NCTIP research calculates congestion costs

In a study released in April 2000 by the New Jersey Alliance for Action, the National Center for Transportation and Industrial Productivity (NCTIP) at New Jersey Institute of Technology measured the quantifiable and qualitative impacts of congestion in the State of New Jersey. The study addressed the impacts both on the average traveler and on entire counties, combining not only the direct impact of travel delay and excess fuel costs, but also the added cost of providing goods and services.

Research Project
Congestion affects the movement of people and goods by increasing travel time and fuel consumption. Longer commutes produce higher levels of stress and lead to a decrease in labor productivity. Congestion translates into higher costs for truck freight operations through driver wages, and also has a negative impact on the manufacturing industry and service sector. Congestion decreases the productivity of just-in-time manufacturing processes by forcing businesses to keep larger inventory than necessary to accommodate unreliable delivery schedules.

Two recent studies dealt with urban mobility and the cost of transportation. One, by the Texas Transportation Institute (TTI), summarized a 15-year research effort that quantified urban mobility, finding that congestion cost U.S. travelers 4.3 billion hours of delay, 6.6 billion gallons of wasted fuel consumed, and $72 billion of time and fuel cost in 1997.

The second study, by The Road Information Program, indicated that New Jersey lags behind the national average in the quality of roadways and bridges. New Jersey motorists drive on substandard roads, resulting in additional operating costs. They also experience increased congestion, which reduces productivity and air quality and increases accidents. The road information program report found that substantial funds, beyond those currently programmed, were required for improving the transportation infrastructure. The study received wide coverage in newspapers throughout the state.

These studies provided critical information on congestion costs at the national level and the relationship between transportation infrastructure and cost. They did not address the significant impacts of congestion on a particular roadway and at a county level or the benefits of transportation improvements in reducing costs. Only by analyzing the cost on the state, county and roadway levels could the full benefits of congestion mitigation strategies be determined.

The NJIT research project, "Mobility and the Costs of Congestion in New Jersey," was a five-month, $89,000 effort funded by NCTIP and the Foundation for the New Jersey Alliance for Action. The principal investigator for the study was Lazar N. Spasovic, NCTIP director, who was supported by research team of transportation faculty and doctoral students.

Methodology
NCTIP methodology built upon the TTI study, which used the Highway Performance Monitoring System (HPMS) database compiled by the Federal Highway Administration (FHWA). HPMS lacked the detail to determine the costs of congestion on specific roadway segments or to determine the potential benefits of implementing alternative highway improvement projects. To address deficiencies in HPMS, the New Jersey Congestion Management System (NJCMS) database was used.

NJCMS included traffic volume and roadway geometry information for 4,000 two-directional links. Given the improved dataset, a number of enhancements to the TTI study were instituted. Analysis of peaking characteristics was improved. Detailed data was used to determine the effects of trucks on congestion. Calculations of average vehicle occupancy (AVO) were updated.

The TTI study assumed the same lane capacity for all roadways of similar type. The NJCMS data included detailed geometry so that specific roadway capacity could be calculated.

The TTI study used a simple approach, where travel speed and congestion level were based on the average daily two-way traffic volume. To relate travel speed to congestion

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NJIT as an assistant professor of civil and environmental engineering (See page 3). In addition to teaching and research, she is very active in recruiting students from underrepresented groups to the transportation field. Most recently, Janice was a participant in a panel discussing careers for women in transportation at “TransAction 2000,” the April 2000 New Jersey State Transportation Conference, in Atlantic City.

Because of NCTIP’s many accomplishments, writing this column is very easy:

✓ We continue to build a strong and successful relationship with the N.J. Department of Transportation (NJDOT), whose research activities are now fully consolidated under Ms. Pippa Woods, assistant commissioner for planning, research and local government services, with William Hoffman heading the Division of Research and Technology. We are looking forward to working with Bill and his team. We also congratulate Nick Vitillo on his appointment as manager of research for NJDOT, and bid a fond “good retirement” to Arthur “Mike” Roberts, former supervising research assistant, with whom the university worked on many projects through the years. NJDOT provides $250,000 in matching funds to NCTIP to support a number of projects that have gone through both its departmental and NCTIP peer review processes.

✓ In November 1999, at at NJDOT’s 1st Annual Research Showcase, John Schuring, chairperson of NJIT’s Department of Civil and Environmental Engineering, and I gave a joint presentation featuring NJDOT-supported research. (This PowerPoint presentation can be viewed at http://transportation.njit.edu/nctip/presentations.htm.) NJIT will host the 2000 Research Showcase Nov. 8 at the New Jersey Performing Arts Center in Newark. (See page 8).

✓ During the Transportation Research Board’s 79th annual meeting in January, Dr. Daniel and I were among a selected group of transportation educators and professionals who met with U.S. Secretary of Transportation Rodney E. Slater to discuss major challenges in educating and training the next generation of transportation professionals; examples of innovative partnerships and how to build on their success; and ways in which the U.S. Department of Transportation can support the learning process that involves formal education, ongoing training, research and technology transfer.

✓ The Center received significant press coverage in a statewide business newspaper for research on effective port management. This research was featured in the last issue of OnRoute (See http://transportation.njit.edu/nctip/newsletter).

✓ Our students made us proud again. Lida Mazaheri (See page 6) received the University Transportation Centers’ (UTC) Student of the Year award. Lida, currently with the Port of Authority of New York and New Jersey, will begin her Ph.D. studies in transportation in the fall of 2000. Yuqing Ding received the George Krambles Transit Scholarship for her dissertation on "Development and Application of Dynamic Models for Predicting Transit Arrival Times." For the past two years, NJIT students, first M. Shoaib Chowdhury (OnRoute, Spring 1999) and now Ding, have received this prestigious award, indicating the quality of the research.

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The National Center for Transportation and Industrial Productivity (NCTIP)
New Jersey Institute of Technology
A Public Research University

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SEMINAR SERIES
A stimulating slate of speakers visited was sponsored by NCTIP during the 1999-2000 academic year:

✓ Zhi-Long Chen, of the Department of Systems Engineering at the University of Pennsylvania, discussed “Modeling and Solving Real-World Truck Routing Problems.” Dr. Chen presented a practical routing model motivated by actual problems encountered in distribution operations; highlighted several key realistic issues not addressed in vehicle routing literature; and proposed a hybrid solution approach combining the column generation framework with fast heuristics.

✓ David Simchi-Levi, of the Department of Industrial Engineering and Management Sciences, at Northwestern University, presented “Quantifying the Bullwhip Effect in Simple Supply Chain: The Impact of Forecasting Lead Times and Information.” Dr. Simchi-Levi addressed the significance of identifying techniques and tools that control the increase in variability in the supply chain, known as the bullwhip effect, and demonstrated why quantifying this effect would be useful to demonstrate the magnitude of the increase in variability and the relationship among forecasting techniques, lead time and increase in variability.

✓ Henry Lieu, a highway research engineer with the Federal Highway Administration (FHWA), spoke on "CORSIM: A State-of-the-Best Practice for Traffic Analysis." CORSIM, an integration of the existing NETSIM and FRESIM models developed by FHWA, is a microscopic, stochastic traffic simulation model that realistically represents the real world dynamic traffic environment. According to Dr. Lieu, CORSIM brings the real world into the office so that engineers can study problems, try new ideas, evaluate them quantitatively and identify solutions prior to implementation in a cost-effective manner.

Unless otherwise specified, seminars are held Thursdays, 3-5 p.m., in the Guttenberg Information Technologies Center, Room 3710, on the NJIT campus in Newark.
A 1999 graduate of Lafayette College, in Easton, Pa., was awarded $1,000 for his winning entry, "Integration of an Intermodal Transportation Planning Model with a Geographic Information System," in the NCTIP-sponsored National Student Paper Competition.

Michael Haynes, who graduated with honors in Civil Engineering, is attending the University of Texas at Austin, where he is pursuing a master's degree in transportation engineering. He had attended the University of Texas at Austin the previous summer as an undergraduate transportation research intern.

Haynes' research interests include incident/accident detection using Automated Vehicle Identification technology in conjunction with traditional detectors, in San Antonio. He also has an interest in the role dynamic traffic assignment systems will play at the traffic management centers of the future. Haynes' other interests include geographic information systems and airline logistics. He expects to complete his degree in May of 2001.

The national student paper competition, held each year at the end of the spring semester, is open to students enrolled in a transportation or transportation-related academic program, or those who are conducting associated research. The winning paper is chosen using a refereed process. Information may be obtained from the NCTIP web site: http://transportation.njit.edu/nctip/student.htm.

Janice Daniel, an assistant professor in the Department of Civil and Environmental Engineering, has joined NJIT's core transportation faculty.

Since her appointment in the fall of 1999, Daniel has researched "Mobility and the Costs of Congestion in New Jersey," and is principal investigator for a study on "Congestion Strategies for Adaptive Signal Systems." Daniel also teaches classes on highway characteristics and capacity, and traffic control.

Daniel's research interests are traffic engineering and operations, adaptive traffic control systems and transportation safety. She has researched work zone safety and congestion strategies and the development of a multimodal-planning tool that assesses the air quality impacts of ramp metering, and provided speed reduction strategies for highway work zones for the Georgia Department of Transportation.

Prior to joining NJIT, Daniel was on the faculty in the School of Civil and Environmental Engineering at Georgia Institute of Technology, where she taught graduate courses in traffic engineering, traffic flow theory, and highway capacity methods. She has worked in the Traffic Engineering Division of the Port Authority of New York and New Jersey and as a transportation engineer for Philip Habib and Associates, a New York City consulting firm. Daniel is a member of the Transportation Research Board's (TRB) Operational Effects of Geometrics Committee and serves on the arterial and interchange subcommittee for the Highway Capacity and Quality of Service Committee.

In 1995, Daniel received her Ph.D. in Civil Engineering from Texas A&M University, where her dissertation involved modeling delays for arterial signal systems. She received her M.S. in Transportation Planning and Engineering from Polytechnic University, in 1989, and a B.S.E. in Civil Engineering from Princeton University, in 1985.

Daniel has worked aggressively to secure financial support for students, especially women and minorities. Since arriving at NJIT, she has submitted proposals to the National Science Foundation (NSF) and TRB. The NSF proposal, titled "Dynamic Flow Control for Urban Freight Movement," develops a control system for intermodal freight transportation. TRB's National Cooperative Highway Research Program received her proposal, titled "Assessment of Variable Speed Limit Implementation Issues," which facilitates the deployment and use of variable speed limits in the United States.
level, the NJIT methodology employed the concept of level of service (LOS). For each roadway link, the travel speed and LOS were computed based on the Highway Capacity Manual (HCM) (Transportation Research Board 1994 and 1998). According to the HCM, LOS = A, B, or C are considered satisfactory operating conditions. As speeds decrease to LOS = D, E or F, however, these changes are considered unacceptable to drivers. Therefore, links with LOS = D, E or F were included as part of the cost of congestion.

The TTI study developed a methodology to study congestion and related costs that is valid and useful on the national level. By enhancing the TTI methodology to make use of the detailed information available in the NJCMS, the NCTIP study was able to determine the cost of congestion on each link in the state. These costs were then summarized to provide costs on an area-wide or county basis, and on specific roadway corridors. In addition, NJCMS data was modified to reflect a proposed highway improvement. "Before" and "after" analyses determined the potential benefit in terms of reduced cost of congestion.

### Congestion Measures

The NCTIP methodology uses a series of congestion measures to quantify the effects on economic productivity and quality of life in New Jersey.

#### Travel Delay

The total travel delay takes into account both recurring and non-recurring delays. Recurring delay is based on computed travel speeds. Non-recurring delay, such as incidents and accidents, is based on the TTI procedure that uses factors to relate non-recurring to recurring delay based on national averages for different roadways.

#### Congestion Cost

The cost of congestion is a function of delay and fuel costs. Delay cost was estimated using an average value of time based on wage data for each county. Fuel costs were estimated using an average cost per gallon of $1.28 (note the June 2000 average of $1.55 per gallon). The TTI study used $12 per hour as an average value of time. The average wage rate was found for each county (U.S. Department of Commerce, Bureau of Economic Analysis, May 6, 1999, prepared by N.J. Department of Labor, May 1999). These wage rates varied from $10.80 for Cumberland to $23.20 for Somerset counties. The wage information improved accuracy, but did not imply that a person earning a lower income should be more congestion-tolerant than a person earning more.

Congestion also causes delays to truck freight, increasing operator costs, such as driver wage, fuel, and inventory, which are passed onto consumers. Truck delay costs are expressed on a dollar-per-mile basis of $2.65 per mile, which was used in the TTI study and is likely to underestimate the cost of trucking in the New York/New Jersey metropolitan region.

### Congestion Cost per Licensed Driver

This figure is the total congestion cost divided by the number of licensed drivers. According to FHWA’s Annual Statistics Report, licensed drivers in New Jersey are 69.2 percent of the total number of residents or 5,546,657. The percent was assumed for all counties.

### Results

Highlights of the results of the analyses are described below.

#### Congestion Measures

**Travel Delay.** The average annual delay per licensed driver in New Jersey is 34 hours, with Somerset County having the highest at 74.3 hours per year. Bergen, Morris and Monmouth counties also are very high. Several central and southern counties, including Camden and Mercer, also have a high delay per licensed driver.

**Congestion Cost.** The total annual cost of traffic congestion in New Jersey in lost time, operating cost and fuel

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Figure 1. The total state-wide annual cost of congestion is $4.9 billion.

Figure 2. The average annual cost of congestion is $880 per licensed driver.
Consumption is approximately $4.9 billion. A county-by-county analysis shows that congestion costs impact all 21 counties. Of the total cost of congestion by county, Bergen, with the largest population, is the highest at $1,063 million; Monmouth, $508 million; and Morris, $446 million. The total annual congestion costs by county are shown in Figure 1.

The congestion costs to auto and bus users are $3.7 billion. Auto and bus users incur approximately 190 million hours of person-delay and 400 million gallons of wasted fuel. The costs to truck operators are $1.2 billion annually in additional operating costs.

**Congestion Cost per Licensed Driver.** The average annual cost of congestion for New Jersey is $880 per licensed driver, with Somerset County the highest at $2,110; Bergen, $1,810; and Morris, $1,430. The annual congestion costs per licensed driver by county are shown in Figure 2.

**Future Growth in Population and Congestion**
Traffic volume in New Jersey will increase as population and employment continue to rise. Currently, many roadways in New Jersey operate at or near capacity conditions during peak periods. There is little excess capacity in the roadway network to accommodate additional growth. Consequently, even small increases in traffic volume result in significant delays and costs.

Traffic volumes are forecast to increase 7 percent by 2005 and 18 percent by 2015. If planned transportation improvements are not implemented, this growth will increase congestion cost by 34 percent in 2005 and 105 percent in 2015. The relative growth of population, traffic and cost of congestion is illustrated in Figure 3.

The impact on congestion levels is not distributed evenly across the state. Ocean, Sussex, Hunterdon and Warren counties will experience the highest traffic growth rates and, as a result, congestion costs will increase most rapidly in these counties.

**Summary of Findings**
Transportation investments frequently must compete with other government spending for scarce resources. Standard measures of effectiveness used by transportation agencies, such as traffic flow and air quality, are useful for comparing alternatives. These measures fail to account for the full marginal costs and benefits of transportation investments and are less than adequate for comparison with other public investments.

The true marginal costs and benefits of transportation improvements include the cost of congestion, as well as secondary economic benefits. Each of these areas should be quantified. Given that the costs of congestion are the largest areas of benefits in most highway improvement projects, the objective of this study was to measure quantifiable and qualitative impacts of congestion in New Jersey. The main findings of the study were:

- Financial and quality of life costs of congestion are real and impact virtually all residents in New Jersey.
- Accurately identifying the cost of congestion is critical and allows decision-makers to more precisely estimate benefits from the mitigation of congestion.
- Given the existing level of congestion throughout the state, coupled with the anticipated growth in population, employment and traffic, costs can be expected to grow dramatically.
- Available and easy-to-use computer modeling systems allow the integration of congestion cost-benefit analysis within budget planning at state, county and municipal levels.

Based on these results, a number of recommendations also were made:

- Transportation investment in heavily traveled corridors in the state can reduce congestion costs significantly.
- Specific highway improvement projects can reduce higher costs produced by traffic congestion.
- Estimation of congestion costs and benefits of mitigation should be routinely included in budgetary discussions on state, county, and local levels and made available to both the public and government officials. In addition, potential benefits of proposed and programmed projects should be estimated and made available.

- In a state that already has the highest population and economic activity density in the nation, and very high pollution costs, there must be a deliberate and informed effort to improve the efficiency of transportation facilities to allow growth to occur at the lowest cost to society.

- Efforts to mitigate congestion should include a balance between construction of new highway and transit facilities and the use of advanced technology, such as advanced traffic control, intelligent transportation systems and employer-based programs, including staggered work schedules and shorter workweeks.

The full text of "Mobility and the Costs of Congestion in New Jersey" may be downloaded from the NCTIP web site: [http://transportation.njit.edu/nctip](http://transportation.njit.edu/nctip).
Among 10 individuals and five institutions receiving the 1999 Presidential Award for Excellence in Science, Mathematics and Engineering Mentoring was Harold Deutschman, professor of civil and environmental engineering at NJIT.

Deutschman was honored for "a distinguished record over the past 29 years initiating, directing and teaching pre-college programs, and mentoring students to enter college and pursue careers in science, mathematics and engineering. His summer engineering program for 9th and 10th-graders, started in 1970, has run continuously for 29 years. He has mentored over 2,500 students, averaging 100 per year, who are predominately underrepresented minority students from the Greater Newark area. More than 95% of Deutschman's mentees have enrolled in college and 70% have majored in science, mathematics, or engineering."

Deutschman directs the Summer Transportation Institute for high school students from the greater Newark area. For three weeks during the summer, approximately 50 predominately young African-American and Hispanic men and women commute daily to NJIT, where they are introduced to the world of transportation, the potentials of new technology and the interrelationship among transportation and the environment, land use, economy, jobs and safety. The award is administered and funded through the National Science Foundation (NSF). Deutschman's program has been supported by the National Center for Transportation and Industrial Productivity for several years.

President Clinton honored individuals and groups that have been exemplary in their encouragement of minorities, women and persons with disabilities to pursue careers in scientific, engineering and technical fields. In presenting the award, the president said that they would "serve as examples to their colleagues and will be leaders in the national effort to train the next century of scientists, mathematicians and engineers."

"No personal influence is as powerful, long-lasting and positive as that of a superlative mentor. The mentors receiving this award ... are a true national resource who play a key role in defining the quality of our nation's future human resources in science, mathematics, technology and engineering," said Rita Colwell, NSF director.

Up to 10 individuals and 10 institutions may qualify for the annual award, which includes a $10,000 grant and a commemorative presidential certificate. The mentoring awards recognize a long-term commitment to providing opportunities for greater participation in science and engineering by all Americans. The awards do this by honoring personal and organizational activities that have increased participation of underrepresented groups in mathematics, engineering and science from kindergarten through graduate level.

Lida Mazaheri, who received an M.S. in Transportation Engineering from NJIT in 1998, was presented with NCTIP's Student of the Year award by U.S. Secretary of Transportation Rodney E. Slater at the TRB 79th Annual Meeting in Washington, D.C., January 2000.

Lida Mazaheri (r) with the NCTIP 1999 Student of the Year award presented by U.S. Secretary of Transportation, Rodney E. Slater at the TRB 79th Annual Meeting in Washington, D.C., January 2000.

Lida Mazaheri plans to pursue Ph.D. studies in transportation. She is a member of Alpha Epsilon Lambda, NJIT's graduate honor society, and also has served on the organization's Executive Board.

At PANYNJ since January 1999, Mazaheri was recently appointed traffic engineer in charge of New York's LaGuardia Airport, where she is responsible for ensuring the safe and orderly flow of vehicular and non-vehicular traffic throughout the airport on a daily basis. Her many projects have included roadway and bridge signage improvements, and projects for both John F. Kennedy International Airport and LaGuardia, including an airport vehicular traffic study, a traffic impact study for a new air terminal, a roadway network/frontage analysis, an assessment of future airport traffic flow conditions, design of pedestrian wayfinding signs and pedestrian safety.

Active in professional organizations, Mazaheri is the newsletter editor for the Institute for Transportation Engineers (ITE) Metropolitan Section of New York and New Jersey, where she also has organized and assisted with the ITE monthly meetings and represented ITE at National Engineers Week. She has been an active member of the Intelligent Transportation Society of America; Institute of Transportation Engineers; and the Women's Transportation Seminar.

Mazaheri received her bachelor's degree in electrical engineering from the University of Texas at Austin. She presented a paper, "Evaluation of Maintenance Approaches at Lincoln Tunnel," at the January 2000 TRB meeting. Mazaheri resides in Wayne, N.J.
Commissioner James Weinstein of the New Jersey Department of Transportation has designated New Jersey Institute of Technology as the International Intermodal Transportation Center (IITC), a university-based resource program that will work closely with public and private sector transportation stakeholders to facilitate economic development and quality of life improvement efforts linked to the intermodal transportation corridor.

One of IITC's primary goals is to identify common and complementary needs within the region, ensuring that a cooperative agenda can be created to further economic growth from the powerful global trade assets shared by the region. Consequently, one of the early projects will be the establishment of a Forum to facilitate expanded communication and collaboration among all the transportation stakeholders in the Corridor.

High on the list of priorities will be support for Portway - a critical State program to strengthen and improve the immediate access corridor between the Newark-Elizabeth Seaport/Airport complex, nearby rail and trucking warehousing terminals, and the interstate and international surface distribution network. IITC also will address broader issues such as freight transportation, brownfields and passenger transportation. In addition, the Center will identify public and private sector investments made in the corridor communities to support mobility and advance intermodal related economic development.

The Center is funded by a $2 million grant from the U.S. Department of Transportation Federal Highway Administration (FHWA) under the High Priority Projects Program of the Transportation Equity Act for the 21st Century (TEA-21). IITC’s steering Committee will include expert staff from such agencies and groups as the New Jersey Department of Transportation, New Jersey Turnpike, Port Authority of New York and New Jersey, North Jersey Transportation Planning Authority, freight carriers, logistic companies, terminal operators, transportation consumers and academia. IITC director, Lazar N. Spasovic, Ph.D., also serves as director of the National Center for Transportation and Industrial Productivity.
work produced by NJIT Ph.D. students in the public transit arena. Krambles was the former general manager of the Chicago Transit Authority. This award, by the foundation that bears his name, encourages students to pursue careers in public transit.

✓ The faculty of NJIT has been very successful in securing sponsored research in transportation. I am particularly pleased that One-Jang Jeng, assistant professor of industrial and manufacturing engineering, has joined the NCTIP family of researchers. Jeng is researching "Reflectorized Delineators at Rail/Highway Grade Crossings." I am greatly satisfied when a junior faculty member has been motivated and mentored by colleagues in his department to apply his talent to solving transportation problems. A full list of recently awarded grants to faculty is on page 5.

Finally, I am extremely pleased to announce the establishment of the International Intermodal Transportation Center (IITC) at NJIT (See page 5). We are very excited with the fact that the IITC scope fully complements that of NCTIP, and we envision intensive and extensive cooperation between the two USDOT centers in supporting the goals of the University Transportation Centers Program.

The National Center for Transportation and Industrial Productivity (NCTIP) at NJIT will host the New Jersey Department of Transportation (NJDOT) Division of Research and Technology's Second Annual Research Showcase on Nov. 8, 2000. The event will be held at the New Jersey Center for the Performing Arts in downtown Newark.

The First Annual Research Showcase, hosted by Rutgers University, drew an estimated 200 statewide transportation researchers, engineers and planners, in addition to legislators, and Federal Highway Administration and NJDOT administrators. Details will soon be available on NCTIP's Web site, transportation.njit.edu/nctip.