TranSearch

Delaware Center for Transportation

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Department of Civil and Environmental Engineering University of Delaware

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UD PROFESSOR INVESTIGATES NEW CONSTRUCTION TECHNOLOGY

With funding from the Delaware Department of Transportation (DelDOT) and significant inkind contributions from a number of companies, Christopher Meehan, assistant professor in the Department of Civil and Environmental Engineering at the University of Delaware, is investigating a new construction technology known as intelligent compaction (IC).

"Any time soil is placed during construction – whether it's for a road, an embankment, or an earth dam – it needs to be compacted," Meehan says. "The compaction process determines the ultimate engineering properties of the soil, including the shear strength, compressibility, and permeability, and these properties are critical to the design of earthworks structures."

The traditional approach to compaction has been to drive a roller over the soil after each layer is deposited. Testing is then done by a field fill control engineer, who "spot tests" areas throughout the construction site.

"The problem with this approach," Meehan says, " is that there is no control of the compaction process itself, and selection of the areas to be



Christopher Meehan, right, consults with DelDOT project manager Jim Pappas next to a GPS-equipped bulldozer.

tested is subjective. Also, the volume of soil that's actually tested is only a very small fraction of the amount that's compacted, so we're making assumptions based on limited information."

Intelligent soil compaction, an emerging technology, has the potential to improve infrastructure performance and safety, decrease costs, and reduce construction time. The new technology uses advanced monitoring and control tools to manage compaction as well as satelliteguided GPS systems to guide the use of the equipment and provide a comprehensive record of the compaction-related earthwork.

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Message from the Director



The last few months have been marked by both excitement and challenges at the Center, including the signing of a new five-year agreement with DelDOT. The new agreement reflects the changes and priorities of both UD and DelDOT, while also improving our financial reporting and accountability standards. Overall, however, the new agreement

continues the center's spirit of cooperation, participation, and partnership for conducting quality research, education, and training, as well as technology transfer and public service.

At our recent Research Showcase, we presented more than 25 posters showing the progress of DCT and UTC projects. We have also started to showcase student theses that faculty and advisors deem relevant to state, regional, and national transportation and infrastructure issues and problems. Student and faculty contributions, complemented by DelDOT and federal participation, have been, and continue to be, the key to our success. This year, we received a record 42 problem statements from DelDOT, FHWA, and the University of Delaware, from which our research committee chose ten projects for Fiscal Year 2010. The diversity of the selected projects reflects not only the needs and priorities of the state, but also many of the issues and problems currently faced on the national level.

According to Meehan, major equipment manufacturers such as Caterpillar have already begun to incorporate new intelligent compaction tools into their products, but research data is needed to transition the use of the technology to actual practice. "We have to show very robustly that it works before it can be incorporated into state construction specifications," Meehan says.

Conducting such research at an actual construction site can be difficult, given typical project contract issues, so the five-day field study conducted by Meehan and his students last summer occurred at a site near Odessa, Del., donated by Greggo and Ferrara, Inc., a construction company located in Wilmington. The company also donated the fill materials as well as the use of a Caterpillar front-end loader and a water truck. Caterpillar donated additional equipment and operators, software, and on-site technical expertise.

"We basically built the sub-base for a road just the way that DelDOT would do it," Meehan says. During this process, the site was used to collect data that will enable comparison of several approaches: the current method, several state-of-the-art technologies for in-situ testing, and the new IC equipment.

The project is currently in the data analysis phase, which will be completed by summer 2009. "We're looking forward to providing hard data that will support implementation of this new technology," Meehan says. "But aside from the research findings that we expect to emerge from the project, I am amazed at the overwhelming support we received from industry to allow us to do this work. The project also provided great field experience for our students." Our challenges reflect what has been taking place nationally and globally, as the economic downturn has affected all industries including transportation. The key to survival and success is to understand the realities of the 21st century and adjust accordingly. With challenge comes opportunity, and the Center has been seeking new opportunities in information technology, the environment, public policy and public safety and security, all of which directly relate to transportation and infrastructure. Our current and future seminars and speakers will be among the national and international leaders in transportation economics, transportation safety and security, and transportation ecology, to name just a few.

During the next few months, we will continue to conduct research and provide new educational opportunities on some of the most pressing issues facing transportation and infrastructure. We also have planned field trips and site visits for UD faculty and students to a number of venues, including the Philadelphia International Airport, Port of Wilmington, DelDOT and DelDOT's Traffic Management Center, and the FHWA Research Center.

For all information regarding DCT activities, please contact us at 302-831-1446 and/or visit our webpage at **www.ce.udel.edu/dct**.



In addition to Greggo and Ferrara, DelDOT, and Caterpillar, the project was enabled by donations of materials, equipment, and expertise from Giles and Ransome CAT, Kessler Soils Engineering, Humboldt Manufacturing Company, the Electrical Density Gauge Corporation, and the Maryland Department of Transportation.

University of Delaware grad students work with DelDOT employees to run in-situ tests of the IC technology.

"It was truly remarkable," Meehan says. "At any given time, we had about a dozen people at the site, and the only one actually being paid from the DelDOT grant was a graduate student whose master's thesis will document the research findings. All of the people out there, including the five other grad students, were donating their time so that we could get this work done."

"This intelligent compaction project has a lot of potential benefit to DelDOT and the contracting community," says Jim Pappas, chief materials and research engineer at DelDOT. "Potential benefits include quicker information gathering for both DelDOT and the contractor, real-time information for the equipment operator, and efficiency increases for the contractor."

"At this point, the IC work is still in the experimental phase," he continues, "but many industry people are seeing the potential benefit, so the timing of this work by Chris and his team is very good."

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UNIVERSITY OF DELAWARE STUDENTS TOUR AMTRAK TRAINING FACILITY



A dozen undergraduate and graduate students from the University of Delaware enjoyed a rare, up-close look at

Amtrak's High-Speed Rail Training Facility, in Wilmington, Delaware. The \$4.7 million facility opened in 1999 to train engineers, conductors, and on-board staff for Acela Express service through the use of cutting edge technology and hands-on laboratories. It houses a full-scale motion simulator that

Improving Freight Movement in Delaware's Central Business Districts

Freight movement by trucks within central business districts (CBDs) is often problematic for delivery drivers, pedestrians, automobile traffic, and downtown merchants. Freight pickup and delivery by trucks both contributes to and suffers from downtown traffic congestion. While the revitalization and economic sustainability of CBDs is paramount, the need for efficient freight movement, pedestrian access, traffic flow, and overall safety is equally important.

A research project being conducted by the Institute for Public Administration (IPA) at the University of Delaware in cooperation with the Delaware Department of Transportation (DelDOT) is addressing how freight movement within Delaware CBDs can be improved to ensure delivery of goods and services while balancing the need for safe traffic flow and pedestrian mobility. The IPA team comprises policy scientist Edward O'Donnell, AICP, associate policy scientist Marcia Scott, and graduate research assistant Sebastian Anderka.

A literature review conducted by IPA reveals that, while timely freight and goods movement is critical to the economic viability and duplicates the experience of operating the Acela Express train set from within the cab, numerous other train cab simulators, an onboard service training laboratory (complete with seats, tables, and food preparation areas), and nine classrooms.

The April 17th visit began with an in-depth presentation by Donald Herman (Director, Operating Practices) and Steve Masters (Senior Analyst, Operating Practices), wherein they covered a broad array of Amtrak issues, including its history, challenges and advantages of passenger rail transport, logistical coordination with other freight and passenger rail systems, and the future of high speed rail in the Northeast Corridor. The students were surprised as the two former train engineers enumerated a dizzying list of tasks and monitoring that the engineer must repeat hundreds of times in a single trip.

competitiveness of a CBD, there has been limited research on freight movement in small commercial districts. A scan of federal, state, and local government freight-movement policies indicates that the regulatory focus has been primarily at the macro, rather than micro, level. Additional guidelines are needed to govern design and demarcation of downtown loading zones and facilities, development and enforcement of downtown loading zone/ parking regulations, and development and placement of regulatory signage. To round out the study, IPA researchers made site visits to observe freight-movement issues firsthand within select Delaware CBDs. Problems observed include design problems (lack and condition of loading-zone facilities), lack of or unclear regulations, and public safety concerns (e.g., intermodal conflicts and illegal or unauthorized parking).

To gain perspectives on issues and possible solutions, IPA formed a 25-member working group of local government planners, the business community, public safety officials, and small-package shippers and haulers. Participants provided valuable insights on factors governing freight movement in CBDs. Freight-movement carriers shared their need to meet time-sensitive and perishable-delivery mandates, maximize safety through front-in and front-out loading-zone deliveries, and cater to businesses that operate on either a credit or cash basis. Participants acknowledged that delivery practices are Then, they were able to see firsthand those challenging logistics as they took turns at the various



locomotive simulators, including the replica of the Acela Express cab. As the simulator staff altered the landscapes, students had to contend with obstacles on the rails, environmental changes, speed limitations, schedule requirements, signal operations, and rail occupancy conflicts. Each of the students came away from the experience with a deeper appreciation for the job of the modern train engineer. The trip was arranged by the student chapter of ITE.



Freight-movement issues, such as this double-parked truck, were observed during the site visits to CBDS by the IPA research team

different in horizontal and vertical markets (like Wilmington) and that a diverse set of tactics is essential to improve downtown freight movement in both environments.

Key suggestions by the working group were for municipalities to designate a primary contact person to promote communication on freight movement among stakeholders and form a municipal working group to include emergency personnel. Other suggestions included the need for municipalities to consistently enforce existing regulations and consider efficiency improvements, such as metered parking in loading zones and strategically placed package-drop boxes. The group felt that DelDOT should provide additional guidelines or develop a model code to address CBD freight-movement issues. Institution of an ongoing, larger working group to facilitate information exchange among stakeholders was recommended.

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UNIVERSITY OF DELAWARE LAUNCHES THE CENTER FOR FUEL CELL RESEARCH

The University of Delaware's growing prominence in the area of fuel cell and hydrogen infrastructure research has culminated with the recent launch of the Center for Fuel Cell Research (CFCR). The mission of the center is to promote basic and applied research to improve fundamental understanding of fuel cells, and to address critical issues and barriers to commercialization.

Hydrogen-powered fuel cells are highly efficient and produce zero emissions at their point of use. For these reasons, fuel cells have the potential to alleviate major concerns facing the nation today such as dependence on foreign petroleum, emission of greenhouse gases, and urban air quality. In particular, fuel cells are well suited for automotive use, especially urban transit vehicles. The urban driving schedule of transit vehicles is perfectly matched to the fuel cell-hybrid drive train, and the centralized aspect of refueling and maintenance greatly simplifies the hydrogen infrastructure issue. Despite their promise, fuel cells today face significant challenges for commercialization, including cost and durability, which translate to research opportunities.

Several factors led to the decision to form the CFCR. First, about 25 faculty in the College of Engineering and the College of Arts and Sciences are already engaged in fuel cell research on topics such as novel materials for membranes, catalysts, gas diffusion layers and bipolar plates, systemlevel fabrication and testing, development of a powerful simulator for fuel cell hybrid vehicles, development of on-board hydrogen storage systems, and renewable methods for hydrogen production based on sunlight. They have established laboratories for fundamental and applied fuel cell research, attracted a large group of student and post-doctoral researchers, become a visible presence at fuel cell conferences, and published in the top journals in the field. Second, the State of Delaware is home to major fuel cell/hydrogen infrastructure corporations including DuPont, WL Gore, Air Liquide, Air Products, and Ion Power. The CFCR will seek to grow and strengthen our relationships with these companies and build research partnerships centered on fuel cells. And third, our fuel cell efforts have been strongly supported by our congressional

delegations. The center will also provide undergraduate and graduate students with the opportunity to participate in fuel cell research and demonstration projects. For Delaware, the center will create an opportunity for national and international recognition and a platform for economic growth.

The most visible activity of the CFCR is the UD Fuel Cell Bus Program. Our first hybrid fuel cell bus has been in operation since 2007. Our second bus has just arrived on campus and is being prepared for induction into the UD fleet. Our third and fourth buses will arrive in the coming year. In addition to the hydrogen refueling station at Air Liquide in Newark, two new refueling stations will be constructed in Dover and Wilmington. As a result of these activities, we will be able to conduct demonstration events and fleet operations in all parts of our state. One of the goals of the CFCR is public education and outreach, and the UD fuel cell buses have performed this task with great success!

> - Professor Ajay K. Prasad Director, Center for Fuel Cell Research

T² CENTER UPCOMING EVENTS

The T^2 Center is planning the following events for the remainder of 2009 and early 2010. We will announce exact dates, locations, and other information as we finalize details.

- National Highway Institute (NHI) Course 133078 Access Management Location and Design
- NHI Course 134006 Highway/Utility Issues
- Cementious Mixtures for Concrete
- Chemical Additives for Concrete
- 4-F Environmental Workshop
- Work Zone Training
- Asset Management Training for Local Government
- Retroreflectivity Regulations



6TH ANNUAL RESEARCH SHOWCASE

Despite rainy weather and the swine flu outbreak at the University of Delaware Newark campus, the transportation research showcase was well attended on May 4, 2009 at the Paradee Center in Dover.

The annual showcase, a poster session hosted by the Delaware Center for Transportation, offers the opportunity for researchers and interested parties to meet and discuss ongoing projects funded by DelDOT and the Federal government. Posters representing Pavement and Materials, Environmental, Planning, Bridge, Traffic and ITS, Transit, and UTC were on display. Researchers, graduate students, and undergraduate students discussed their results to date with representatives from various agencies across the state.

We extend our thanks to those from DelDOT, the Federal Highway Administration, Enterprise Flasher, and Delaware River and Bay Authority who attended the showcase.





Some of the members of the new ASHE at UD student chapter at their May 19th meeting; from left, Brett Marshall, Tom Costabile, Kerry Yost, Bob McGurk, Ryan Barton, Scott Slavens, Chris Manco, and (center) Rachael Vaicunas

ASHE STUDENT CHAPTER AT UNIVERSITY OF DELAWARE SET FOR FALL INAUGURATION

The Delaware Center for Transportation, the Delaware T2 Center, and the First State Section of the American Society of Highway Engineers (ASHE) teamed up this spring to launch an ASHE Student Chapter at the University of Delaware. An open meeting in March resulted in eight undergraduates enthusiastic to form the professional student organization. Three more joined the initial eight, forming a "constitutional congress" to adopt by-laws and elect officers in preparation for the fall semester, when they can be officially recognized as a Registered Student Organization by UD. At that time the First State Section will also grant them official status as an ASHE Student Chapter (expected to be just the second in the nation, along with a chapter at Drexel University).

The chapter will enable students to regularly interact socially and professionally with engineering consultants, highway contractors, and DelDOT planners, engineers, and construction personnel. Students will attend First State Section meetings, and Chapter meetings will attract guest speakers. First State Section members have pledged to assist with behind-the-scenes tours of construction projects and operational centers. Students will learn professional and leadership skills, gain meaningful insight from these real-world applications, and begin to develop important professional contacts. In addition to the opportunity to mentor, ASHE members will get an inside look at the future crop of engineers, many of whom they'll want to consider for their organizations upon graduation.

Many ASHE members contributed to this new linkage between professional practitioners and students, including Mark Luszcz (DelDOT), Rod Pieretti (retired, JJID), Bob Muir (Drexel University), Dick Prentice (McMahon Associates), Sonia Marichic-Goudy (McCormick Taylor), Larry Klepner (T2 Center), and Matt Carter (T2 Center). The inaugural officers of the Student Chapter are Kerry Yost (President), Tom Costabile (Vice President), Chris Manco (Secretary), and Rachael Vaicunas (Treasurer).

The students' work in establishing this new professional association was applauded at the May 14 First State Section Hall of Fame Banquet at Cavaliers Country Club in Newark. The energy of the group is growing as they add students to their ranks, plan a formal recruitment drive for the fall, and establish an active schedule of meetings and field activities.

DPPI Issues "How Delaware Compares"

How does Delaware's estimated appropriation under the American Recovery and Reinvestment Act of 2009 (ARRA) compare to that of its neighbors?

How do Delaware's highway and alcohol-related fatalities compare to other states in the region and the nation as a whole?

Find the answers to these transportation-related and other qualityof-life questions in "How Delaware Compares," an inventory of the state's standing on key indicators that has been undertaken as a partnership between the University of Delaware and the Delaware Public Policy Institute (DPPI). Improving on a model initiated some years ago by DPPI, the current project—managed by the Institute for Public Administration (IPA)—will not only provide timely Delaware-focused data, but will also include analysis, insight, and context from faculty experts. According to Dr. Daniel Rich, University of Delaware Professor of Public Policy, "How Delaware Compares' will be a valuable source for government, business, and community leaders as well as Delaware citizens. It provides a reliable and concise basis for benchmarking the performance of the First State in key policy and service areas against the performance of other states and the nation."

The areas covered in "How Delaware Compares" include:

- AGRICULTURE Dr. Robin W. Morgan, Dean of the College of Agriculture and Natural Resources and Professor of Molecular Biology
- CRIME, LAW ENFORCEMENT AND CORRECTIONS Dr. Kenneth C. Haas, Professor of Sociology and Criminal Justice
- ECONOMIC PERFORMANCE AND POTENTIAL Dr. William R. Latham, Associate Professor of Economics and of Urban Affairs & Public Policy
- EDUCATION Dr. Nancy W. Brickhouse, Director of the School of Education and Professor of Science Education
- EMPLOYMENT AND LABOR/POPULATION Edward C. Ratledge, Director of the Center for Applied Demography and Survey Research
- **ENERGY** Dr. John Byrne, Director of the Center for Energy and Environmental Policy and Distinguished Professor of Public Policy
- ENVIRONMENT Dr. Nancy M. Targett, Dean of the College of Earth, Ocean and Environment and Professor of Marine Biosciences
- **GEOGRAPHY** Dr. John H. Talley, Director of the Delaware Geological Survey and State Geologist
- **HEALTH** Eric Jacobson, Assistant Professor in the School of Urban Affairs & Public Policy and Associate Director and Policy Scientist for the Institute for Public Administration
- HOUSING Dr. Steven W. Peuquet, Director of the Center for Community Research and Service and Associate Professor in the School of Urban Affairs & Public Policy

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- RESEARCH, TECHNOLOGY & ECONOMIC DEVELOPMENT

 Dr. Mark A. Barteau, Senior Vice Provost for Research
 and Strategic Initiatives, Robert L. Pigford Chair of Chemical
 Engineering, and Professor of Chemistry and Biochemistry
- **SOCIAL WELFARE** Dr. Michael Gamel-McCormick, Dean of the College of Education & Public Policy and Professor of Human Development & Family Studies
- STATE AND LOCAL GOVERNMENT FINANCE/TAXES Dr. Kenneth A. Lewis, Chaplin Tyler Professor of Economics and Associate Chair for Graduate Programs for the Alfred Lerner College of Business and Economics
- **TRANSPORTATION** Dr. Ardeshir Faghri, Professor of Civil & Environmental Engineering and Director of the Delaware Center for Transportation

Dr. Rich says, "Enriched by commentaries from University of Delaware faculty experts, this data source provides a solid foundation for evaluating factors central to Delaware's quality of life and economic prosperity. It also provides a framework for identifying areas in need of public and private sector attention and improvement."

The "How Delaware Compares" project team consists of Project Manager and Associate Policy Scientist Lisa Moreland, Assistant Policy Scientist Troy D. Mix, Assistant Policy Scientist Mark Deshon, Doctoral Students Geoffrey Edwards and Xuan "Olivia" Jiang and Undergraduate Research Assistant Eva Carey. IPA Director Jerome R. Lewis, Associate Director Eric D. Jacobson, and Edward C. Ratledge, Director of the Center for Applied Demography and Research, serve as senior advisors.

Dr. Lewis says, "Many outside groups provide rankings for Delaware that may or may not prove to be accurate. The 'How Delaware Compares' project, which will be launched in the fall, provides a more up-to-date reflection of the actual position of Delaware with respect to other states. Our faculty experts provide valuable context to the information."

For further information, please contact Lisa Moreland, Project Manager, at 302-831-4955 or lisamk@udel.edu.



University of Delaware Students on a construction site, wearing the donated vests from Enterprise Flasher.

ENTERPRISE FLASHER DONATES SAFETY VESTS TO DCT

Whether as interns or researchers, University students and DCT staff are often working on highway rights-of-way. They are vulnerable to being struck by passing motor vehicles, and drivers must be able to see them from the greatest possible distance. The DCT has mandated that our students and staff must wear appropriate safety vests and hard hats when working on Delaware's roadways.

The Enterprise Flasher Company of Wilmington, DE recently donated thirty Type 3 safety vests to the DTC for student and staff use. The vests meet all current federal and state standards for retroreflectivity and body coverage.

The DCT sincerely thanks Mike Peco and his colleagues at Enterprise Flasher for their generosity and continuing efforts to improve highway safety.

DELAWARE DOT HOSTS PAVEMENT TECHNOLOGY DEMONSTRATION PROJECT



Workshop attendees gather at the demonstration site where the precast concrete slab is being installed. During the overnight hours of May 21-22, 2009, DelDOT hosted an audience of about 130 people who watched the

installation of a precast prestressed concrete pavement (pcpp) slab at the intersection of US 40, US 301, and DE 896 in Glasgow. The group also attended a workshop with sessions both before and after the field demonstration. Featured speakers included engineers from DelDOT, A-Del Construction, contractor at the site, and Coastal Precast Systems, fabricator of the concrete slabs. The project at this intersection requires the installation of 162 pcpp panels over a period of several weeks.

The Highways for Life group at the Federal Highway Administration sponsored the demonstration. The Florida T² Center and the Delaware T² Center (part of the Delaware Center for Transportation at the UD) handled the logistical aspects.

The demonstration was intended to show that pcpp slabs have several advantages over traditional concrete pavements. Manufacturing the panels off-site leads to higher materials control and durability, reduced lane closure times, and improved work zone safety.



Construction workers placing the pre-cast concrete slab in place.

The Federal Highway Administration has a large amount of information concerning pcpp technology online at www.fhwa.dot.gov/pavement/pub_listing.cfm.

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Research

NEW PROJECTS

Following are the projects approved by the DCT Policy Council for our FY'09 Annual Research Program starting on July 1, 2008:

Long-Term Performance Monitoring of a Recycled Tire Embankment in Wilmington, Delaware

This project is aimed at determining the environmental and engineering properties that should be monitored during the construction of shredded tire embankments including instrumentation, installation, monitoring and an analysis plan.

Principal Investigator:

Nii Attoh-Okine, Paul Imhoff, Victor Kaliakin and Chris Meehan, *Department of Civil and Environmental Engineering*

Project Manager:

Jim Pappas, Materials and Research

Infrastructure Security and Emergency Preparedness

Objectives for this project are in the process of being revised. Synopsis will appear in the next newsletter.

Principal Investigator:

Sue McNeil, Department of Civil and Environmental Engineering

Project Manager: Dwayne Day, *Transportation Management Center*

Testing and Operation of Delaware's First "Smart Bridge" - continuation

Under this project, diagnostic tests, analysis and interpretation of data from Bridge 1-821 located on Interstate 495 in New Castle County are being carried out. Additionally guidelines for maintenance of the SB system and integration of new sensor systems are being developed.

Principal Investigator:

Tripp Shenton, Department of Civil and Environmental Engineering Project Manager:

Jiten Soneji, Bridge Design

Integrating Transportation/ Transit Planning in the Overall Planning Process

This project, which is aimed at making transportation and transit planning proactive rather than reactive, will include such strategies as creating patterns of future land development that support transit-ready communities; using Local Area Plans as a vehicle for ensuring connectivity, mobility-friendly design, transit-ready components, and layout of subdivision and roads that are conducive to mobility, walkability, and all modes of transit; and addressing MOU's in the planning process.

Principal Investigator: Ed O'Donnell, *Institute of Public Administration*

Project Manager: Cathy Smith, Delaware Transit Corporation

Optimizing Accessible Taxi Service to Augment Traditional Public Transit Services in Delaware

This project will explore expansion of accessible taxibased transportation initiatives to augment traditional public transit services, particularly in Kent and Sussex Counties, and expand cost-efficient mobility options for Delawareans.

Principal Investigator: Doug Tuttle, Institute of Public Administration Project Manager:

Cathy Smith, Delaware Transit Corporation

Roundabouts

The project will determine the potential success of roundabouts in Delaware through field observations (and software analysis) of existing roundabouts to assess geometric design parameters, driver/ bicyclist behavior, and pedestrian issues.

Principal Investigator: Stephen Mensah, Department of Civil and Environmental Engineering

Project Manager: Dan LaCombe, Division of Planning

Safe Routes to Schools for Children – Mode Share Data Analysis

The consequences of children not walking or biking to school include environmental impacts, increased traffic in the vicinity of schools, increased rates of obesity and other associated health problems, and a decrease in the social health of communities. The purpose of this project is to provide mode share data for a sampling of elementary school students for the Delaware SRTS program.

Principal Investigator: William DeCoursey, Institute of Public Administration

Project Manager: Sara Coakley, *Division of Planning* A Meta-Analysis of Studies, Projects and Practices on Planning for a Sustainable Environment with Special Emphasis on the States of Vermont and Delaware – Phase II

Principal Investigator: Chandra Aleong, *Delaware State University*

Project Manager: Ralph Reeb, *Division of Planning*

Investigation of Intelligent Compaction Technology: Phase 2 – A Field Study

This project focuses on calibrating intelligent compaction technology for local soils in Delaware, demonstrating the utility of this technology to local contractors to ensure that it is successfully adopted, and showing DelDOT the improvements in compaction monitoring and construction quality that can result when this technology is used.

Principal Investigator:

Chris Meehan, Department of Civil and Environmental Engineering

Project Manager: Jim Pappas, *Materials and Research*

Advancing Asset Management in DelDOT

While a number of asset management activities are ongoing, there is a need to link these various activities, begin to fill the gaps in data and procedures, and explore new tools to support the integration of existing tools to decisionmaking tools.

Principal Investigator:

Sue McNeil, Department of Civil and Environmental Engineering

Project Manager: Curt Cole, *Maintenance and Operations*

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ONGOING PROJECTS:

As each project is completed, an abstract will be available on the DCT website: www.ce.udel.edu/dct.

An Examination and Presentation of Travel in Sussex County

This project focuses on compiling and presenting available travel and demographic data for Sussex County, including origins and destinations, projections and their impacts, trip purpose, employment, seasonal variation, and trip generation.

Principal Investigator:

David Racca, Center for Applied Demography and Survey Research

Project Manager: Mike DuRoss, *Division of Planning*

Bridge Management Using In-Service Data (Phase II)

In this continuing phase of the project, using an in-housedeveloped In-Service Bridge Monitoring System (ISBMS), peak gauge data is being incorporated into the data collected by the ISBMS, enabling better prediction of the load rating stress, and weigh-inmotion (WIM) data is being compared to the stresses seen during a certain time period, enabling identification of the average weight of trucks crossing the bridge and correlation of the truck weights to the stress in the bridge.

Principal Investigator:

Michael Chajes and Harry Shenton,

Department of Civil and Environmental Engineering

Project Manager:

Jiten Soneji, Bridge Design

Establishment of a Geotechnical Information Database

DelDOT has subsurface investigation test results and pile driving analyzer test results for foundation studies located throughout the state. Currently this information is located on paper, tape, and disks. This project is aimed at converting the data to a standard format that can be easily accessed with current technology and converted to future storage technology.

Principal Investigator:

Chris Meehan, Department of Civil and Environmental Engineering

Project Manager: Jim Pappas, *Materials and Research*

Pavement Performance Models

This project focuses on the development of pavement models using existing data to enable DelDOT to better anticipate future needs of each pavement and make informed decisions about maintenance, rehabilitation, and replacement.

Principal Investigator:

Sue McNeil and Nii Attoh-Okine, Department of Civil and Environmental Engineering

Project Manager: Jennifer Pinkerton, *Materials and Research*

A Feasibility Study of Bus Rapid Transit (BRT) in Delaware

Like most states in the Mid-Atlantic region, Delaware is experiencing increasing volumes of traffic and traffic congestion, as well as an increase in its aging population (60+) along with an influx of retirees. These changes in demographics and traffic volumes will produce greater demands and needs for transportation services and programs. They also suggest the need to explore alternative means to meet the anticipated transportation demands.

Principal Investigator: Bernie Dworsky, Institute of Public Administration Project Manager:

Cathy Smith, Delaware Transit Corporation

Construction of Approach MSE Walls to IRIB: Reduction of Geotechnical Field Data

Settlement plates, inclinometers, and piezometers were used to monitor the IRIB approach during construction, but the data collected needs to be analyzed to provide DelDOT with accurate soil properties in that area as well as feedback regarding the design calculations.

Principal Investigators:

Dov Leshchinsky and Chris Meehan, Department of Civil and Environmental Engineering

Project Manager: Doug Robb, *Bridge Design*

Letting Scenic & Historic Roads in Delaware Tell Their Story

This project will develop a web-based manual to facilitate the identification, designation and management of scenic and historic highways.

Principal Investigator: David Ames, *Center for Historical Architecture and Design*

Project Manager: Maria Andaya, *Roadside Environment*

Enhancing Delaware's Highways: A Natural Vegetation Project

The project is investigating vegetation models conceived to restore Delaware's roadside landscapes to a more natural state reflecting the regional flora.

Principal Investigator: Sue Barton, *Department of Plant and Soil Sciences*

Project Manager:

Chip Rosan, Roadside Environment

Fuel Cell Bus

This project is a research effort to develop, build, and deploy a fuel cell powered hybrid transit vehicle, to be used on the UD Campus and within the state of Delaware. The work focuses on developing a fuel cell powered technology demonstration vehicle, establishing a refueling infrastructure, and conduct¬ing reliability, safety, and durability studies.

Principal Investigator:

Ajay Prasad, Department of Mechanical Engineering **Project Manager:** Sean Ricketson, FTA

DOT UTC TIER II

The research under this grant addresses rail, surface, air, and water transportation, including complex issues such as air quality, safety, security and pollution.

Principal Investigator: Sue McNeil, *Department of Civil* and Environmental Engineering

Project Manager: Amy Stearns, *RITA*

Near Real-Time Monitoring of Indian River Inlet Scour Hole Edge Evolution Seaward of the Bridge Piers: Phase I

A near-real-time monitoring system that images the sea bed adjacent to the bridge piers, augmented by current meter data yielding critical forcing conditions that can be related to scour hole variability, will be used to make informed management decisions and develop appropriate plans of action.

Principal Investigator:

Jack Puleo, Center for Applied Coastal Research

Project Manager: Doug Robb, *Bridge Design*

Resiliency of Transportation Corridors

published by the UD University Transportation Center

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University Transportation Center

Department of Civil & Environmental Engineering

University of Delaware

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ELAWARE

Director's Message



This summer marks our first full cycle of activities as a University Transportation Center. Projects are producing research products, graduates are going out into the workplace, we have awarded

our second round of graduate fellowships and support for undergraduate summer research, papers are being presented at conferences, and UDUTC events such as brown bag seminars and distinguished lectures are well attended.

In this newsletter, we report on three projects. Two of these projects relate to understanding corridor governance. The third project addresses highway vegetation and sustainability. These projects address our theme "resiliency of transportation corridors" but from different perspectives. Additional information is available on the UTC website (www.ce.udel.edu/UTC/). We also report on the involvement of the UD-UTC in a new initiative to provide a Graduate Certificate in Transportation Leadership.

The remainder of the newsletter summarizes the recent awards (Graduate Fellowships, Undergraduate Research participants, 2009-2010 Research Projects, speakers and brown bags.) Of particular note is the project by Lynnette Overby to introduce middle school students to transportation concepts through dance.

IN THIS ISSUE

Lynnette, a Professor in Theater is working with students in Education on this exciting project.

In addition other events of note include:

- Robert (Buz) Paaswell, Distinguished Professor of Civil Engineering and Director, University Transportation Research Center, City College of New York, presented a UTC/DCT Distinguished Lecture (12/4/08) titled "Transportation Mega-Projects in New York; Behind the Scenes."
- Michelle Oswald (UTC 2008 Student of the Year and Fellowship recipient) was awarded the Women's Transportation Seminar (WTS) Philadelphia Chapter-Sylvia Alston Graduate Scholarship, and the American Council of Engineering Companies/Maryland Scholarship. She was also awarded a 2009 Eisenhower Graduate Fellowship by the Federal Highway Administration.
- Spring brown bag seminars were well attended. Topics and presenters were:
- "On the Road to Sustainability: Managing Highway Vegetation" -3/24/09, Susan Barton, Jules Bruck, and Anne Lucey
- "The Planning and Policy-Making Infrastructure for Transportation in the Northeast Corridor" – 3/24/09, Bob Warren and David Beauchamp.

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- "Developing Delaware's Agenda in Transportation within the Northeast Corridor" – 4/22/09, Ed O'Donnell, Troy Mix, and Geoff Edwards
- Students and faculty participated in the Delaware Center for Transportation Research Showcase (5/1/09)
- Twenty six UD students attended the Transportation Research Board's Annual Meeting in Washington DC in January.
- Kelly Ambrose, Lauren Lobo and Chance Maulkin are participating in summer undergraduate research. Kelly is working with Rusty Lee on freight issues. Lauren and Chance are

Understanding Corridor Governance



The northeast corridor remains one of the most complex transportation and public policy topics in the country. A corridor of this magnitude, with wideranging technical and

coordination challenges, demands coordinated governance that can balance regional and local transportation needs. State and local entities are responsible for the bulk of transportation policy decisions, while corridor-wide policymakers are few and far between. With public agencies along the corridor compelled to respond to the demands of local stakeholders, locally desirable solutions often prevail over what may be more efficient and effective corridor approaches. In an effort to bridge the gap between corridor-wide planning and existing forms of transportation management, Institute for Public Administration faculty, staff, and research assistants are working on two UDUTC research projects focused on corridor governance.

A Northeast Corridor Directory. Researchers need an accurate picture of northeast corridor management before they can begin to address the issue of governance. IPA senior management fellow Robert Warren, a Professor in the School of Urban Affairs & Public Policy (SUAPP), and research assistants, David Beauchamp and Xuan Jiang, have compiled a directory of public transportation agencies participating in the Research Experience for Undergraduates (REU) at the Disaster Research Center. Lauren's research with Chris Meehan will look at landslides. Chance's research with Sue McNeil is looking at the impact of sea level rise on the Northeast rail corridor in Maryland and Delaware.

Two brown bag seminars are scheduled for the fall semester and we are planning more DCT/ UTC Distinguished Lectures. Specific dates, times and locations will be posted on the UTC website. In the meantime, browse through the projects and explore the work done by the students and researchers.

Sue McNeil

Professor of Civil and Environmental Engineering University of Delaware

within the corridor. Defining the northeast corridor as the area lying within 50 miles of Interstate 95 between Boston and Washington, D.C., the directory catalogues some 80 public agencies and authorities involved in governing some aspect of transportation in this region. The directory provides contact information for metropolitan planning organizations and entities involved in managing aviation, marine ports, rail, bridges, tolls, and tunnels along the corridor.

In addition to phonebook-style listings of agencies and authorities, the directory offers commentary on the size and scope of agencies and authorities and details the patterns of change in corridor governance. Transportation entities run the gamut from relatively small, single-mode focused operations, such as the Susquehanna Area Regional Airport Authority, to vast operations like the Port Authority of New York & New Jersey (PANYNJ), which manages air, rail, marine, bus, ferry, and bridge and tunnel infrastructure. These agencies operate as units within governments and as authorities with independent legal standing. Identified trends in corridor governance include centralizing control of transportation providers and shifting management from the private to the public sector. For example, the Delaware River and Bay Authority assumed responsibility for several small, regional airports in recent years and, as of 2007, PANYNJ manages the formerly private Stewart International Airport. Finally, the directory identifies the economic development mission of many public transportation agencies as an often ignored, and potentially complicating, factor in northeast corridor governance.

The Transportation Leadership Graduate Certificate Program

UD UTC is pleased to participate in the Transportation Leadership Graduate Certificate (TLGC) Program. The Certificate program has been developed under the leadership of Tom Humphrey, a nationally recognized transportation educator and professional, and Professor Martin Pietrucha at Penn State University with the assistance of an executive committee of UTC directors.

The purpose of the Transportation Leadership Graduate Certificate Program (the "Certificate") is to make a significant contribution in helping to enhance the transportation profession; establishing an adequate reservoir of professionals to compensate for anticipated retirements; and to better prepare professionals from several disciplines to assume 21'st Century leadership roles at the executive levels in the rapidly growing field of transportation.

The TLGC Program provides a unique opportunity for practicing professionals and post-baccalaureate students to gain access to an exciting range of graduate-level, transportation courses taught by leading faculty at some of the nation's premier universities. To obtain the certificate, participants take two courses from a list of core courses and two electives. All courses are taught through distance education.

This Fall, Civil Infrastructure Systems (CIEG 655) taught by Professor McNeil and Professor Attoh-Okine serves as an elective course in the Certificate program. The course will be taught as both a regularly scheduled class and a distance-based class so that students not physically on campus are able to take the course.

To learn more about the Transportation Leadership Graduate Certificate visit www.transleader.org/

To learn more CIEG 655 Civil Infrastructure Systems contact Professor McNeil at smcneil@udel.edu

To learn how to enroll in this course as a non-degree student, contact Kathy Werrell (werrell@udel.edu; 302-831-4863) for detailed admissions procedures.

(Continued on page 3)

Delaware's Agenda in the Corridor. SUAPP doctoral student Geoff Edwards is conducting research on Delaware's transportation agenda within the northeast corridor. With direction from IPA staff members Troy Mix and Edward O'Donnell, this research seeks to 1) frame broad corridor issues from the perspective of regional stakeholders, 2) engage these stakeholders in a process of articulating transportation priorities, and 3) develop an agenda to guide Delaware's relationship with the rest of the corridor. Work has focused on identifying regional transportation issues through stakeholder interviews and the review of studies and plans impacting the

On the Road to Sustainability: Managing Highway Vegetation



Enhancing Delaware Highways was established as a project in 1998 with funding from the National Urban and Community

Forestry Advisory Program and the Delaware Department of Transportation to explore roadside vegetation management practices along Delaware roadways. Project goals were to incorporate ecologically sound practices, utilize uniquely regional plantings and improve the efficiency of roadside maintenance. During the past 10 years, over 70 pilot plots have been established along Delaware roadways to test establishment and management techniques. A theme of the project has been the replacement of the traditional management style of repetitive maintenance routines (such as regular mowing) with progressive management that accommodates unique conditions at each roadside site (such as editing existing vegetation to promote desirable native plants and remove undesirable invasives).

Why focus on roadside vegetation? In fact, roadside rights-of-way make up a significant quantity of highly visible land. By managing this land sustainably, the Department of Transportation has an opportunity to steward Philadelphia-Baltimore region. Future efforts will develop a transportation policy agenda for Delaware that reflects emerging trends and addresses local concerns within the context of broader corridor issues.

Several trends are likely to impact future transportation conditions in Delaware and the region. The planned expansion of the Panama Canal could result in significant increases in port usage at Jacksonville, Florida, and attendant increases in freight traffic through Delaware. By 2035, the Wilmington Area Planning Council estimates a 150 percent increase in truck volume along the Delaware portion of the I-95 corridor. Significant

its land resources and improve the regional aesthetics of travel throughout the state. Sustainable practices include an evaluation of soil conditions prior to planting; managing water through bioinfiltration rather than collection and removal; selection of welladapted plants for individual sites; increasing biodiversity through reduced mowing; use of local materials; and the recognition of the importance of community involvement in the planning process. The roadside beautification strategy of the 90's that focused on large masses of a non-native annual flower, cosmos, has been replaced by purposeful reduced mowing, warm-season grass meadows, native shrub masses and tactical plantings of flowering perennials at high visibility locations.

The EDH team--Susan Barton (UD researcher and extension specialist), Valann Budischak (UD extension associate and project administrator), Rick Darke (private consultant), and Gary Schwetz (Delaware Center for Horticulture program manager)--have written and produced two manuals: Enhancing Delaware Highways Concept and Planning Manual and Enhancing Delaware Highways Establishment and Management Manual. These policy manuals are designed to be used by DelDOT planners, designers and vegetation management staff as well as by consultants and communities working with DelDOT to design and manage roadside vegetation. Procedures for evaluating sites and selecting appropriate design approaches are included. Specific guidelines for seed and plant establishment as well as mowing procedures and weed control are outlined.

increases in rail traffic are also anticipated. How this traffic is ultimately accommodated will depend, at least in part, on the status of infrastructure improvements called for in documents like the 2002 Mid-Atlantic Rail Operations Study. This study identified numerous impediments to competitive freight rail in the PHL-BAL region. Finally, Base Realignment and Closure activities in Aberdeen, Maryland will likely spur regional employment growth. The addition of new employees and residents to the region will heighten the need to enhance regional commuter options.

- Troy Mix

As part of the EDH project, a major survey of Delaware drivers was conducted in 2004. A significant finding was that unmowed grass with a mowed edge was as attractive as a completely mowed cloverleaf. For several years, DelDOT has been allowing highway medians and roadsides along Route 1 to grow tall and has maintained a mowed edge adjacent to the road surface for safety and aesthetics. This practice has saved money and enhanced the biodiversity of Delaware roadsides.

Current research projects include an evaluation of vegetation management strategies under guardrail and roadside signs; warm-season grass establishment using sawdust and mushroom compost as a seed carrier; and a mowing height study comparing 2-inch and 6-inch mow heights.



Anne Lucey, a graduate student funded by a UDUTC grant, is working on a project to determine whether an awareness of environmental benefits

positively influences public perception of sustainable roadside vegetation management strategies. This study will provide DelDOT with accurate information regarding public perception of roadside vegetation. The data will assist DelDOT in making more informed decisions about environmentally and economically responsible roadside vegetation management. It will also further our knowledge of how people perceive sustainable landscape practices and determine whether an understanding of the associated environmental benefits affects their acceptance of a different landscape aesthetic.

- Sue Barton

UD-UTC Graduate Fellowships

Trevor Booz, Geoff Edwards, and Charles W.W. Mitchell III have been selected to receive 2009-2010 UD-UTC Graduate Fellowships. The fellowships are awarded to students pursuing master's and Ph.D. degrees; selection is based on academic qualifications and relevance to the UDUTC theme and goals.

For more about the fellowships and fellowship recipients, see the online version of the newsletter at www.ce.udel.edu/UTC/News/ utc_newsletter_summer09.pdf (page 4)

Undergraduate Research

Cory Castellucio, Sarah Dalton, Charlie Mitchell, and Melissa Stewart have all worked on undergraduate research. To learn more about what they have done, see the online version of the newsletter at www.ce.udel.edu/UTC/News/utc_ newsletter_summer09.pdf (page 4)

2009-2010 Projects

Five projects, involving four colleges and engaging both graduate and undergraduate students, were selected for funding as part of the 2009-2010 UTC research program:

- Understanding the Impacts of Climate Change on the I-95 Corridor in Maryland and Delaware - David Ames, School of Urban Affairs and Public Policy, and Sue McNeil, Department of Civil and Environmental Engineering
- The Impact of Disruptions along the I-95 Corridor on Congestion and Air Quality
 Earl (Rusty) Lee, Department of Civil and Environmental Engineering, and James Corbett, College of Earth, Ocean, and Environment

- The Effects of Learning Through the Arts on Transportation Knowledge and Skills of Elementary School Students, University Students and Classroom Teachers - Lynnette Overby, Department of Theater
- Historic Resiliency of Bridges on the BOSFOLK Corridor - Harry (Tripp) Shenton, Department of Civil and Environmental Engineering
- Resiliency of Transportation Corridors During Disaster: An Examination of Cross Border Networks - Tricia Wachtendorf, Department of Sociology and Criminal Justice

For more information on each of the projects see the online version of the newsletter at www.ce.udel.edu/UTC/News/utc_ newsletter_summer09.pdf (page 4 and 5) and the current research webpages.

UTC Supports Two Students in Disaster Program

Two civil engineering students affiliated with the UD-UTC, Chance Malkin and Lauren Lobo, are participating in the fifth National Science Foundation Research Experiences for Undergraduates (REU) program at the University of Delaware this summer. The program is hosted by UD's Disaster Research Center (DRC), the first social science research center in the world devoted to the study of disasters.

Malkin is working with Professor Sue McNeil on a project entitled "Climate Change and Rising Sea

Levels: A Geographic Information Systems Analysis of the Potential Impact on Railroad Corridors in New Castle County, Delaware." Advised by Assistant Professor Chris Meehan, Lobo is working on "Landslide Hazard Mapping of Earthquake-Prone Transportation Areas: Case study of an Area in the Oat Mountain along Route 5 of the United States." The UTC is providing funding for both of the students to participate in the program.

Upcoming Events and Opportunities

Brown Bag Lunches for Spring 2009

Wednesday September 16, 12:15-1:15 pm

• Infrastructure Security and Emergency Preparedness, Sue McNeil, Rusty Lee, Joe Trainor, Rachel Davidson, Tricia Wachtendorf, Laura Black, Gabriella Wasileski, Charlie Mitchell, Sarah Dalton

Friday November 6, 12:15-1:15 pm

Resiliency of Transportation Corridors During Disasters, Tricia Wachtendorf and Ben Johnson

Other Events

Transportation Infrastructure Preservation and Management: Developing a Problem-Driven Research Agenda Washington DC, November 12-13, 2009. www.TRB.org/conference/2009/Infrastructure

Deadlines

November 1, 2009 - Winter undergraduate research applications www.ce.udel.edu/UTC/Undergraduate.html

September 15, 2009, Student of the Year nominations www.ce.udel.edu/UTC/SOY.html

Contact Us

Want to learn more about the UTC?

See our website: www.ce.udel.edu/UTC/

Want to be notified by email when UDUTC is sponsoring transportation related events or about UDUTC funding opportunities or graduate fellowships?

Contact Marikka Beach (marikka@udel.edu) to be added to the email distribution list.

Resiliency of Transportation Corridors

RESEARCH PAYS OFF



Estimating Maintenance Costs for Mixed High-Speed Passenger and Freight Rail Corridors

A New Tool for Rail Planners

ALLAN M. ZAREMBSKI AND JOHN F. CIKOTA, JR.

Zarembski is President, Zeta-Tech Associates, Inc., Cherry Hill, New Jersey; and Cikota is Senior Transportation Analyst, Federal Railroad Administration, Washington, D.C. n increasingly attractive strategy for introducing high-speed passenger rail service begins by examining the freight corridors between well-populated cities. The corridors should offer the potential for improved passenger rail service that could be time-competitive with airplane and automobile for door-to-door trips in the range of 100 to 500 miles. The next task is to determine the upgrading necessary for the corridors to accommodate high-speed passenger operations in addition to the current freight traffic.

State agencies and other transportation planners investigating these options often need estimates of maintenance-of-way costs for the proposed high-speed rail routes. For example, the Mid-West Regional Railway Initiative (MWRRI), a consortium of states, recently wanted to examine projected maintenance-ofway costs for several proposed high-speed rail corridors in the Midwest, including Chicago to Detroit, Chicago to St. Louis, and Chicago–Milwaukee–St. Paul.

TranSearch

Problem

Future high-speed rail operations most likely will make use of track shared with freight trains. Because the experience in these corridors has been with freight-only traffic, transportation planners must determine the increase in the maintenance-of-way costs from the introduction of high-speed passenger traffic. These added costs reflect the increased track class and the tighter track requirements for the higher speeds of the passenger trains, as well as costs associated with the dynamic impacts of the higher-speed passenger trains and the increased traffic density, with correspondingly reduced opportunities for maintenance.



Because most railroad tracks in North America are privately owned, access agreements must be negotiated with the private owners. These agreements must specify how costs, such as for maintenance-of-way, are to be shared, or alternatively what access charges must be paid.

Solution

A recent Federal Railroad Administration (FRA) study looked at the maintenance-of-way costs associated with upgrading freight corridors for higher-speed operation—specifically the ongoing infrastructure maintenance costs for meeting varying traffic, track, and operating conditions. These ongoing or steadystate right-of-way maintenance costs included such cyclic capital costs as rail replacement, tie renewals, surfacing, ballast replacement, and the like, which are normally capitalized for accounting, as well as the maintenance costs for such tasks as inspections, spot repairs, and routine maintenance. Capital upgrade costs were excluded.

Costs were generated for three operating scenarios, covering a range of tonnage and traffic mix:

- Predominantly freight;
- Mixed traffic; and
- Predominantly passenger.

The costs were converted to total costs per track mile and included

- Maintenance-of-way operating expenses;
- Cyclic capital expenditures for track;

• Bridge and building costs (maintenance and capital); and

• Communications and signals costs (maintenance and capital).

Cost Models

To determine a range of right-of-way maintenance costs that included both the maintenance and the cyclic capital costs, two models were used:

• A model that calculates the level of work required to maintain a defined segment of track or territory, to estimate the noncapital track-maintenance expenditures for specific track segments and territories; and

• A model that calculates the cyclic capital costs from the standard service-lives and costs for track components, to estimate the future or steady-state spending required to replace components that wear out.

Minimum and maximum costs were developed for

Track Maintenance Cost Factors: Sample Case		Cost Per Track Mile (\$1,000)				Cost Per Passenger Train Mile (\$)			
		Total Tonnage (MGT)				Total Tonnage (MGT)			
Ratio of Passenger to Freight Trains	FRA Track Class	5 or fewer	5–15	15–30	30 or more	5 or fewer	5–15	15–30	30 or more
2 passenger: 1 freight	4	26.6	31.0	42.0	60.8	1.97	0.77	0.52	0.45
	5	29.2	34.4	46.8	68.8	3.41	1.39	0.96	0.89
	6	33.0	39.3	53.8	80.3	5.50	2.29	1.60	1.52
10 passenger: 1 freight	4	29.4	38.1	54.7	***	2.49	1.08	0.96	***
	5	31.5	41.5	59.9	***	2.95	1.32	1.20	***
	6	35.8	48.3	70.6	***	3.90	1.82	1.69	***
40 passenger: 1 freight	4	31.9	47.2	***	***	3.13	1.55	***	***
	5	34.4	52.1	***	***	3.48	1.77	***	***
	6	37.5	58.1	***	***	3.91	2.04	***	***

Track Maintenance Cost Factors: Sample Case

MGT = million gross tons

*** Elements of the matrix that represent unrealistic combinations of tonnage and high-speed passenger trains were intentionally omitted, including predominantly passenger operations with tonnage levels above 15 MGT and equal passenger-freight operations with tonnage levels above 30 MGT.

NOTE: maximum passenger speed is as follows: FRA Class 4, 80 mph; FRA Class 5, 90 mph; FRA Class 6, 110 mph.

each cell in the cost matrices. The minimum costs represented the typical Class I freight railroad practice, in which passenger trains operate on a freight railroad right-of-way; the maximum costs reflected maintenance practices on high-speed railroad track, such as Amtrak's Northeast Corridor.

The resulting costs were then calibrated to costs independently developed in a bottom-up cost study on two track segments in the Midwest:

- Buffington Harbor to Ft. Wayne, Indiana; and
- Watertown to Madison, Wisconsin.

The first segment would add high-speed passenger trains to a line with five freight trains per day, about 15 million gross tons (MGT) of traffic annually, and an operating speed of 40 mph. The second segment would add high-speed passenger trains to a line with two freight trains per day, less than 5 MGT, and an operating speed of 25 mph. Costs included activities to keep the railroad in safe condition for operations.

Allocating Costs

The resulting total costs per track mile were allocated between passenger and freight trains, allowing for the calculation of a cost per passenger train mile. An engineering-based cost allocation model divided the track maintenance costs among the different traffic types, including freight and passenger trains.

The model applies engineering damage equations to calculate the portion of track damage-or component life consumption-from each defined type of traffic operating on a specific track segment. The calculated relative damage is then used to allocate the track maintenance costs in an auditable and accountable way. The result is a set of cost matrices presenting total cost per track mile and cost per passenger train mile.

The table on page 30 presents the results of a sample analysis for three different mixes of passenger and freight trains-low, medium, and high percentage of passenger trains-and four different densities of total traffic. The results are presented for three different FRA track classes with maximum passenger train operating speeds: FRA Class 4 at 80 mph, FRA Class 5 at 90 mph, and FRA Class 6 at 110 mph. The total maintenance-ofway cost per track mile is presented, as well as the cost per passenger train mile-the commonly used measures for determining costs and access charges. The final methodology and tables were presented in an FRA technical monograph that will serve as a handbook for planners of new high-speed rail operations (1).

Benefits

The Rail Planner's Handbook will assist planners of high-speed rail service in estimating the costs of the



appropriate maintenance or capital cost for any segment of a proposed high-speed passenger railroad.

The handbook has been used to estimate future maintenance-of-way costs for several proposed rail corridors and for parts of the MWRRI consortium plan, which are investigating high-speed passenger operations on freight lines. The handbook is expected to become an indispensable aid in the planning of high-speed rail service throughout the United States.

In practice, the operation of publicly funded passenger trains on private freight railroads will require the negotiation of access charges, and the negotiated charges probably will not be the same as the costs shown in the matrices. The cost matrices, however, indicate the expected total spending that will be required on a steady-state basis and provide an example allocation of the costs.

For more information, contact Allan M. Zarembski, Zeta-Tech Associates, Inc., 900 Kings Highway North, Cherry Hill, NJ 08034; telephone 856-779-7795; e-mail Zarembski@zetatech.com.

Reference

1. Technical Monograph: Estimating Maintenance Costs for Mixed High-Speed Passenger and Freight Rail Corridors. Federal Railroad Administration, U.S. Department of Transportation, Washington, D.C., 2004.

EDITOR'S NOTE: Appreciation is expressed to Amir N. Hanna, Transportation Research Board, for his efforts in developing this article.

Suggestions for "Research Pays Off" topics are welcome. Contact G. P. Jayaprakash, Transportation Research Board, Keck 488, 500 Fifth Street, NW, Washington, DC 20001 (telephone 202-334-2952, e-mail gjayaprakash@nas.edu).

Artist's rendering of high-speed rail on a freight corridor in California.

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