New Jersey Institute of Technology (NJIT) was presented.

The study concluded that an ITS educational program should be developed that would consist of a concentration in the Interdisciplinary Graduate Program in Transportation with a set of courses emphasizing the systems and technology of ITS. The graduate program at NJIT is a freestanding academic program offering M.S. and Ph.D. degrees in Transportation.

The study also determined ITS elements in other graduate programs, such as electrical and computer
efficiency; computer and information science; social science and policy studies; and industrial management; in undergraduate technology oriented courses in ITS that are offered to engineering majors; and an ITS certificate program open to current graduate students and professionals desiring to improve ITS skills.

Maria P. Boilé, Lazar N. Spasovic, Louis J. Pignataro

Efficiency and Equity Issues in an ITS-Driven Urban Transportation Planning Process

Intelligent Transportation Systems (ITS) encompass the use of communication and surveillance systems, computer technologies, and traffic engineering and management techniques to improve the productivity of the nation’s transportation facilities, increase safety, and reduce congestion and pollution. One area of ITS is electronic toll collections, where vehicles pay tolls electronically without stopping, usually through some sort of radio frequency communication between the vehicle and a toll plaza.

ITS cannot be viewed as a panacea for solving all traffic problems. Improvements from these technologies must be sustained by responsible public transportation policies, such as demand management. Congestion pricing, for example, to vary traffic flow vis-à-vis time of travel and prevailing levels of density, is technologically feasible. Peak period pricing is an old economical concept where users are charged different fees for the use of a facility during different time periods. Fees charged are usually a function of the facility operating regime or the timely demand for facility capacity. They are widely used in telephone service and electric energy consumption. Transportation congestion pricing assumes that during peak congestion periods, travelers will be charged a toll proportional to the cost imposed on other users of the facility. The pricing is economically efficient because tolls are comparable to marginal costs. However, pricing can be inequitable where low-income drivers must avoid the facility because of the higher toll. As long as the drivers that are tolled off a road are reimbursed for this inconvenience, the equity issue is nonexistent.

This project sought ways for improving the urban transportation planning process and procedures so that new ITS technologies and accompanying transportation public policies could be taken into account.

John Tavantsis

Telecommuting: Organizational and Individual Considerations

Two streams of research have developed regarding the phenomenon of telecommuting, first in transportation research and public policy and, more recently, in human resources. The transportation research program, which continues today, focuses on telecommuting as a strategy for reducing air pollution by means of employee trip reduction. The human resource stream of research is more recent.

This study examined the job satisfaction and performance of telecommuters. Mikovich and Bourdreau (1994) had summarized the state of knowledge, noting that there were many testimonials on behalf of telecommuting, but scarce documentation. The study provided a comprehensive review and annotated bibliography of literature on telecommuting in management and transportation, and accommodated the National Center for Transportation and Industrial Productivity at NJIT.
goal of improving productivity through enhanced institutional and organizational efficiency, as well as the need for organizational research to advance the knowledge and understanding of telecommuting as a viable transportation strategy.

As the role of telecommuting in the organizational mix of job redesign needs to be understood at three levels of analysis: the individual worker, the work group, and the organization as a whole, this research examined the state of telecommuting in the United States. Factors related to effectiveness in telecommuting problems were distinguished and research directions identified. This project provided a comprehensive review and annotated bibliography of literature on telecommuting in management and transportation.

NAOMI ROTTER
Representative Publications and Presentations

1999

Refereed Journals and Conference Papers -


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Participating Faculty/Principal Investigators


Bonitsis@megahertz.njit.edu

burchell@rci.rutgers.edu

tnc0766@tesla.njit.edu

Xiuli Chao, professor of industrial and manufacturing engineering, NJIT. Ph.D., University of Toronto, 1989. Fields of Expertise: performance measure and evaluation, queuing systems, network flows.

Chao@megahertz.njit.edu

Steven I. Chien, assistant professor of civil and environmental engineering, NJIT. Ph.D., University of Maryland, 1995. Fields of Expertise: transportation system analysis, urban transportation planning, intelligent transportation systems, traffic simulation, intermodal transportation service planning and design.

Chien@megahertz.njit.edu

daniel@admin.njit.edu

das@megahertz.njit.edu

dauen@megahertz.njit.edu

Harold Deutschman, professor of civil and environmental engineering, NJIT. Ph.D., Northwestern University, 1969. Fields of Expertise: urban transportation planning, mass transit systems.
deutschman@admin.njit.edu

Robert Dresnack, professor of civil engineering, NJIT. Ph.D., New York University, 1966. Fields of Expertise: environmental impact analysis, surface and air traffic induced noise quality impacts, water resources.
dresnack@admin.njit.edu

Kenneth Farmer, associate professor of physics, director, Microelectronics Research Center, NJIT. Fields of Expertise: physics in metal-insulator-semiconductor device structures and silicon microfabrication, micromachining and fusion bonding.
farmer@megahertz.njit.edu

golub@admin.njit.edu

grebel@megahertz.njit.edu

Joshua Greenfield, associate professor of civil engineering; program coordinator for surveying engineering technology, NJIT. Ph.D., Ohio State University, 1987. Fields of Expertise: geographic information systems (GIS), surveying, systems integration, man-machine interface.
greenfield@megahertz.njit.edu

kleinman@tesla.njit.edu


Beaton@megahertz.njit.edu


Bernstein@jmu.edu

Michael Bieber, associate professor of computer and information science, NJIT. Ph.D., 1990, University of Pennsylvania. Fields of Expertise: decision support systems, hypertext, hypermedia.
bieber@megahertz.njit.edu

Athanassios K. Bladikas, chair, Department of Industrial and Management Engineering; director, Interdisciplinary Program in Transportation, NJIT. Ph.D., 1983, Polytechnic Institute of New York. Fields of Expertise: logistics, transportation finance, public transportation.

Bladikas@njit.edu


Boilé@lafayette.edu


Bonitsis@megahertz.njit.edu

Yuri Parakhin, associate professor of electrical and computer engineering, NJIT. Ph.D., 1999, University of Illinois at Urbana-Champaign. Fields of Expertise: information theory, wireless communications, computer networks, signal processing.

Parakhin@megahertz.njit.edu
Alain Kornhauser, professor of operations research and financial engineering; director, transportation program, Princeton University, Ph.D. 1971, Princeton University. Fields of Expertise: transportation systems, operations research. alaink@soil.princeton.edu

Kenneth D. Lawrence, professor of management, NJIT. Ed.D., Rutgers, The State University of New Jersey, 1979. Fields of Expertise: forecasting, marketing, data analysis. lawrence@megahertz.njit.edu

Edward K. Morlok, UPS foundation professor of transportation, and professor of systems engineering, University of Pennsylvania. Ph.D., 1967, Northwestern University. Fields of Expertise: redesign of transportation services and logistics systems, integration of transportation with production/translation industries and distribution/delivery systems. morlok@seas.upenn.edu

Kyriacos C. Mouskos, assistant professor of civil and environmental engineering, NJIT. Ph.D., University of Texas, 1991. Fields of Expertise: traffic engineering, urban transportation networks, intelligent transportation systems. mouskos@megahertz.njit.edu

Louis J. Pignataro, distinguished professor of transportation, executive director, Institute for Transportation, NJIT. Ph.D., Technical University of Graz, Austria, 1961. Fields of Expertise: traffic engineering, transportation planning, economic development, impact of transportation investments. pignataro@admin.njit.edu

Naomi Rotter, professor of management, NJIT. Ph.D., New York University, 1974. Fields of Expertise: behavioral issues in transportation, human resource management, training, selection, needs assessment, performance appraisals. rotter@megahertz.njit.edu

M.A. Saadeghvaziri, associate professor of civil engineering, NJIT. Ph.D., University of Illinois at Urbana-Champaign, 1988. Field of Expertise: structural engineering, fine element and computational methods, earthquake engineering, structural applications of composite materials. ala@megahertz.njit.edu

Hindy L. Schachter, professor of management, NJIT. Ph.D., Columbia University, 1978. Fields of Expertise: public administration, communication, management of transportation agencies. schachterh@admin.njit.edu

Lazar N. Spasovic, director, National Center for Transportation and Industrial Productivity; associate professor of transportation and management, NJIT. Ph.D., University of Pennsylvania, 1990. Fields of Expertise: transportation systems analysis, network modeling, freight transportation, intermodal issues. spasovic@megahertz.njit.edu

John Tavantzis, professor of mathematics, NJIT. Ph.D., New York University, 1976. Fields of Expertise: dynamical systems, numerical methods, control theory, equilibrium network assignment. tavantzis@megahertz.njit.edu

H. Joseph Wen, associate professor of management, NJIT. Ph.D., Virginia Commonwealth University, 1993. Fields of Expertise: transportation information systems, geographic information systems (GIS), databases. wen@admin.njit.edu
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