MOBILITY AND THE COSTS OF CONGESTION IN NEW JERSEY

A Final Report to

THE FOUNDATION OF THE NEW JERSEY ALLIANCE FOR ACTION

THE NATIONAL CENTER FOR TRANSPORTATION AND INDUSTRIAL PRODUCTIVITY

NEW JERSEY INSTITUTE OF TECHNOLOGY
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The New Jersey Institute of Technology (NJIT) is a public research university enrolling nearly 8,200 bachelor's, master's and doctoral students in 76 degree programs through five colleges: Newark College of Engineering, the New Jersey School of Architecture, the College of Science and Liberal Arts, the School of Management, and the Albert Dorman Honors College. Research initiatives include manufacturing, microelectronics, multimedia, transportation, computer science, information science, solar astrophysics, environmental engineering and science, and architecture and building science.

Yahoo! Internet Life magazine has ranked NJIT the "most wired" public university in America for two consecutive years, U.S. News and World Report's "1999 Annual Guide to America's Best Colleges" ranked NJIT among the nation's top universities, and Money magazine's most recent issue of "Best College Buys" rated NJIT as the sixth best value among U.S. science and technological schools, and among the top 100 overall.

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The Foundation of the New Jersey Alliance for Action is a tax-exempt, non-profit corporation dedicated to improving life in New Jersey through research and public education projects that will provide a better understanding of our state.

The mission of the Foundation of the New Jersey Alliance for Action is to serve as a catalyst for initiatives, which will improve the quality of life of every resident of New Jersey. It will seek to enhance the economic wellbeing, the environment, the infrastructure and all those areas which affect how the people of our State live, work, raise families and spend their leisure time.

To carry out that mission, the Foundation is committed to gain funding for sponsorship of programs and projects, which can be implemented to improve the quality of life of our citizens. It will conduct research, inform and educate the public on those issues, as well as on how specific partnerships between the public and private sectors will benefit every citizen of New Jersey.

The Foundation is overseen by a board of trustees composed of some of New Jersey's most prominent business, labor, professional and education leaders.

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The National Center for Transportation and Industrial Productivity (NCTIP) at New Jersey Institute of Technology (NJIT) is one of four national centers designated by the U.S. Congress under the Intermodal Surface Transportation Efficiency Act (ISTEA) legislation of 1991. The Center was reauthorized in 1998 under 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 Strategy's objectives 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 a resource for and works closely with the New Jersey Department of Transportation, which provides funding for mutually acceptable projects.

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

Front and back cover photos of I-80 and US 46 in Fairfield and Wayne Townships
taken by Skycomp (410-884-6900) for the New Jersey Department of Transportation.

DISCLAIMER STATEMENTS

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New Jersey Congestion Management System (NJCMS) data used in the study are provided by the New Jersey Department of Transportation and the North Jersey Metropolitan Planning Authority (NJTPA). The research team gratefully acknowledges the provision of such a comprehensive resource. However, making the data available to the team implies no endorsement of the study results by NJDOT and NJTPA.

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EXECUTIVE SUMMARY

- The total annual cost of traffic congestion in New Jersey in lost time, operating cost, and fuel consumption is approximately $4.9 billion. A county-by-county analysis shows that congestion costs impact all twenty-one counties, from the most populous to the smallest.

- Of the total cost of congestion by counties, Bergen, the most populous is the highest with $1.063 billion, followed by: Monmouth, $508 million; Morris, $446 million; Middlesex, $474 million; Somerset, $398 million; Essex, $330 million; and Camden, $290 million. (See Table 5)

- The congestion costs to auto and bus users are 75 percent of the total. Auto and bus users incur approximately 190 million hours of person-delay at a cost of $3.2 billion in congestion costs plus 400 million gallons of wasted fuel consumed at a cost approaching $500 million. The costs to truck operators are 25 percent of the total, or about $1.2 billion annually in additional operating costs.

- The average annual cost of congestion for New Jersey is estimated at $880 per licensed driver, with Somerset County the highest at $2,110. The next highest counties are Bergen, $1,810; Morris, $1,430; Monmouth, $1,240; Middlesex, $970; Hunterdon, $940; Warren, $920; and Camden, $830. (See Table 6 of the report and Figure 6 at the end of the Executive Summary.)

- As important, people traveling longer time to and from their jobs experience higher levels of stress, and this, in turn, leads to decreased labor productivity, and a reduced quality of life.

- Congestion leads to higher costs of truck freight and service operations which are passed on to consumers and which have negative impacts on the manufacturing industry and the service sector.

- In delays per licensed driver caused by congestion, Somerset County is highest. Bergen, Morris and Monmouth are also very high, along with Middlesex and Camden.

- Other counties, including Camden, Gloucester and Mercer, also have high delays.

- Growth in traffic volume in New Jersey will continue into the future as both population and employment continue to rise. Currently, many roadways in New Jersey operate at or near-capacity congested conditions during the peak periods. New Jersey Congestion Management System data indicate that there is little excess capacity in the roadway network to accommodate additional growth. Consequently, even small increases in traffic volume will result in significant increases in traffic delay and cost.

- 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 result in increases in congestion cost of 34 percent in 2005 and 105 percent in 2015. (See Figure 7 at the end of the Executive Summary.)

- 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.

FINDINGS AND RECOMMENDATIONS

- Transportation investment in heavily traveled corridors in the state can reduce congestion costs significantly. For example, a number of major transportation improvement projects are programmed for the US Route 1 corridor extending from Trenton to Woodbridge, which if constructed, can save over $300 million in annual congestion costs. Transportation projects planned for the NJ 70 and NJ 73 corridors extending form suburban Burlington County to the Delaware River Bridges could save over $200 million annually in congestion costs.

- Specific highway improvement projects can reduce higher costs produced by traffic congestion. For example, doubling the capacity of the Edison Bridge across the Raritan River in Middlesex County (listed on the State Transportation Improvement Plan), would result in an annual congestion cost savings of $4 million. Widening US Route 1 in Edison and Woodbridge would save $9 million annually in congestion costs.

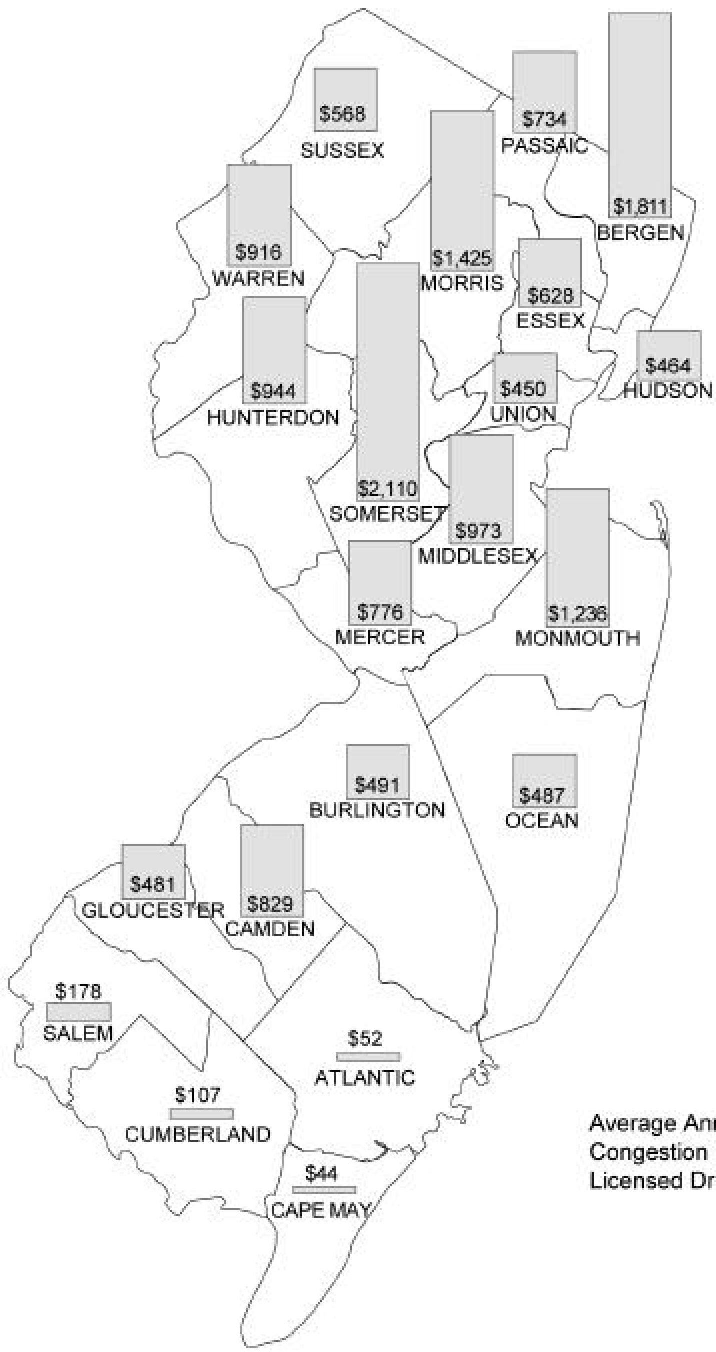
- The costs of congestion are real and impact virtually all residents in New Jersey. Being able to accurately identify the cost of congestion is critical and allows decision-makers to develop a more accurate estimate of benefits from mitigation of congestion.

- Estimation of congestion costs and benefits of mitigation should be routinely included in budgetary discussions on a state, county, and local level and as part of such process made available to both the public and to government officials. In addition, the potential benefits of proposed and programmed projects should be estimated and made available as well.

- Efforts to mitigate congestion should include a balance between construction of new highway and transit facilities with the use of advanced technology such as advanced traffic control, and intelligent transportation systems, etc. There is also a role for employer-based programs such as staggered work schedules and shorter workweeks to help relieve congestion.

- Stable transportation funding is essential to properly maintain the existing and future transportation infrastructure to move people most efficiently from their origin to destination.

- These efforts should reduce the future impacts of congestion. If congestion is not mitigated, then there will be a loss of attractiveness for the state to induce new businesses. In addition, employers will be unable to attract new employees. Ultimately, businesses and even our children may relocate to other areas.



Average Annual Cost of Congestion is $880 per Licensed Driver

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Figure 6
Annual Cost of Congestion Per Licensed Driver

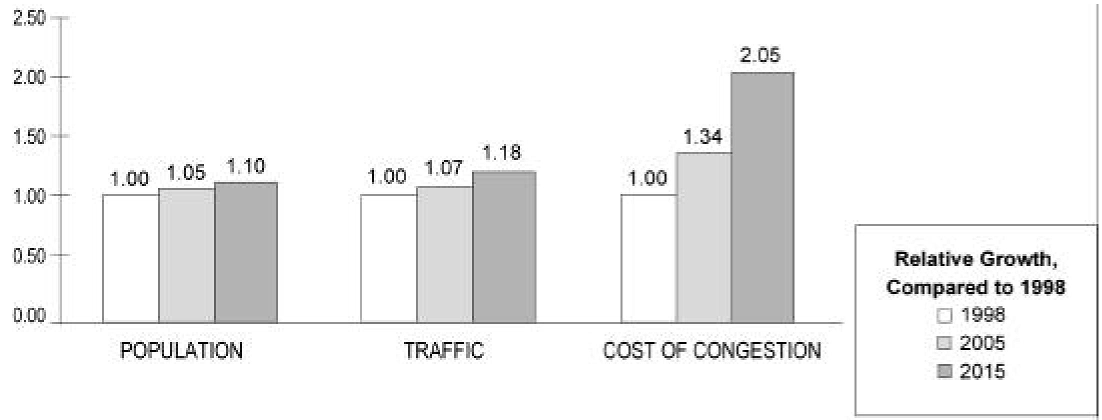

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Figure 7
Relative Growth of Population, Traffic, and Cost of Congestion

MOBILITY AND THE COSTS OF CONGESTION IN NEW JERSEY

OBJECTIVES

The objective of the *Mobility and the Costs of Congestion* study is to measure quantifiable and qualitative impacts of congestion in New Jersey on mobility, the cost of transportation, and economic productivity. The study addresses the impacts of congestion on both an individual level (impacts on an average traveler), as well as on an area-wide levels (impacts on an entire county). Consequently, the costs of congestion are estimated on a per county basis as well as on a per driver basis. The cost combines not only the direct impact of travel delay and excess fuel costs, but also the added cost due to congestion of providing goods and services.

The results of the study are products that could be used to inform the general public as well as to develop information that will be used in developing public policy on issues dealing with improving mobility, alleviating congestion, and securing stable funding sources for transportation improvements. The development of clear and concise summary information including graphics and tables to convey the results of the study is a key element.

This report presents the results and summarizes the methodology that was used to analyze the cost of congestion in New Jersey. The results focus on the cost of transportation, i.e., the costs borne by auto and truck users in terms of increased travel time and additional operating costs due to travel delay.

BACKGROUND

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

Two recent studies have dealt with the issue of urban mobility and the cost of transportation. A study by Texas Transportation Institute (TTI) "*The 1999 Annual Mobility Report*", presents a summary of the fifteen-year research effort that quantifies urban mobility. TTI's primary product is the Roadway Congestion Index (RCI) that is calculated for fifty urban areas in the United States. Portions of New Jersey are included in the New York City (NYC) and Philadelphia urban areas. The NYC area is the eighth most congested while Philadelphia is the third fastest growing congested area. The secondary product of this study is the estimated congestion cost due to increased travel delay and fuel consumption. The study found 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.

A study by The Road Information Program (*New Jersey's Roads and Bridges: A Report on Conditions, Current Use and Ability to Meet Future Travel Needs*, 1998) indicated that the state lags behind the national average in the quality of its roadways and bridges. New Jersey motorists are driving on substandard roads, which results in additional operating costs. In addition, New Jersey motorists are experiencing increased congestion. The impact of such increased costs and congestion is reduced productivity, reduced air quality, and increased accidents. Substantial funds, beyond what is currently programmed, are required for improving the transportation infrastructure in New Jersey. This study received wide coverage in newspapers throughout the state.

The above two studies provide critical information on both the costs of congestion on the national level, and the relationship between the transportation infrastructure and cost of transportation. However, they neither address the significant impacts of congestion on a particular roadway and county level, nor evaluate the benefits of transportation improvements in reducing the cost of congestion. Only by analyzing the cost of congestion on the state, county and roadway levels could the full benefits of congestion mitigation strategies be determined.

METHODOLOGY

The NJIT methodology builds upon the Texas Transportation Institute (TTI) study discussed in the previous section. The TTI study used the Highway Performance Monitoring System (HPMS) database compiled by the Federal Highway Administration (FHWA) as the basis for their study. The HPMS data is an excellent reference in that it provides a consistent set of data that allows for comparisons among urban areas in fifty states. However, it lacks the detail necessary to determine the costs of congestion on specific roadway segments and to determine the potential benefits of implementing alternative highway improvement projects. To address these deficiencies in the HPMS data, the New Jersey Congestion Management System (NJCMS) database was used as the basis for this study. The NJCMS includes traffic volume and roadway geometry information for approximately 4,000 two-directional links that make up the interstate, state and major county roadway network in New Jersey. All twenty-one counties are represented in the NJCMS. These 4,000 links were grouped into three classifications to provide consistency with the TTI study: freeways, principal arterials, and other arterials.

Freeways refer to roadways with limited access and egress points, generally at grade separated interchanges. The capacity of a freeway is generally a function of the number of lanes. The interstate network, the New Jersey Turnpike and the Garden State Parkway are all examples of freeways.

Principal arterials refer to major roadways with frequent access and egress points, generally at either at-grade signalized or unsignalized intersections, although some grade-separated interchanges may be present. The capacity of an arterial is generally a function of the presence of traffic signals. NJ 4 and NJ 17 in northern New Jersey and NJ 70 and NJ 73 in southern New Jersey are examples of principal arterials.

The “Other arterials” category refers to more minor arterials that are included in the NJCMS database. In general, these roadways were excluded from the recent TTI study. The County 500 series roadway network is generally included in the “Other arterials” category.

The enhancements of the newer methodology over the TTI methodology are summarized below:

1. Traffic volumes by direction and by hour of the day: the NJCMS data includes traffic volumes by direction for each hour of the day. In comparison, the TTI data includes only two-directional average daily traffic volumes. Consequently, the detailed information available from the NJCMS provides an opportunity to differentiate between roadway links that have similar average daily traffic volumes, but different peaking characteristics. Because of the different peaking characteristics, one link may be congested for several hours per day while another may be congested for only a single hour per day, or in only one direction. Because of the limited traffic data on the national level with regard to the direction of peak period travel, the TTI study made the very conservative assumption that if a roadway was congested, it was congested in both directions during both the a.m. and p.m. peak periods. This rather prudent assumption probably led to an overestimate of congested conditions in many urban areas in the country. Using the NJCMS data reduces the probability of such an overestimate appearing in the results of the NJIT study.

2. Truck volumes by direction and by hour of the day: the NJCMS data includes truck volumes by direction for each hour of the day. In comparison, the TTI data assumes that all roadway links have five percent trucks. Again, the detailed information available from the NJCMS provides an opportunity to measure the impacts of roadways with heavy truck flows. Heavy truck flows have a significant impact on both roadway capacity and average vehicle operating costs.

3. Average vehicle occupancy by county and roadway group: the NJCMS data includes average vehicle occupancy for each hour of the day. In comparison, the TTI data assumes that all roadway links have average vehicle occupancy of 1.25 persons per vehicle. Again, the detailed information available from the NJCMS provides an opportunity to more accurately measure the costs of congestion.

4. Detailed geometric information by roadway link: the NJCMS data includes information such as lane, shoulder and median widths and the location of traffic signals. This information is needed to accurately assess roadway capacity. Many freeways and expressways in New Jersey were built to older design standards with narrow lanes and shoulders and, as a result, have lower capacity. In addition, the capacity of arterials is generally limited by the number of traffic signals. In

comparison, the TTI study assumed the same lane capacity for all roadways of similar type (freeways or arterials) and did not address any roadway-specific information.

5. Level of Service: as part of the new methodology, the concept of level of service (LOS) was introduced. Level of service refers to a quality of traffic flow with LOS = A being the best operation and LOS = F representing unsatisfactory operations. For each link, the peak hour travel speed and level of service was computed based on the procedures of the *Highway Capacity Manual* (Transportation Research Board 1994 and 1998). According to the *Highway Capacity Manual*, LOS = A, B, or C are considered satisfactory operating conditions. Consequently, increases in congestion which resulted in roadways operating at LOS = A, B, or C were not included as part of the cost of congestion. Although travel speeds decreased and travel times increased, these changes were considered acceptable to all drivers. As speeds decreased to LOS = D, E or F, however, these changes were considered unacceptable to drivers. Therefore, links with LOS = D, E or F were included as part of the cost of congestion. The cost of congestion was based on the difference between the free-flow speed and the estimated peak period operating speed. In contrast, the TTI study used a much simpler approach. One of four different peak hour speeds was selected for each link based on the average daily two-way traffic volume per lane. Again, this speed was assumed for travel in both directions on the roadway link.

The TTI study makes a significant contribution in developing a methodology to study congestion and related costs. The study is valid and useful on the national level. However, by enhancing the TTI methodology to make use of the detailed information available in the NJCMS, the NJIT study can determine the cost of congestion on each link in the state. These costs could then be summed to provide costs on an area-wide (county) basis or on specific roadway corridors. In addition, the NJCMS data could be modified to reflect a proposed highway improvement. By utilizing the study methodology, a "before" and "after" analysis could be done to determine the potential benefit, in terms of the reduced cost of congestion, of the proposed improvement.

The methodology uses a series of congestion measures to quantify how congestion affects economic productivity and quality of life in New Jersey. The measures are:

- Roadway Congestion Index (RCI)
- Travel Congestion Index (TCI)
- Travel Delay
- Congestion Cost
- Congestion Cost Per Licensed Driver

The measures are defined and summarized below:

Roadway Congestion Index (RCI): cars per road space; a measure of vehicle travel density on major roadways in an urban area. An RCI exceeding 1.0 indicates an undesirable congestion level, on average on the freeways and principal arterial street system during the peak period.

Average daily vehicle-miles of travel (VMT) on freeways, principal arterials and other arterials are calculated by multiplying the average travel volume by the length of roadway. The resulting ratios in the equation below are combined using the amount of travel on each portion of the system so that the combined index measures conditions on the freeway and arterial street systems. This variable weighting allows comparisons of areas with much freeway travel and areas with little freeway travel. The computation is shown in the following equation.

$$RCI = \frac{\left(\frac{Freeway\ VMT}{Lane\ Mile}\right) * Freeway\ VMT + \left(\frac{Arterial\ VMT}{Lane\ Mile}\right) * Arterial\ VMT}{14{,}000\, Freeway\ VMT + 5{,}500\, Arterial\ VMT}$$

Travel Rate Index (TRI): amount of extra travel time; measure of the amount of extra time it takes to travel during the peak period. The travel rate (in minutes per mile) in the peak is compared to off-peak, uncongested speeds. A TRI of 1.20, for example, indicates that it will take 20 percent longer to travel to a destination during the peak period than during the off-peak period.

The computation is shown in the following equation:

$$TRI = \frac{\left(\frac{FreewayTravelRate}{FreeflowRate}\right) * FreewayVMT + \left(\frac{ArterialTravelRate}{FreeflowRate}\right) * ArterialVMT}{FreewayPeakPeriodVMT + ArterialPeakPeriodVMT}$$

Travel Delay: hours lost due to recurring delay during the peak travel periods are estimated from travel speed estimates on the freeways and principal arterial streets. The estimation of travel speed for freeway and arterial streets under uncongested and congested conditions is a complex process based on the procedures of the *Highway Capacity Manual (*Transportation Research Board 1994 and 1998*)*.

The travel delay is computed as the difference between the zero-volume travel time and the travel time under each hourly demand. Note that the zero-volume travel time for arterials includes delays incurred at signalized and unsignalized intersections.

Hours lost due to non-recurring delays (incidents and accidents) during the peak travel periods are estimated using the TTI procedure. The hours lost due to non-recurring delays vary primarily as a function of roadway congestion. First, as roadways become more congested, the number of accidents generally increase. Second, the impacts of peak period accidents and incidents on delay is greater for congested roadways, as any loss in roadway capacity results in demands exceeding available capacity and long additional delays.

The TTI procedure uses general factors to relate non-recurring to recurring delay based on national averages for different roadway types.

Congestion Cost: the cost of congestion is a function of two variables: delay cost and fuel cost. Delay cost is estimated using an average value for each hour of travel time. Average values of time were based on wage data obtained for each county.

Fuel costs are estimated using an average cost per gallon of fuel of $1.28 for the entire state of New Jersey. Calculating the average cost of a gallon of fuel is straightforward. However, estimating the value of travel time is much more complex.

In some transportation studies, particularly toll road studies, the value of travel time is based on an average wage rate. These studies typically use a value of time between 40 and 110 percent of the average wage rate.

In other studies, the use of a wage rate to determine value of time leads to bias in the study as it favors roadway improvements in higher income areas. These studies use a constant value of time, typically the minimum wage, to address these equity issues.

In the TTI study, an average value of time of $12.00 per hour was used. For NJIT study, the average wage rate per capita was found for each county. These wage rates varied from a low of $10.80 for Cumberland County to $23.20 for Somerset County. The data are shown in **Table 1**.

The use of the actual New Jersey county based wage information allowed the study team to achieve a higher accuracy of the estimated cost of congestion. It does not imply that a person that earns a lower income should be more congestion-tolerant than a person earning more.

In addition to fuel costs, congestion causes delays to truck freight that must spend additional time in transit. This delay translates to increased operator costs (driver wage, fuel, etc.) and inventory costs, which are in turn passed onto consumers. Truck delay costs are expressed on a dollar-per-mile basis. A value of $2.65 per mile was used for this study. This value is 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: total congestion cost divided by the number of licensed drivers. According to FHWA annual statistics report, the licensed drivers in New Jersey are 69.2 percent of the total number of residents or 5,546,657. The same percent was assumed for all counties.

Table 1: Per Capita Personal Income for New Jersey - 1997

COUNTY	POPULATION	ANNUAL	HOURLY
Atlantic	236,400	$ 30,187	$ 15.09
Bergen	848,100	$ 43,123	$ 21.56
Burlington	412,400	$ 27,849	$ 13.92
Camden	505,800	$ 26,500	$ 13.25
Cape May	98,700	$ 26,419	$ 13.21
Cumberland	135,000	$ 21,663	$ 10.83
Essex	759,800	$ 32,581	$ 16.29
Gloucester	248,000	$ 24,340	$ 12.17
Hudson	550,600	$ 24,943	$ 12.47
Hunterdon	120,000	$ 39,830	$ 19.92
Mercer	331,000	$ 36,598	$ 18.30
Middlesex	704,700	$ 30,881	$ 15.44
Monmouth	594,200	$ 33,952	$ 16.98
Morris	451,800	$ 42,913	$ 21.46
Ocean	478,100	$ 25,725	$ 12.86
Passaic	466,300	$ 25,560	$ 12.78
Salem	64,000	$ 25,162	$ 12.58
Somerset	272,700	$ 46,392	$ 23.20
Sussex	142,500	$ 28,162	$ 14.08
Union	497,500	$ 35,157	$ 17.58
Warren	97,800	$ 26,687	$ 13.34

Source: U.S. Department of Commerce, Bureau of Economic Analysis, May 6 1999. Prepared By: New Jersey Department of Labor, May 1999.

RESULTS

Three sets of analyses were prepared for this preliminary work. The first set of analyses utilized the methodology to summarize the existing delay and cost indices for each of the twenty-one counties in New Jersey.

The second set of analyses focused on specific areas. The methodology was utilized to estimate the existing cost of congestion for two corridors in New Jersey. These costs provide a basis for estimating the potential benefit of roadway improvements in the corridor. In addition, two highway improvement projects that are programmed for implementation in the next few years were also analyzed. The annual delay and cost for the roadways associated with these two projects “before” and “after” the improvement were computed.

The third set of analyses focused on future conditions. The methodology was utilized to estimate the future cost of congestion for the entire state of New Jersey in the years 2005 and 2015. A summary of the results follows.

The Roadway Congestion Index (RCI) was determined for each roadway link and aggregated for each county. The RCI is summarized in **Table 2** by County and Roadway Group. The average value for all roadways is shown graphically in **Figure 1**. The following conclusions can be seen in the table:

Table 2: Roadway Congestion Index (RCI)

County	Freeways	Principal Arterials	Other Arterials	All Roadways
Atlantic	0.62	1.22	0.68	0.77
Bergen	1.09	2.48	1.33	1.52
Burlington	0.79	1.29	0.57	0.91
Camden	0.91	1.48	1.06	1.10
Cape May	0.35	0.59	0.87	0.50
Cumberland	0.26	0.82	0.91	0.60
Essex	1.28	1.39	1.02	1.30
Gloucester	0.54	1.29	0.94	0.73
Hudson	1.01	1.94	1.38	1.19
Hunterdon	0.68	1.09	0.82	0.78
Mercer	0.87	1.39	0.91	1.01
Middlesex	0.99	2.08	1.22	1.23
Monmouth	0.94	1.52	1.31	1.13
Morris	0.91	1.60	1.20	1.05
Ocean	0.86	1.16	1.23	0.95
Passaic	1.26	2.03	0.99	1.58
Salem	0.67	1.12	0.73	0.75
Somerset	0.77	1.87	1.61	1.06
Sussex	0.53	1.03	0.81	0.92
Union	1.06	1.83	0.89	1.18
Warren	0.49	1.18	0.60	0.62

- Passaic, Bergen and Essex Counties have the highest RCI for the state. In general, the counties in Northern New Jersey have higher values than the counties in Southern New Jersey.

- Much of South Jersey has RCI values less than 1.0, indicative of generally uncongested conditions during peak periods.

- Camden County has the highest RCI in Southern New Jersey at 1.1.

The Travel Rate Index (TRI) was determined for each roadway link and aggregated for each county. The TRI is summarized in **Table 3** by County and Roadway Group. The average value for all roadways is shown graphically in **Figure 2**. The following conclusions can be seen in the table.

- Morris, Passaic and Essex Counties have the highest TRI for the state. In general, the counties in Northern New Jersey have higher values than the counties in Southern New Jersey.

- Much of South Jersey has TRI values of approximately 1.0, indicative of generally uncongested conditions during peak periods.

- Camden County has the highest TRI in Southern New Jersey, exceeding 1.1.

Table 3: Travel Rate Index (TRI)

County	Freeways	Principal Arterials	Other Arterials	All Roadways
Atlantic	1.00	1.16	1.08	1.02
Bergen	1.12	1.73	1.64	1.12
Burlington	1.02	1.42	1.04	1.07
Camden	1.10	1.65	1.28	1.12
Cape May	1.00	1.10	1.12	1.01
Cumberland	1.00	1.11	1.24	1.03
Essex	1.16	1.72	1.26	1.13
Gloucester	1.02	1.50	1.33	1.06
Hudson	1.17	1.70	1.46	1.15
Hunterdon	1.19	1.29	1.12	1.10
Mercer	1.03	1.48	1.24	1.09
Middlesex	1.08	1.70	1.50	1.10
Monmouth	1.10	1.57	1.32	1.14
Morris	1.19	1.57	1.30	1.15
Ocean	1.09	1.43	1.34	1.10
Passaic	1.18	1.60	1.25	1.15
Salem	1.01	1.15	1.20	1.02
Somerset	1.09	1.96	1.30	1.13
Sussex	1.10	1.29	1.31	1.08
Union	1.10	1.51	1.14	1.13
Warren	1.10	1.35	1.12	1.09

The difference in the results between the RCI and the TRI is due to two factors. The first is the percentage of travel in each county, which takes place on freeways versus arterials. The density-speed relationship of these two types of roads is much different. The second is the general nature of the density-speed relationship, which is very much non-linear. Under uncongested conditions, small or moderate increases in density will not affect speed on freeways. A freeway that operates with a density between 0 and 90 percent of capacity will generally operate at the same average speed. However, at densities between 90 and 100 percent of capacity, small changes in density will result in significant drops in average speed. These types of changes lead to the differences seen in **Tables 2 and 3**.

The travel delay was determined for each roadway link and aggregated for each county. The results are shown graphically in **Figure 3**. The travel delay was then divided by the number of licensed drivers in each county for each roadway link and the county total. The travel delay per licensed driver is summarized in **Table 4**. The results are shown graphically in **Figure 4**.

Table 4: Annual Hours of Delay per Licensed Driver

County	Freeways	Principal Arterials	Other Arterials	All Roadways
Atlantic	0.08	1.60	0.36	2.04
Bergen	8.73	52.40	1.01	62.14
Burlington	1.13	20.96	0.00	22.09
Camden	4.63	32.31	1.07	38.01
Cape May	0.00	1.20	0.69	1.89
Cumberland	0.00	1.84	3.67	5.51
Essex	7.82	17.53	0.13	25.48
Gloucester	0.91	17.30	5.10	23.31
Hudson	10.12	9.04	0.93	20.09
Hunterdon	14.30	10.03	1.24	25.57
Mercer	1.41	26.32	0.79	28.52
Middlesex	7.00	29.96	4.29	41.24
Monmouth	5.95	35.74	4.40	46.09
Morris	18.46	32.15	2.06	52.67
Ocean	3.81	12.51	2.68	19.00
Passaic	5.93	28.23	0.08	34.24
Salem	0.40	2.93	5.17	8.49
Somerset	7.94	65.70	0.63	74.27
Sussex	0.21	12.14	6.71	19.06
Union	8.03	10.62	0.00	18.65
Warren	10.84	18.55	1.62	31.01
Weighted Average	6.59	25.65	1.73	33.97

The following conclusions can be drawn from the table:

- Somerset County has the highest delay per licensed driver in the state. Bergen and Morris Counties are also very high.
- Several central and southern counties including Camden, Gloucester, and Mercer, also have a very high delay per licensed driver.

The cost of congestion includes the cost associated with the travel delay determined in the previous section, the truck operating costs and the wasted fuel cost. The cost of congestion is summarized in **Table 5** by County and Roadway Group. The value for all roadways is shown graphically in **Figure 5**. The following conclusions can be seen in the table:

Table 5: Total Annual Cost of Congestion [millions of dollars]

County	Freeways	Principal Arterials	Other Arterials	All Roadways
Atlantic	0.35	6.75	1.40	8.49
Bergen	182.60	864.43	15.63	1,062.65
Burlington	8.90	131.31	0.00	140.21
Camden	39.87	243.09	7.34	290.29
Cape May	0.00	2.02	1.01	3.03
Cumberland	0.00	3.80	6.18	9.98
Essex	109.85	219.12	1.38	330.35
Gloucester	3.75	62.07	16.66	82.48
Hudson	95.03	75.92	5.81	176.76
Hunterdon	47.32	27.37	3.70	78.39
Mercer	11.75	161.59	4.41	177.75
Middlesex	92.68	331.47	50.12	474.28
Monmouth	81.43	374.82	51.95	508.20
Morris	161.66	266.89	17.06	445.61
Ocean	36.37	103.67	21.23	161.26
Passaic	49.66	186.67	0.48	236.80
Salem	0.44	2.85	4.59	7.88
Somerset	53.88	340.75	3.60	398.23
Sussex	0.77	36.78	18.49	56.05
Union	72.25	82.76	0.00	155.00
Warren	24.28	34.76	2.96	62.00
Total	1,072.82	3,558.90	233.97	4,865.69

- The total cost of congestion for the State of New Jersey is approximately 4.9 billion dollars. This represents over five percent of the national total reported in the TTI study.

- The annual congestion costs of $4.9 billion are borne by both auto users and truck operators. Both auto drivers and their passengers incur lost time due to congestion. The costs to auto users are approximately 75 percent of the total cost of congestion. Auto users incur approximately 190 million hours of person-delay at a cost of $3.2 billion in congestion costs plus 400 million gallons of wasted fuel consumed at a cost approaching $0.5 billion. The costs to truck operators are primarily due to increased labor and operating costs. These costs are approximately 25 percent of the total cost of congestion or $1.2 billion annually.

- Transit buses almost exclusively operate in mixed traffic sharing New Jersey highways with autos and trucks. Therefore, congestion impacts not only auto drivers and their passengers, truck operators but also commuters on transit buses.

- Bergen County represents approximately 20 percent of this total. Camden, Middlesex, Monmouth and Morris and Somerset Counties are also very high. In general, the northern counties experience higher congestion costs than the southern counties.

As stated earlier, the cost of congestion is based on an average person value of time per hour, truck operating costs of $2.65 per mile, and fuel cost of $1.28 per gallon. The average wage rate for each county in 1997, shown in **Table 1**, was used as an estimate for the value of time.

The average cost of congestion per licensed driver is summarized in **Table 6**. The value for all roadways is shown in **Figure 6**. **Table 6** shows:

Table 6: Annual Total Cost of Congestion per Licensed Driver [dollars]

County	Freeways	Principal Arterials	Other Arterials	All Roadways
Atlantic	2.12	41.26	8.53	51.92
Bergen	311.13	1,472.91	26.62	1,810.66
Burlington	31.18	460.12	0.00	491.30
Camden	113.90	694.52	20.96	829.38
Cape May	0.00	29.59	14.77	44.36
Cumberland	0.00	40.68	66.17	106.85
Essex	208.93	416.75	2.62	628.29
Gloucester	21.86	361.69	97.09	480.63
Hudson	249.40	199.27	15.24	463.91
Hunterdon	569.88	329.57	44.51	943.96
Mercer	51.28	705.49	19.25	776.02
Middlesex	190.06	679.73	102.79	972.58
Monmouth	198.04	911.56	126.34	1,235.94
Morris	517.06	853.66	54.55	1,425.27
Ocean	109.92	313.34	64.16	487.42
Passaic	153.89	578.49	1.47	733.86
Salem	9.87	64.46	103.58	177.91
Somerset	285.53	1,805.69	19.09	2,110.31
Sussex	7.82	373.02	187.53	568.37
Union	209.85	240.39	0.00	450.24
Warren	358.73	513.60	43.71	916.04
Weighted Average	$193.42	$641.63	$42.18	$877.23

- Somerset County has the highest congestion cost per licensed driver in the state, exceeding $2,100. Cape May County has the lowest congestion cost in the state, approximately $45 per driver.

- Bergen County in the north has very high cost exceeding $1,800 per licensed driver. Camden County in the south exceeds $800 per driver. In general, the per driver congestion costs are higher for the northern counties.

- The average cost of congestion for New Jersey of $880 per licensed driver is higher than the results of the latest TTI study which found average costs of congestion of $640 and $445 per licensed driver for the New York and Philadelphia metropolitan areas, respectively. Much of the increase can be attributed to the higher wage data, particularly in Northern New Jersey.

The congestion costs per licensed driver are rather revealing. While the total congestion as defined by the RCI and TRI is high in densely populated Northern counties, congestion as measured per licensed driver is very real and present in the less densely populated counties of southern New Jersey.

SAMPLE ANALYSIS OF TRANSPORTATION CORRIDORS AND IMPROVEMENTS

Sample highway corridors in the northern and southern portions of the state were analyzed to determine the potential benefit of transportation improvements due to the reduction in congestion costs. The corridors are US 1 through Mercer and Middlesex Counties and NJ 70 / NJ 73 in Burlington and Camden Counties.

The US 1 corridor is one of the most heavily traveled corridors in the state. This 36-mile long corridor begins in Trenton, continues through the Princeton and New Brunswick areas and terminates north of Edison and Woodbridge. A number of major transportation improvement projects are programmed for this corridor including the construction of grade-separated interchanges at several locations. Using the methodology, the existing annual cost of congestion for this corridor exceeds $300 million per year.

The NJ 70 and NJ 73 corridors are two of the most heavily traveled corridors in the southern part of this state. Each of these 30-mile long corridors extends from suburban Burlington county through Cherry Hill and Camden to the Delaware River bridges leading to Philadelphia. A number of transportation improvements are programmed, including elimination of the existing NJ 70 / NJ 73 traffic circle. Again, using the NJIT methodology, the existing annual cost of congestion for these two corridors exceeds $200 million.

In addition to the corridors, two specific highway improvement projects were selected from the Transportation Improvement Program (TIP) to determine their benefit due to the reduction in congestion costs. The first project is the Edison Bridge (US 9) across the Raritan River in Middlesex County. The existing bridge is a four-lane facility with substandard features including narrow lanes and shoulders. As part of this project, a new three-lane modern bridge would be built parallel to the existing span. The existing bridge would be converted to a three-lane facility with wider lanes and shoulders. Using the methodology and modifying the NJCMS database to reflect the proposed six-lane facility, an annual cost savings of four million dollars was estimated.

The second project is the US 1 Section 7L project in Edison and Woodbridge Townships in Middlesex County. The existing section of US 1 is a four-lane facility with substandard features including narrow lanes and shoulders. As part of this project, the roadway would be widened to provide a modern six-lane facility. Using the methodology and again modifying the NJCMS database, an annual cost savings of nine million dollars was estimated.

FUTURE GROWTH IN POPULATION AND CONGESTION

Growth in traffic volume in New Jersey is likely to continue into the future as both population and employment continue to rise. Currently, many roadways in New Jersey operate at capacity or near-capacity congested conditions during the peak periods. These congested conditions lead to the large costs discussed earlier. In addition, there is little excess capacity in the roadway network to accommodate additional growth. Consequently, even small increases in traffic volume will result in significant increases in traffic delay and cost.

A comparison of population growth, traffic growth, and the cost of congestion illustrates these impacts. As seen in **Table 7**, and shown in **Figure 7**, population growth is forecast to grow by 10 percent through 2015. Traffic is forecast to grow at a somewhat faster rate, by 18 percent through 2015. However, the cost of congestion is expected to more than double during the same period. Even though this future cost of congestion is exaggerated because this increase in costs does not include the planned roadway improvements, the consequence of traffic growth is clear. Given the peak period traffic conditions that exist throughout the state, even small increases in future traffic volumes will have significant impacts on traffic congestion, and therefore costs, on the average driver.

Table 7: Future Growth in New Jersey Population, Traffic and the Cost of Congestion

	PERCENTAGE CHANGE FROM 1998 TO	
	2005	2015
Population	5%	10%
Traffic	7%	18%
Cost of Congestion	34%	105%

Sources: New Jersey Department of Labor Market and Demographic Research, March 1999 and New Jersey Department of Transportation New Jersey Congestion Management System Version 1.5, October 1999.

As a result of varying population and traffic growth rates among the counties, the impact of increased traffic volumes on congestion level is not distributed evenly across the state. Analysis results on a county basis are summarized in **Table 8**. Ocean, Sussex, Hunterdon and Warren Counties will experience the highest traffic growth rates, resulting in congestion cost increasing most rapidly in these counties.

Table 8: Future Growth Impact – County Analysis

	Percentage Change from 1998 to					
County	Population		Traffic		Congestion Cost	
	2005	2015	2005	2015	2005	2015
Atlantic	10%	20%	9%	21%	96%	296%
Bergen	3%	6%	8%	20%	42%	153%
Burlington	8%	16%	6%	15%	26%	70%
Camden	2%	3%	4%	10%	17%	43%
Cape May	3%	8%	11%	26%	60%	279%
Cumberland	1%	2%	5%	12%	42%	120%
Essex	0%	0%	-1%	-3%	-10%	-31%
Gloucester	7%	14%	7%	17%	37%	96%
Hudson	1%	2%	2%	6%	11%	37%
Hunterdon	13%	24%	13%	31%	67%	227%
Mercer	2%	6%	6%	15%	26%	73%
Middlesex	9%	21%	10%	24%	53%	157%
Monmouth	7%	15%	10%	25%	37%	99%
Morris	8%	15%	6%	14%	23%	67%
Ocean	9%	18%	16%	40%	82%	263%
Passaic	1%	1%	3%	7%	17%	39%
Salem	1%	2%	9%	21%	46%	112%
Somerset	17%	34%	11%	26%	40%	123%
Sussex	8%	16%	14%	34%	91%	253%
Union	1%	1%	3%	8%	12%	44%
Warren	7%	13%	13%	31%	46%	138%
Total	5%	10%	7%	18%	34%	105%

Sources: New Jersey Department of Labor Market and Demographic Research, March 1999 and New Jersey Department of Transportation New Jersey Congestion Management System Version 1.5, October 1999.

CONCLUSIONS

This report summarizes the results and the methodology used for the analysis of the cost of congestion in New Jersey.

From the analysis on a county basis, it is shown that the existing annual cost of congestion is considerably higher in northern New Jersey and comparable, if not higher, than the per driver costs reported in recent studies for the New York and Philadelphia metropolitan areas. A similar conclusion can be drawn for the hours of delay per driver. The calculated values for the Roadway Congestion Index (RCI) and the Travel Rate Index (TRI) represent a clear indication of more dense traffic conditions in the northern part of the state and in certain southern urban areas.

The RCI and TRI measures provide a good overview of travel conditions in a large area, but they do not account for the variability of traffic conditions along different roadways. The travel delay and cost of congestion was therefore calculated for each roadway segment individually as a function of its own geometry and traffic volume. By focusing on specific roadway segments and corridors, the potential benefits of proposed highway improvement projects can be better estimated.

In addition to analyzing existing traffic conditions, congestion costs and potential benefits, it is important to analyze future conditions as well. The roadway network in New Jersey currently operates at near-capacity conditions at many locations (or even above capacity in some areas) during the peak periods. The relationship between traffic volume and delay is non-linear. Traffic speeds are constant and delays are minimal at low traffic volumes. However, as traffic volume on a roadway approaches and reaches capacity, traffic delays increase rapidly. Therefore, even the small increases in traffic volume which are forecast for the future will result in large increases in the cost of congestion.

RECOMMENDATIONS

Transportation investments frequently must compete with other forms of government spending for scarce resources. Standard measures of effectiveness used by transportation agencies, such as traffic flow and air quality, are generally useful for comparing among different transportation alternatives. These measures fail to account for the full marginal costs and benefits of transportation investments and are therefore less than adequate for comparing transportation with other types of 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. However the costs of congestion are, in most highway improvement projects, the largest areas of benefits. The financial and quality of life costs of congestion are real and impact virtually all drivers in New Jersey.

Given the derivable and quantifiable cost of congestion, investment in transportation infrastructure improvements is an offset to that cost.

Given the existing level of congestion throughout the state coupled with the anticipated growth in population, employment and traffic, the cost of congestion can be expected to grow dramatically in the future.

In a state that already has the highest population density, the highest density of economic activity, and very high pollution costs, there must be a deliberate and informed effort to improve the efficiency of transportation facilities in order to allow this growth to occur with the least increase in societal cost.

This effort should include a balance between construction of new highway and transit facilities with the use of advanced technology such as advanced traffic control, and intelligent transportation systems, etc. There is also a role for employer-based programs such as staggered work schedules and shorter workweeks to help relieve congestion. Stable transportation funding is essential to properly maintain the existing and future transportation infrastructure to move people most efficiently from their origin to destination.

These efforts will reduce the future impacts of congestion. If congestion is not mitigated, then there will be a loss of attractiveness for the state to induce new businesses. In addition, employers will be unable to attract new employees. Ultimately, businesses and even our children may relocate to other areas.

Therefore, being able to accurately identify the cost of existing and future congestion is critical and allows decision-makers to develop a more accurate estimate of the potential benefits from the mitigation of congestion.

These costs and benefits should be routinely included in budgetary decision-making on a state, county, and local level and as part of such process made available to both the public and to government officials. In addition, the potential benefits of proposed and programmed projects should be estimated and made available as well.

Available and easy to use computer modeling systems allow the integration of congestion cost-benefit analysis within budget planning at the state, county and municipal levels. The Appendix contains a sample of such a system developed by the study team to calculate the cost of congestion, starting from the individual roadway level.

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2. Transportation Research Board, *1994 Highway Capacity Manual with the 1997 updates*. Special Report 209E, Washington, DC, National Research Council, 1998.

3. Walters, Johnatan, *TEA Time*, Governing, October 1999 Vol. 13, No.1. 32-36

4. New Jersey Department of Labor, U.S. Department of Commerce, Bureau of Economic Analysis, May 6, 1999.

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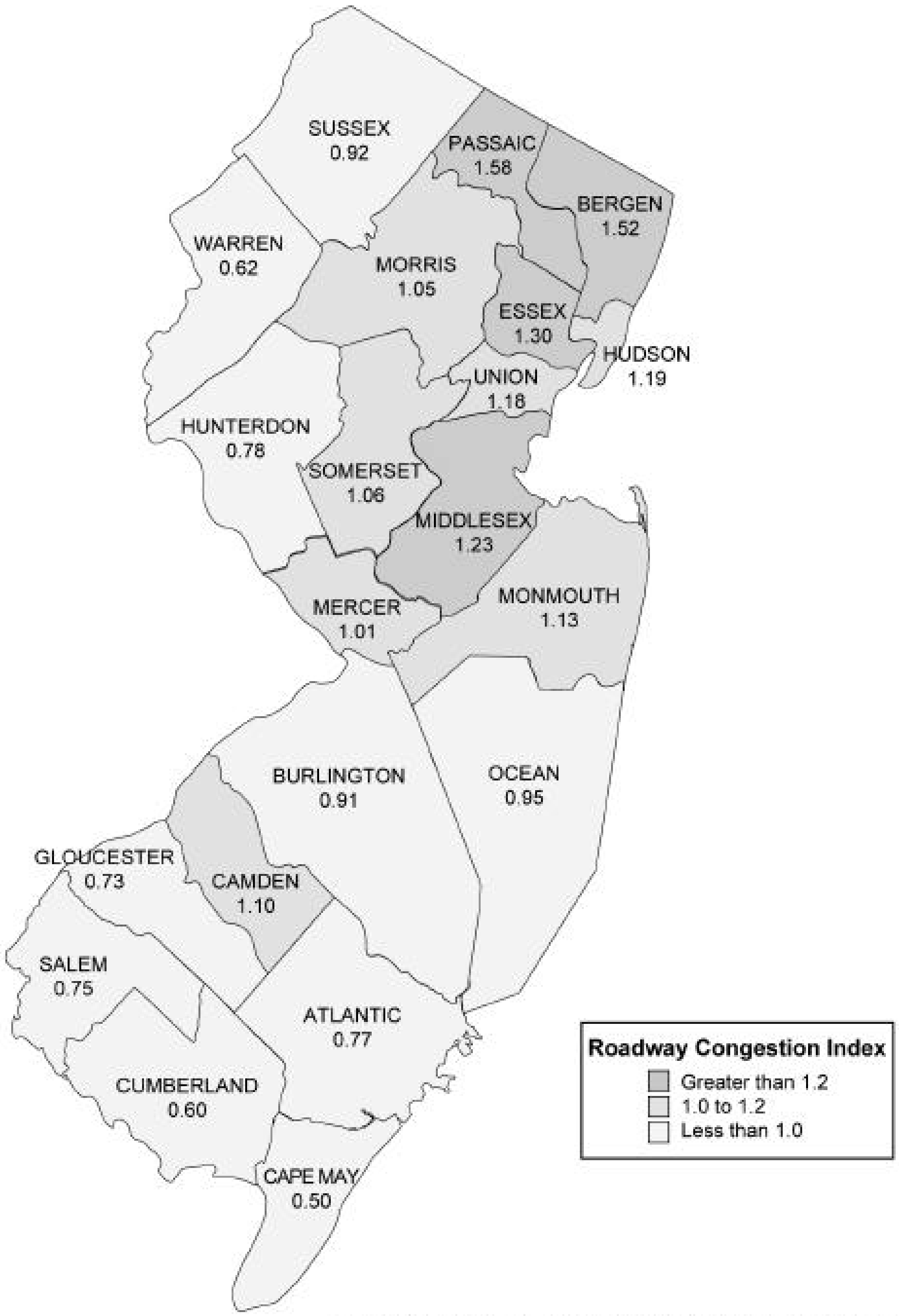
6. The Road Information Program, *New Jersey's Roads and Bridges: A Report on Conditions, Current Use and Ability to Meet Future Travel Needs*, 1998.

7. New Jersey Congestion Management System (NJCMS), New Jersey Department of Transportation (NJDOT), North Jersey Transportation Planning Authority.

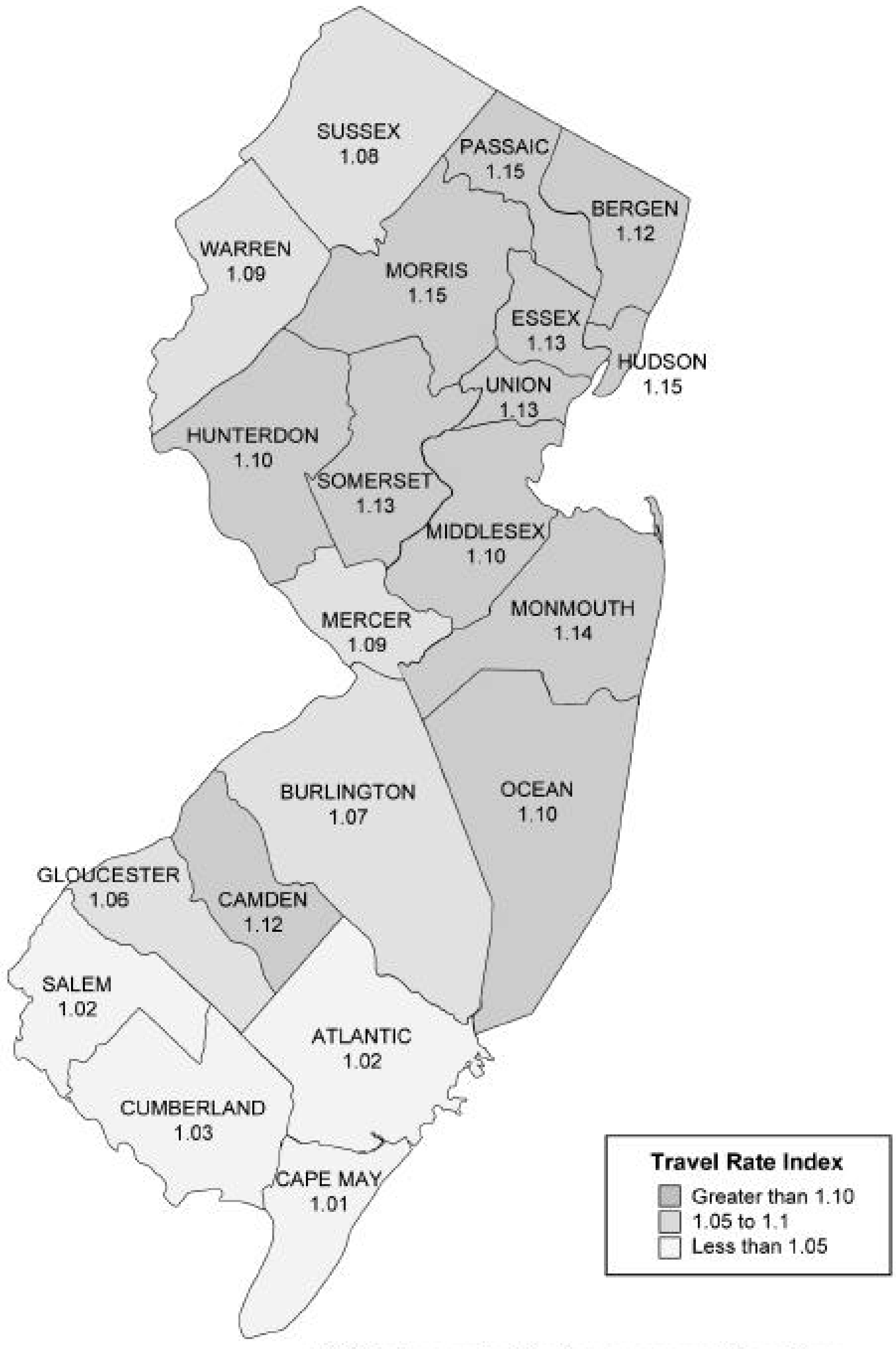
FIGURES



*An RCI value of less than 1.0 refers to uncongested conditions
A value greater than 1.2 refers to severe congestion

MOBILITY AND THE COSTS OF CONGESTION IN NEW JERSEY
NJIT - The National Center for Transportation and Industrial Productivity
The Foundation of the New Jersey Alliance for Action

Figure 1
Roadway Congestion Index (RCI)



*A TRI value equal to 1.0 refers to uncongested conditions
A value greater than 1.1 refers to severe congestion

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Figure 2
Travel Rate Index (TRI)
(all roadways)

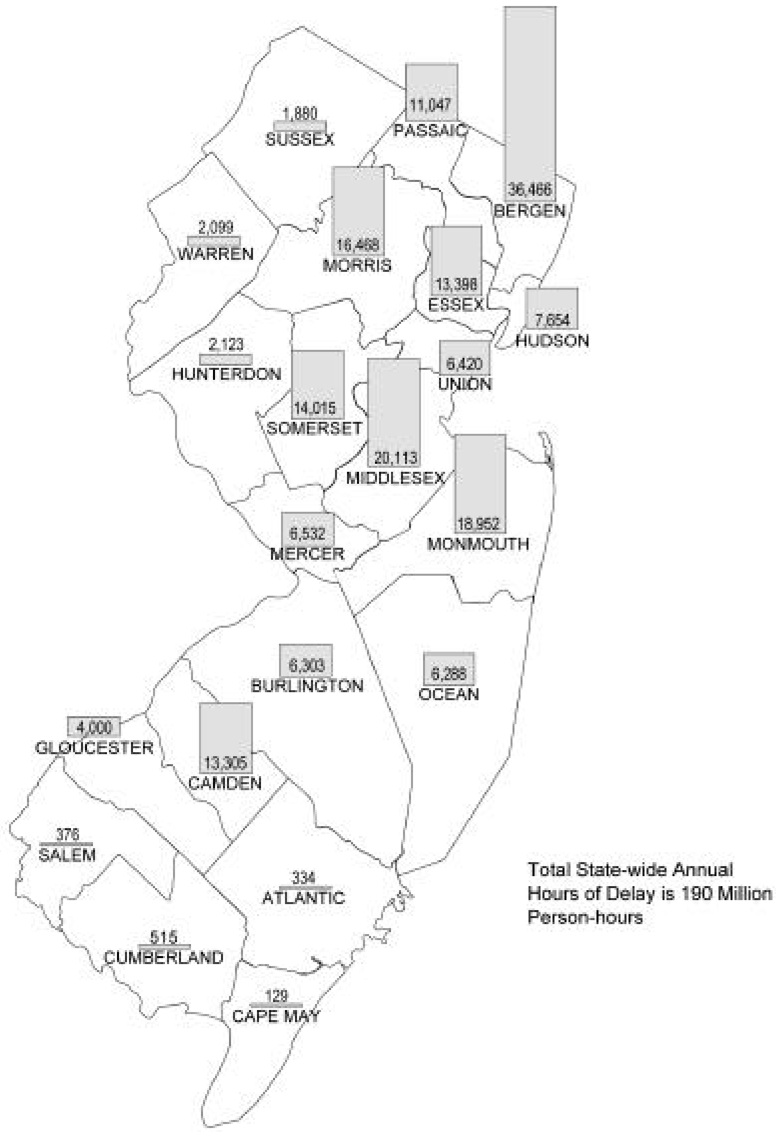

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Figure 3
Annual Hours of Delay
in Thousands of Person-Hours

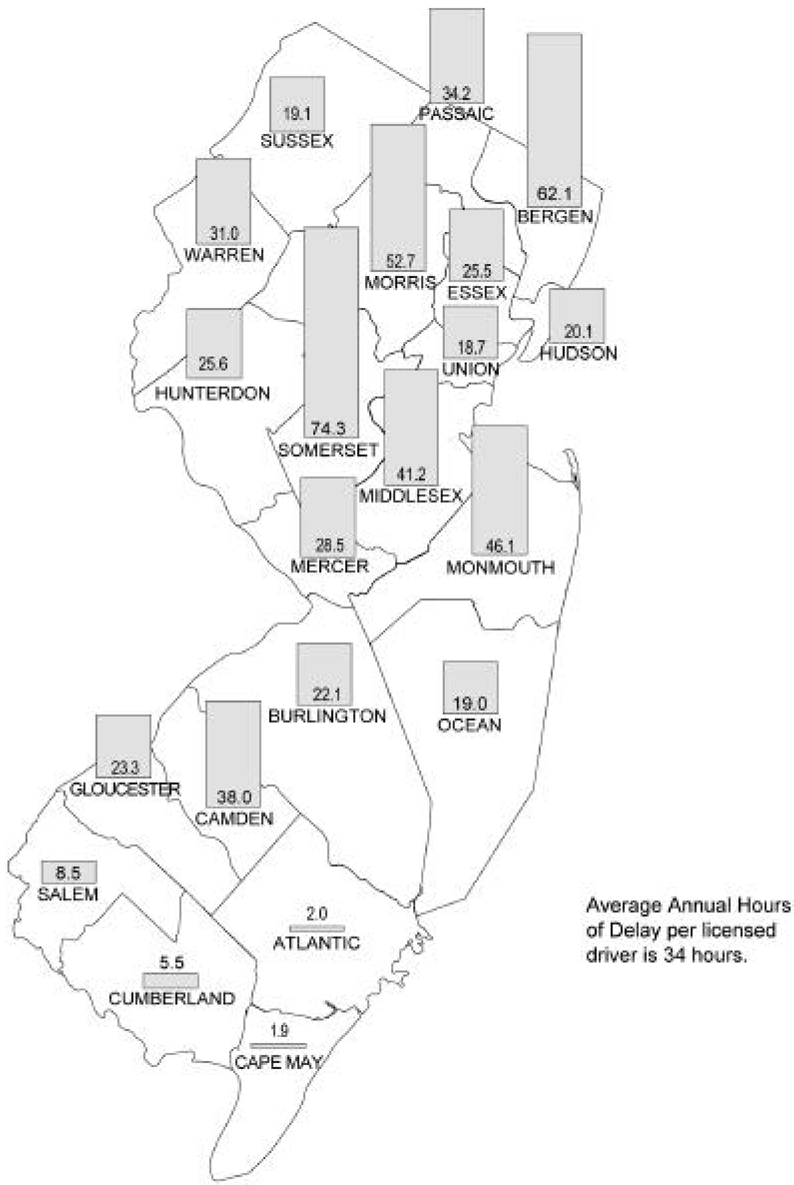

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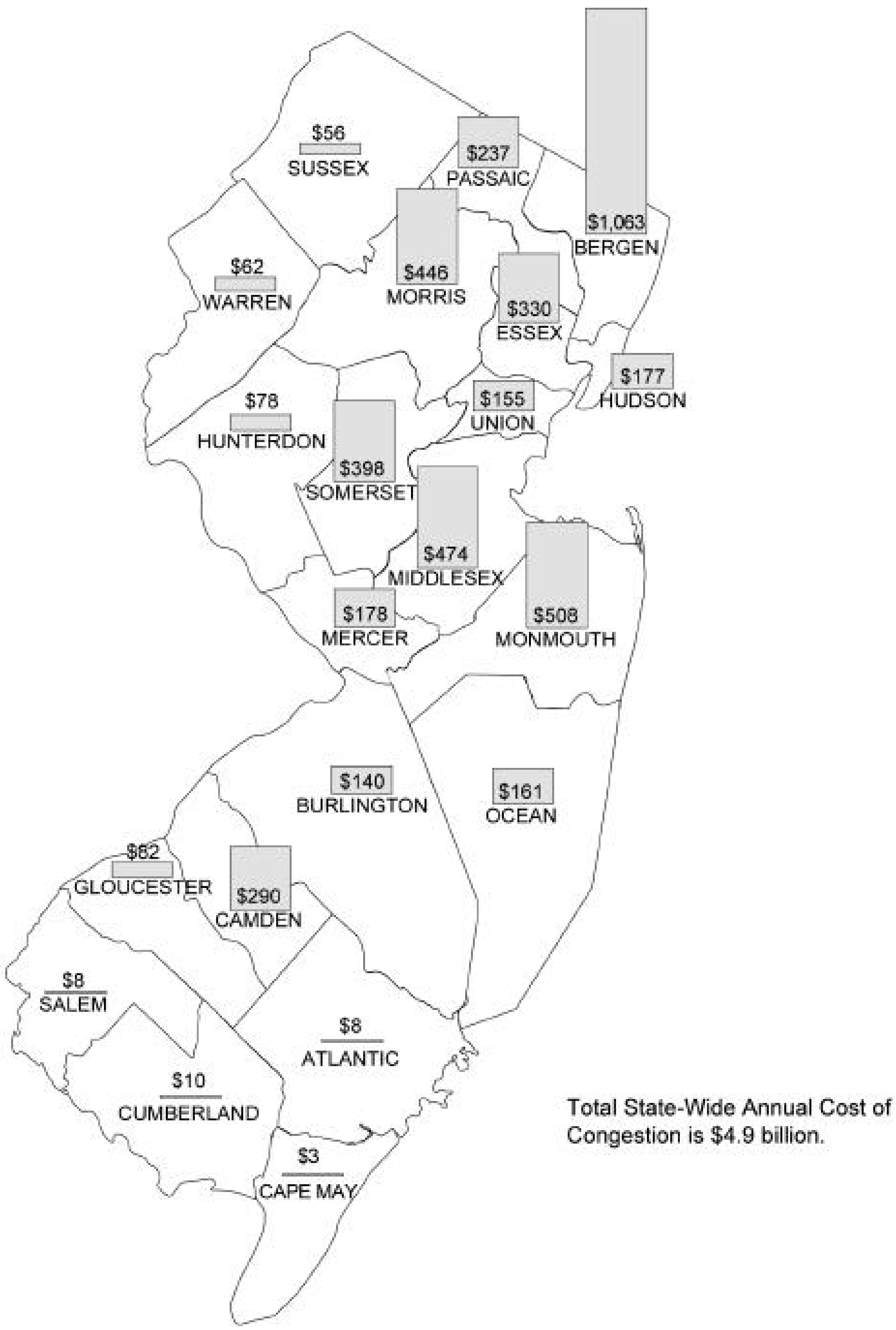
Figure 4
Average Annual Hours
Per Licensed Driver



MOBILITY AND THE COSTS OF CONGESTION IN NEW JERSEY
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Figure 5
Total Annual Cost of Congestion
In Millions of Dollars

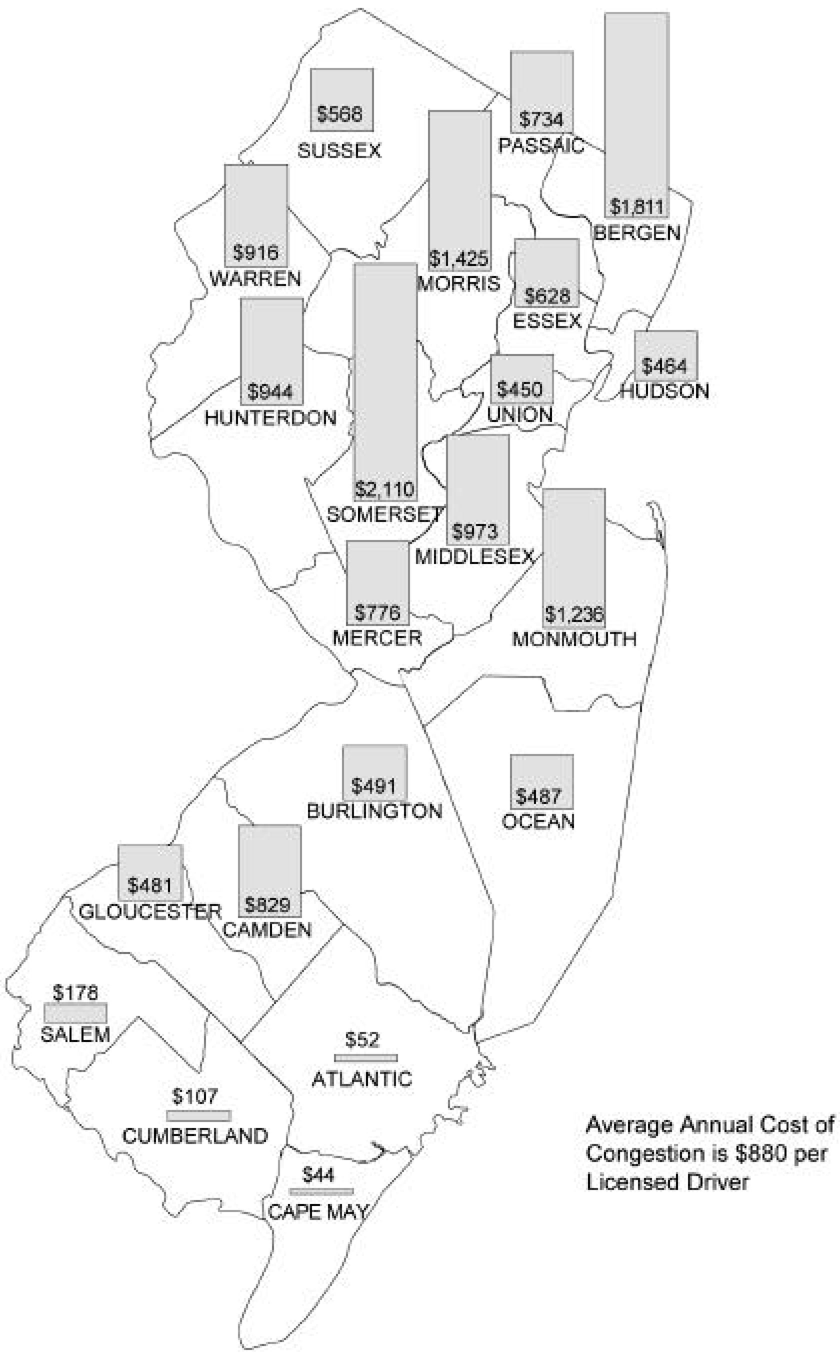

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Figure 6
Annual Cost of Congestion Per Licensed Driver

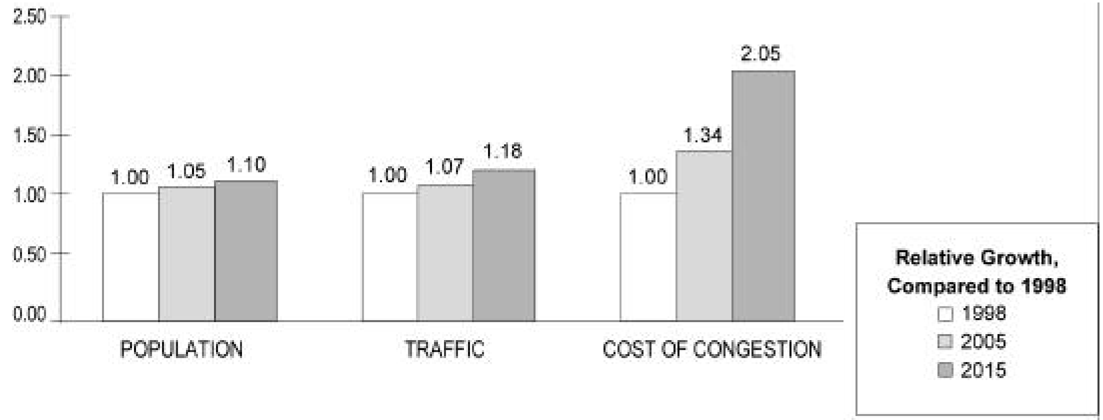

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Figure 7
Relative Growth of Population, Traffic, and Cost of Congestion

RESEARCH TEAM

Lazar N. Spasovic is director of the National Center for Transportation and Industrial Productivity. As director, Dr. Spasovic is responsible for a U.S. Department of Transportation grant with a budget of $3 million. Dr. Spasovic is an expert in the areas of Intermodal Freight Transportation, and Transportation Systems Analysis. He is currently the principal investigator on two major research efforts in freight transportation. The first project deals with optimizing container operations at one of the largest port terminals in the Port of Newark. The second project, funded by the New Jersey Department of Transportation, involves developing a database on commodity flows in New Jersey. Dr. Spasovic is a member of the Transportation Research Board's Committee on Freight Transportation Planning and Logistics. Dr. Spasovic holds a Ph.D. degree in Systems Engineering from the University of Pennsylvania, an M.S. in Civil Engineering from the University of Maryland at College Park, and Diploma in Transportation Engineering from Belgrade University.

Kenneth J. Hausman is an adjunct professor of transportation economics and urban transportation planning at NJIT. He received his B.S. in Civil Engineering and M.S. in Transportation from the University of Maryland at College Park. For the past fifteen years, he has worked in transportation consulting in New Jersey for varied public and private clients. Most recently, he served as project manager for the NJ 23 / US 46 / I-80 interchange study – a million dollar planning study of one of the busiest interchanges in the state of New Jersey. He developed the East River Crossings User Cost Model for the New York City Bureau of Bridges – this model is used to analyze alternative work schedules as part of the ongoing major reconstruction of the Brooklyn, Manhattan, Williamsburg and Queensboro bridges. He was also responsible for the travel demand forecasting for the alternatives analysis for the proposed parallel span to the Goethals Bridge – the alternatives analyzed included highway, HOV and transit elements. His areas of expertise are in the areas of transportation planning, travel demand forecasting, and engineering economics. He is also a registered professional engineer in New Jersey.

Janice Daniel is an assistant professor in the Department of Civil and Environmental Engineering at New Jersey Institute of Technology. Her research interests and work experience are in the area of traffic engineering and operations. Dr. Daniel has conducted research on adaptive traffic control systems, work zone safety and congestion strategies. Prior to coming to NJIT, Dr. Daniel was on the faculty at Georgia Institute of Technology in the School of Civil and Environmental Engineering. Dr. Daniel received her Ph.D. in Civil Engineering from Texas A&M University in 1995, where her dissertation work involved modeling delays for arterial signal systems. She received her M.S. in Transportation Planning and Engineering from Polytechnic University in 1989 and her B.S.E. in Civil Engineering from Princeton University in 1985.

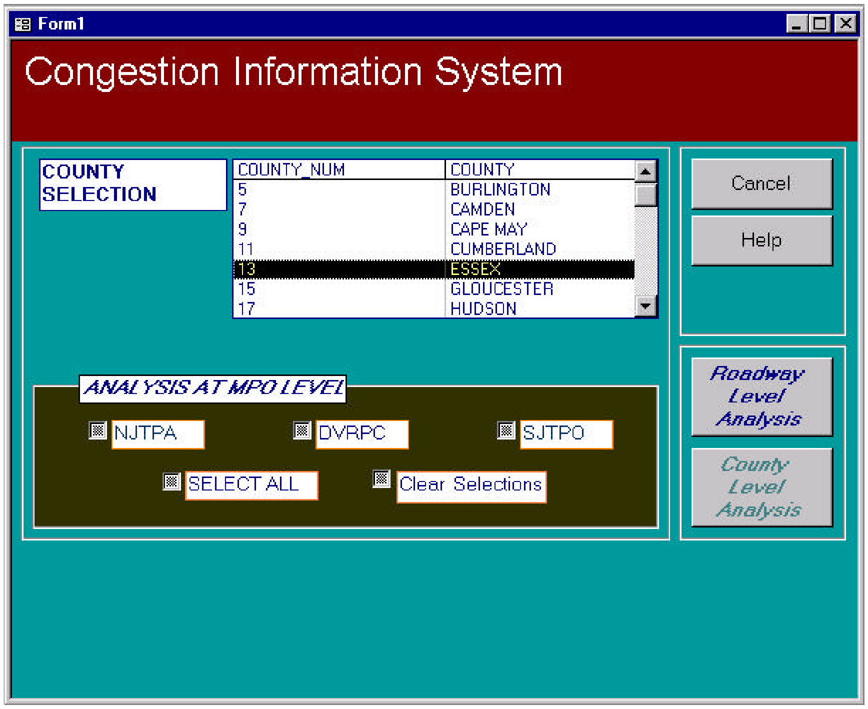
Athanassios K. Bladikas is chair of Industrial and Manufacturing Department and director of the Interdisciplinary Program in Transportation. Dr. Bladikas is an expert in the area of Public Transit, Finance and Pricing, and Logistics. Dr. Bladikas received an MBA in operations research from Columbia University and a Ph.D. in transportation planning and engineering from Polytechnic University in New York.

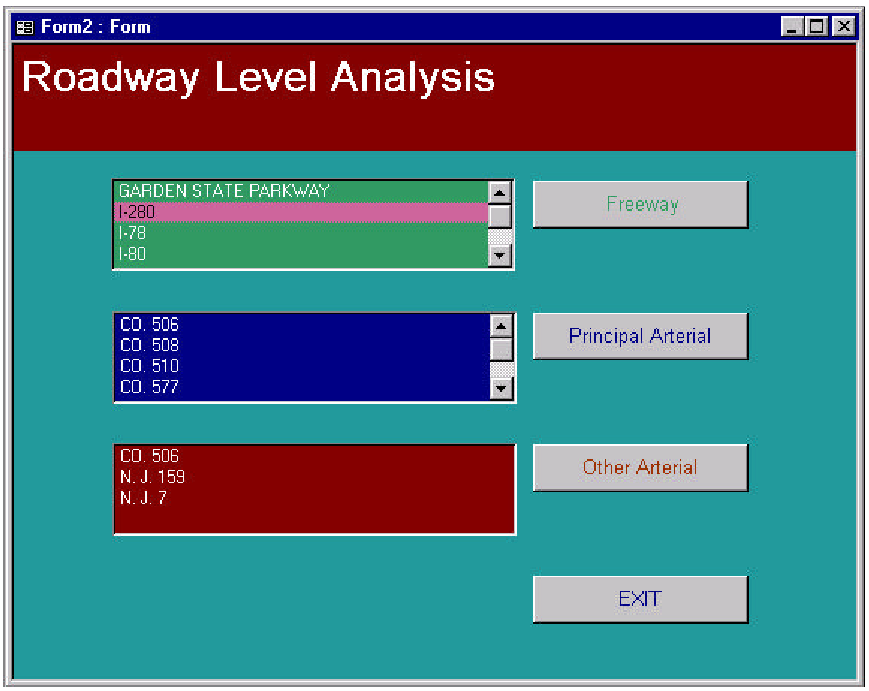
Alexios Sideris, a Ph.D. student in the Transportation Program at New Jersey Institute of Technology (NJIT), holds a BS/MS in Civil Engineering from the National Technical University of Athens ('95) and an MS in Transportation Engineering from NJIT ('99). His research interests include transportation facilities management, knowledge-based decision support systems for operations planning, and marine terminal optimization. His Master's Thesis focused on the land-side terminal operations at the Port of Newark/Elizabeth. The objective was to develop a dynamic modeling tool to provide ad hoc estimate of the expected number of truck arrivals on a daily basis. He plans a career in transportation logistics management.

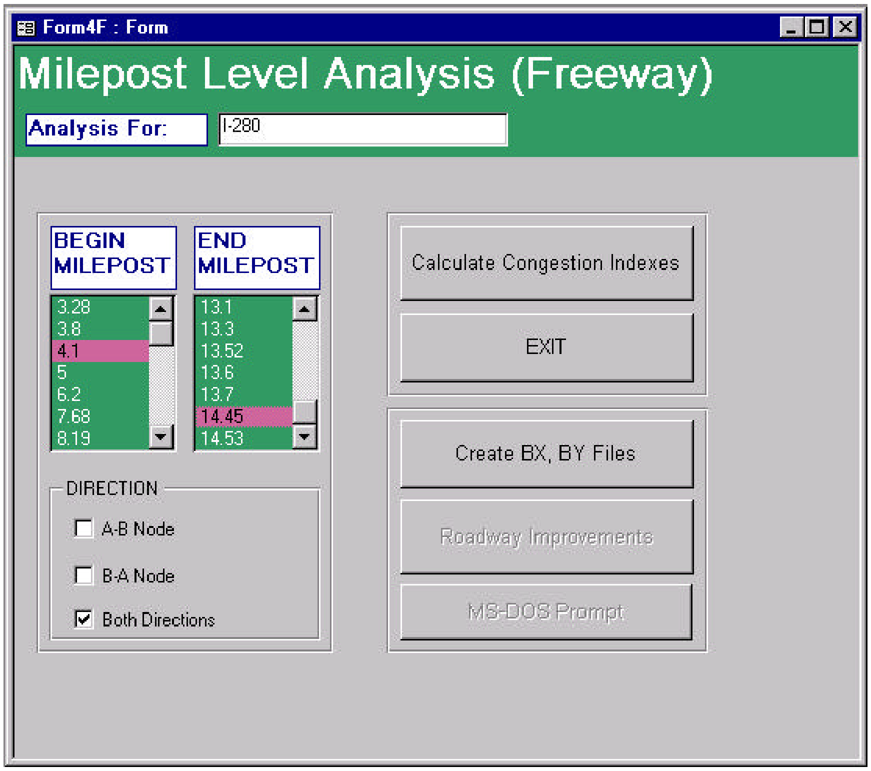
Jakub Rowinski, a Ph.D. student in the Transportation Program at New Jersey Institute of Technology (NJIT), received a B.S. degree in Civil Engineering from Lafayette College. As an undergraduate student, he published a paper on modeling freight flows over New Jersey highways. His research interests include transportation planning and multimodal freight transportation systems analysis.

APPENDIX

CONGESTION COST INFORMATION SYSTEM






Form4F : Form
Milepost Level Analysis (Freeway)
Analysis For:
I-280
BEGIN MILEPOST
3.28
3.8
4.1
5
6.2
7.68
8.19
END MILEPOST
13.1
13.3
13.52
13.6
13.7
14.45
14.53
DIRECTION
A-B Node
B-A Node
Both Directions
Calculate Congestion Indexes
EXIT
Create BX, BY Files
Roadway Improvements
MS-DOS Prompt

frmALLSUMS

Congestion Level Report

SYSTEM TRAFFIC VOLUME CALCULATIONS

ROAD FACILITY TYPE	Daily VMT [000]	Lane Miles	Daily VMT per Lane [000]	AM Peak VMT	PM Peak VMT	Peak VMT per LaneMile	RCI Roadway Congestion Index	TRI Travel Rate Index
FREEWAYS	916.5	69.1	13.3	144.6	141.1	4.1	0.95	1.21

SYSTEM TRAVEL SPEED CALCULATIONS

Speed Based on TTI [mph]	Weighted Avg. AM Peak [mph]	Weighted Avg. PM Peak [mph]	Free Flow Link Speed [mph]	Peak Period Average Speed [mph]	Peak Period Average Congested Speed [mph]
60.0	49.1	51.6	59.7	51.9	47.6

SYSTEM TRAVEL DELAY CALCULATIONS

Daily Recurring Delay [veh-hrs]	Annual Recurring Travel Delay [person-hrs]	Daily Incident Travel Delay [veh-hrs]	Annual Incident Travel Delay [person-hrs]	Daily Recurring Truck Delay [veh-hrs]	Daily Recurring Pass. Delay [veh-hrs]
1173.7	366,777	2934.2	916,942	116.5	1057.2

Under Severe Delay [veh-hrs]	Under Heavy Delay [veh-hrs]	Under Moderate Delay [veh-hrs]	Under Uncongested Travel [veh-hrs]	Daily VMT [000] Under Severe Conditions	Daily VMT [000] Under Heavy Conditions	Daily VMT [000] Under Mod. Conditions	Daily VMT [000] Uncongested Conditions
940.5	209.6	23.5	9.8	53.5	88.3	42.5	101.4

CONGESTION WASTE FUEL COST

Average Fuel Economy	Daily Recurring Delay Waste Fuel [gallons]	Daily Incident Delay Waste Fuel [gallons]	Total Annual Fuel Waste [mill. gallons]	Daily Recurring Delay Fuel Cost ($)	Daily Incident Delay Fuel Cost ($)
20.7	2941.5	7353.8	2.6	$3,454	$8,635

DAILY COST OF DELAY

Daily Passenger Recurring Delay Cost ($)	Daily Truck Recurring Delay Cost ($)	Total Daily Recurring Delay Cost ($)	Daily Passenger Incident Delay Cost ($)	Daily Truck Incident Delay Cost ($)	Total Daily Incident Delay Cost ($)
$19,822	$16,012	$35,835	$49,556	$40,031	$89,587

TOTAL ANNUAL COST OF CONGESTION

Annual Recurring Delay Cost ($)	Annual Incident Delay Cost ($)	Annual Congestion Cost (million-$)
$9,822,256	$24,555,640	$34.38

Table View | Paste Results to MS Excel | EXIT