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"Big Data" in Railroad Maintenance Planning 2015

ARTICLE BY DIANE KUKICH

Close to 250 railway engineers, managers, economists, analysts, and researchers turned out for a one-day mini-conference at the University of Delaware focused on converting the "mountain" of inspection data collected by railway systems into effective maintenance planning information.

Held at the Trabant University Center on Wednesday, December 9, the *Second Annual Big Data in Railroad Maintenance Planning Conference* was organized by Allan Zarembski, professor and director of UD's Railroad Engineering and Safety Program, and Nii Attoh-Okine, professor in the Department of Civil and Environmental Engineering.

In welcoming the attendees, Tunde Ogunnaike, dean of the College of Engineering, said that it is incorrect to call the early 21st century the "information age."

Allan Zarembski (left) and Nii Attoh-Okine are co-chairs of the Dec. 9 conference, "Track Maintenance Planning in the Era of Big Data.

"People confuse data and information," he said. "We're drowning in data that has to be converted into useful information to get us from the data age to the information age. Then we have to develop that information into knowledge that can make the world better."

Conference co-chair Allan Zarembski introduces keynote speaker Patrick Nowakowski, who is a 1975 UD alumnus and president of the Long Island Railroad.

Keynote speaker Patrick Nowakowski, who earned his bachelor's degree in civil engineering at UD in 1975 and is now president of the Long Island Railroad (LIRR), understands all too well how important it is to translate data into useful information that can be used to develop tools for efficient and cost-effective track and railcar maintenance, repair and replacement.

The largest and oldest commuter railroad in the U.S., the LIRR employs more than 7,000 people and serves 86 million passengers a year at 124 stations on 620 miles of track.

Nowakowski, who went to UD in the pre-electronic age when the first tool engineers learned how to use was the slide rule, now presides over an organization that collects data using video cameras, on-track engineering inspection vehicles, and such high-tech techniques as ground penetrating radar and geographic information systems.

He pointed out that data has also come to play an important role in customer service.

"We now have a tremendous demand for instant

communication on the status of trains," Nowakowski said. "People want real-time information about what's going on, and we're using not only electronic signs on platforms but also social media to disseminate this information."

"Data in itself is useless," he said in concluding his talk. "We need it to document history, predict trends, and help us prioritize and plan."

David Staplin, retired deputy chief engineer at Amtrak and chair of the Railroad Advisory Board at UD, said that while safety and service have improved in recent years, the industry still has a long way to go.

"The key to improving service and safety going forward is that we need to be more reliable, and big data is the key to reliability," he said. "We need better data and more data, and we need to share our data and expertise."

The conference technical sessions addressed railroad needs from big data, big data analysis techniques, and applications and case studies.

Tripp Shenton, chair of UD's Department of Civil and Environmental Engineering, shared information with the attendees about UD's offerings in railway engineering, including four courses, with another one to be added next year, a graduate certificate program, short courses, and an active research program.

The conference was hosted by the Department of Civil and Environmental Engineering along with Professional Engineering Outreach at UD. It was sponsored by the American Railway Engineering and Maintenance-of-Way Association (AREMA), the Georgetown Rail Equipment Company (GREX), Harsco Rail, Protran Technology and Ensco.

Harry W. (Tripp) Shenton III, chair of the Department of Civil and Environmental Engineering, welcomes participants

IPA Policy Scientists Instruct MATS UTC Sustainability Course Modules

TROY MIX, AICP, IPA POLICY SCIENTIST

MARCIA SCOTT, IPA POLICY SCIENTIST

Troy Mix and Marcia Scott, policy scientists with the Institute for Public Administration (IPA) at the University of Delaware, developed and instructed portions of an online graduate-level Transportation Sustainability course in fall 2015. Sponsored by the Mid-Atlantic Transportation Sustainability Center – Region 3 University Transportation Center (MATS UTC), the course was a collaborative endeavor among ten professors from six partner schools—the University of Delaware, University of Virginia, Virginia Tech, Old Dominion University, Marshall University, and Morgan State.

Over twenty graduate students from the consortium universities enrolled in the course, which provided a multi-disciplinary introduction to transportation sustainability and major methods, models, and tools for evaluating and improving transportation systems. Weekly, three-hour online learning modules provided an overview of transportation sustainability, energy-efficient urban transportation, sustainable urban freight, coastal infrastructure resiliency, sustainable materials, enhanced water quality management, sustainable land use, healthy communities, and finance and policy.

Scott taught a two-week module on planning healthy, sustainable, and complete communities. This module examined transportation sustainability from planning and public health perspectives to convey how the design of communities and the built environment impacts the physical, social, environmental, and economic health of a community and its members. Content explored approaches to improve the built environment, enhance community design, and develop plans and public policies that support healthy and complete communities.

Scott's lectures were made available both as a downloadable narrated presentation and via IPA's Complete Communities YouTube Channel (www.youtube.com/user/CompleteCommunities). The first assignment for this module asked students to compare and contrast Walk Scores® of their home address vs.

Complete Streets Infographic prepared by UD graduate engineering student Ben Fisher

college address. The analysis required students to assess whether Walk Score is a good measure of walkability and can be used as a proxy to predict obesity rates, sprawl, property values, and marketability of "great places." The second assignment required students to prepare an impactful and visually appealing infographic that summarizes/highlights the benefits of either Complete Streets or Complete Communities. Six of the top student submissions were featured on the MATS UTC website, including an Infographic on Complete Streets by UD's Ben Fisher.

Mix instructed a two-week module focused on finance and policy aspects of sustainable transportation planning. Video lectures, research articles, and a documentary addressed the economic value and impacts of transportation, the stakeholders involved in planning and financing transportation, and policy options and challenges for implementing sustainable transportation.

Rounding out this last module of the semester, students prepared policy memos that assessed one region's long-range plan for implementing and monitoring regional transportation sustainability. "Not surprisingly, students found the plan failed to integrate many of the ideal technical and policy solutions examined in the course," explained Mix. "What made this course different from most—and I hope particularly valuable—was the simultaneous consideration of technical solutions and the messy, multi-stakeholder world of the policy process."

Using GIS Story Maps to Engage Citizens

SAVANNAH EDWARDS, PUBLIC ADMINISTRATION FELLOW, INSTITUTE FOR PUBLIC ADMINISTRATION

MARCIA S. SCOTT, POLICY SCIENTIST, INSTITUTE FOR PUBLIC ADMINISTRATION

Often, a picture is worth 1,000 words. This expression certainly rings true when Geographic Information System (GIS) story maps are used to bridge communication gaps in transportation and land use planning.

According to ESRI, an international supplier of GIS software, "Story maps use geography as a means of organizing and presenting information. They tell the story of a place, event, issue, trend, or pattern in a geographic context. They combine interactive maps with other rich content—text, photos, video, and audio—within user experiences that are basic and intuitive." GIS story maps are effective communication platforms and are ideal for engaging the public or "citizen planners" in complex land use- and transportation planning, and public policy issues. They combine both geospatial data and visual images to convey information to non-technical audiences (who have online access) in a fun and compelling way.

While the format of a story map is dictated by the planning topic, access to data, and availability of basemaps, ESRI story map application (apps) templates come in a variety of "flavors" that can be modified or customized. Some of the available layouts include a series of narrative-based maps, sequential map-based tours, and maps with interactive data-analysis features such as a 'swipe' template that allows viewers to display and compare two maps (or layers) simultaneously. Links to social media, crowdsourcing, online polls, and multi-media content can heighten the potential of GIS story maps to engage the public, once it is published and shared online.

Savannah Edwards and Brandon Grabelsky, Public Administration Fellows at the Institute for Public Administration (IPA) at the University of Delaware, have developed a series of GIS Story Maps to illustrate best practices ass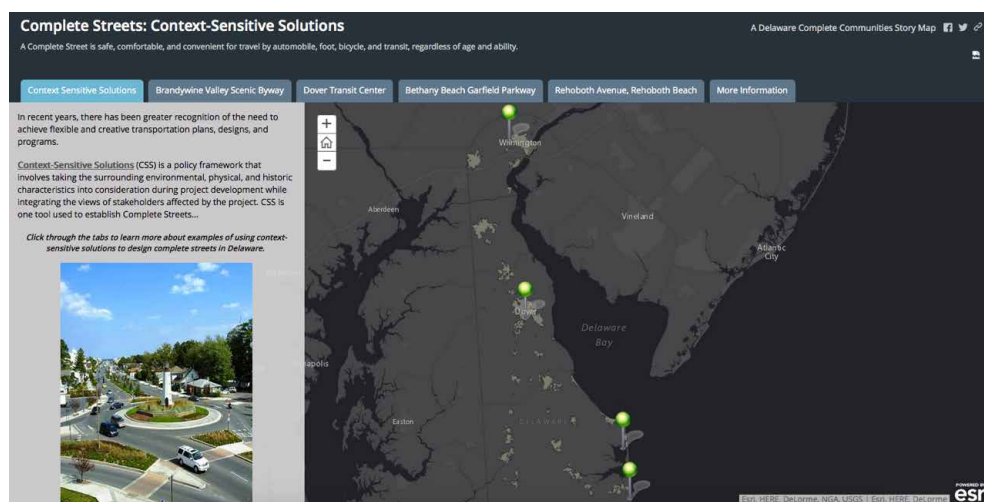ociated with Planning for Complete Communities in Delaware. Prior to work on this project, Edwards and Grabelsky were non-GIS users. To build their technical skills and knowledge of GIS, each student created a free ArcGIS Online account, viewed online story map tutorials and examples, took ESRI virtual campus courses, and participated in a FirstMap Introductory Seminar. IPA Associate Policy Scientist Nicole Minni, GISP, provided technical support and guidance on an as-needed basis.

Edwards completed four GIS story maps that exemplify four of the five elements of Complete Community. These include story maps on 1) context-sensitive solutions as one tool to implement Complete Streets, 2) mixed-use development to achieve Efficient Land Use, 3) planning for aging-friendly environments to illustrate Healthy and Livable Communities, and 4) historic preservation planning as one aspect of Inclusive and Active places. Grabelsky's GIS story map focuses on Freeboard as a floodplain management strategy. This exercise was one facet of his extensive work on "Creating Flood-Ready Communities in Delaware," which will be showcased within the "Sustainable and Resilient" section of IPA's online *Delaware Complete Communities Planning Toolbox* (www. completecommunitiesde.org)

The five GIS Story maps can be viewed online at IPA's GIS story map gallery, called Implementing Complete Communities in Delaware

With support from MATS UTC, IPA Public Administration Fellow Savannah Edwards developed a GIS StoryMap on Context-Sensitive Solutions as part of the Delaware Complete Communities Planning Toolbox.

Biochar to the Rescue

BY DIANE KUKICH
PHOTOS BY EVAN KRAPE

When stormwater runs off impervious surfaces like pavements and roofs, it bypasses nature's filtering system and moves rapidly through storm drains, sewer systems and drainage ditches into creeks and rivers, carrying with it pollutants such as nutrients, heavy metals and bacteria.

The U.S. Environmental Protection Agency has been promoting the use of "green infrastructure" to manage and reduce stormwater pollutants, but the design, installation and maintenance of this type of infrastructure is expensive.

Environmental engineering faculty members Paul Imhoff, Pei Chiu and Julia Maresca at the University of Delaware believe there may be a better way to manage stormwater runoff and pollutants, using existing greenways and landscape areas, and they recently received more than $400,000 to investigate their novel idea.

With funding from the National Fish and Wildlife Foundation, the National Cooperative Highway Research Program (NCHRP) IDEA Program and the Delaware Department of Transportation (DelDOT) the team will study the use of biochar to improve infiltration, water retention, and nutrient retention and transformation in soils. Biochar is a carbon-rich solid, similar to charcoal, produced as an upcycled byproduct from the pyrolysis of waste biomass.

"A key feature of biochar is its relatively large internal porosity, surface area and ability to promote beneficial microbial processes," Imhoff says. "The benefit of biochar addition to soils with poor structure and limited organic matter was recently 'discovered' through a

Along a roadway in Middletown, Paul Imhoff (center) works with graduate students Joe Brown and Sriya Panta on a project to use biochar for management of stormwater runoff and pollutants.

study of the terra preta soils of the Amazon basin. Biochar that was added to the soil centuries ago continues to dramatically influence soil fertility today."

With a two-year grant from NCHRP through its IDEA (Innovations Deserving Exploratory Analysis) program, the team will conduct lab tests to quantify the impact of biochar on water retention, infiltration and nitrogen transformation in highway greenways.

Imhoff explains that the typical highway right-of-way comprises highly compacted soil covered by just a few inches of topsoil that is stabilized by the application of fertilizer and grass seed.

"This condition clearly does not create anything like a 'natural' soil, and the vegetation often grows poorly with a shallow root structure," he says. "Recent studies show that such conditions result in stormwater runoff with minimal water quality treatment as well as poor water retention and infiltration."

"We think that amending soils with biochar will lead to significant increases in water retention, slowing down the movement of stormwater," he adds. "This approach may also enhance the transformation of nitrogen compounds in stormwater."

The team, which includes engineers and environmental scientists from RK&K Engineers and reGenesis Consulting Services Inc., will also carry out two pilot-scale field demonstration projects in Middletown, Delaware, with a two-year grant from the National Fish and Wildlife Foundation.

Stormwater quality and quantity data will be collected on biochar-amended and untreated sections of a filter strip and a drainage ditch over a period of 18 months. Microbial assays will be used to quantify biochar's influence on microbial populations in soils.

These data will be used to develop metrics for soil restoration with biochar, including increase in field capacity, runoff reduction volume, annual nitrogen reduction and soil restoration economics.

"We believe that by restoring the greenways, municipalities and state departments of transportation will reduce the need to purchase additional rights-of-way for stormwater treatment, decrease the number and complexity of best management practices and cut design and installation costs," Imhoff says.

A UD research team is investigating the use of biochar for management of stormwater runoff and pollutants.

RESEARCH

Projects selected from the FY16 1739 Research Program solicitation will be reported when the Notices to Proceed are issued by DelDOT.

As each project is completed, a final technical report will be available on the DCT website: http://www.ce.udel.edu/dct

1687-A LIGHTING-URBAN DESIGN

The purpose of this literature search is to provide transportation planners and engineers with the most effective types of lighting (fixtures, placement, light color and types) to improve pedestrian visibility at night, not simply driver visibility. Ending 2/19/16

Principal Investigator: Ardeshir Faghri, Department of Civil and Environmental Engineering

Project Manager: Ralph Reeb, Division of Planning

1687-B PAVEMENT-STORMWATER

This literature search will weigh the potential water quality benefits of installing porous pavement shoulders against the construction, maintenance and operations costs to maintain them. Ending 2/18/16

Principal Investigator: Ardeshir Faghri, Department of Civil and Environmental Engineering

Project Manager: Mark Harbeson, DelDOT Stormwater Quality Program

1687-G PAVEMENT-INSPECTION

This research will address the question of what is an acceptable variation in values between pavement evaluation surveys that use visual and auto-visual surveys.
Ending 2/2/16

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

Project Manager: Sarah McDougall, Procurement Management Engineer

1687-H TRAFFIC-SAFETY

The end result of this research project will be to provide transportation planners and engineers with guidance for the deployment of radar speed signs which could be employed in a systematic manner to restore and maintain a balance between mobility and neighborhood quality of life. Ending 2/24/16

Principal Investigator: Mingxin Li, Department of Civil and Environmental Engineering

Project Manager: Michael Somers, Division of Planning

1687-K TRAFFIC-SAFETY

The goal of this research project is to develop Delaware-specific values for determining work zone lane capacities along multilane signalized corridors. This has safety implications for both users and construction personnel in work zones. No-cost extension to 6/8/16 pending

Principal Investigator: Mingxin Li, Department of Civil and Environmental Engineering

Project Manager: Adam Weiser, Division of Transportation Solutions

DEVELOPMENT OF CAPACITY ADJUSTMENTS FOR ADAPTIVE CONTROL SYSTEMS

This research will compare data on current practices around the country and compare this to conditions along Delaware roads to see if the computed capacities compare to observed behavior. Comparing predicted behavior with data from the Traffic Management Center, this research will further develop the "true" capacity for a segment. Ending 8/31/16

Principal Investigator: Rusty Lee, Department of Civil and Environmental Engineering

Project Manager: Gene Donaldson, Transportation Management Center

PASSENGER AND FREIGHT RAIL SERVICE SUPPORT

The Delaware Center for Transportation will provide expert technical review, research and support with regard to passenger and freight operations in the areas of cost allocation, evaluation of railroad infrastructure, and engineering analysis. Ending 2/28/16

Principal Investigator: Allan Zarembski, Department of Civil and Environmental Engineering

Project Manager: Albert Loyola, Delaware Transit Corporation

TRAFFIC MONITORING PROGRAM USER'S MANUAL

This project will develop a traffic monitoring program user's manual containing the most important information and step-by-step procedures for DelDOT personnel to maintain an accurate and up-to-date data on volume, classification and weight for all roads in the state was well as maintaining a high quality HPMS program. Ending 12/31/16

Principal Investigator: Ardeshir Faghri, Department of Civil and Environmental Engineering

Project Manager: Kevin Gustafson, Division of Planning

AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS – PILE DOWNDRAG DESIGN PROVISIONS

This project focuses on assessment of the new AASHTO LRFD bridge design specifications for pile downdrag, and the associated implications for the design of future deep foundation projects in the State of Delaware. No-cost extension to 8/31/17 pending.

Principal Investigator: Chris Meehan, Department of

Civil and Environmental Engineering

Project Manager: Jason Hastings, Bridge Design

SUMMER AND FALL 2015 TRAVEL TIME, DELAY, AND SPEED DATA COLLECTION AND ANALYSIS

This project entails data collection during peak travel times on roadway segments throughout the state. Each segment will be traveled at least four times for maximum accuracy. Once data collection is completed, data will be transformed into the GIS database and transported to the ARCGIS software.

Ending 12/31/16

Principal Investigator: Ardeshir Faghri, Department of Civil and Environmental Engineering

Project Manager: Mark Eastburn, Division of Planning

TRAVEL DEMAND MODELING SUPPORT

Support for this project will assist DelDOT with the development, maintenance, application and evaluation of a travel demand forecasting model. The model supports planning studies for Delaware's MPOs and various DelDOT sections on an as-needed basis. Ending 8/31/16

Principal Investigator: Rusty Lee, Department of Civil and Environmental Engineering

Project Manager: Mike DuRoss, Division of Planning

MONITORING OF A GEOSYNTHETIC REINFORCED

SOIL (GRS) INTEGRATED BRIDGE SYSTEM (IBS) IN THE STATE OF DELAWARE

The objective of this research project is to construct and monitor the performance of this innovative bridge technology and hopefully be a model for future GRS-IBS structures in the state of Delaware. Ending 8/31/16

Principal Investigator: Christopher Meehan, Department of Civil and Environmental Engineering

Project Manager: Jason Hastings, Bridge Design

A COMPREHENSIVE REVIEW AND UPDATE OF THE TRAFFIC MONITORING PROGRAM AT DELDOT

To assist in the compliance comply with Federal regulations, this research project will evaluate the accuracy of traffic data being presented in the Traffic Summary with regards to traffic volumes. Ending 12/31/16 .

Principal Investigator: Ardeshir Faghri, Department of Civil and Environmental Engineering

Project Manager: Kevin Gustafson, Division of Planning

STATEWIDE TRAFFIC DATA ANALYSIS AND EVALUATION

This project will provide technical support related to roadway and lane capacities based on geometric variables, speeds, and measures of effectiveness along with potential signal timing plans. Ending 8/31/16

Principal Investigator: Rusty Lee, Department of Civil and Environmental Engineering

Project Manager: Gene Donaldson, Transportation Management Center

LOCAL GOVERNMENTS

HAVE YOU COMPLETED A TRANSITION PLAN REQUIRED BY THE AMERICANS WITH DISABILITIES ACT? IF NOT, IT IS ESSENTIAL YOU BEGIN TO DO SO NOW.

NOT SURE WHAT A TRANSITION PLAN IS? CONTACT MATT CARTER (MATHEU@UDEL.EDU) AT THE DELAWARE T^2 CENTER AND LET'S GET YOU STARTED. ENFORCEMENT IS HEATING UP AND YOU NEED TO GET ~~AHEAD OF~~ LESS BEHIND IT!

Research Pays Off:

Synthetic Aperture Radar Satellite Remote Sensing for Pavement and Infrastructure Monitoring

ARDESHIR FAGHRI, MINGXIN LI, ABDULKADIR OZDEN AND KAZ TABRIZI

ARDESHIR FAGHRI, *Professor, Department of Civil and Environmental Engineering, University of Delaware.*

MINGXIN LI, *Research Associate II, Department of Civil and Environmental Engineering, University of Delaware*

ABDULKADIR OZDEN, *Graduate research assistant, Department of Civil and Environmental Engineering, University of Delaware*

KAZ TABRIZI, *Executive Vice President, Advanced Infrastructure Design, Inc.*

Recent developments in satellite remote sensing and availability of high-resolution Synthetic Aperture Radar (SAR) products have created an opportunity for SAR-based monitoring in pavement and infrastructure management. Therefore, SAR-based monitoring has become valuable for monitoring and rehabilitating the nation's deteriorating roadway infrastructure elements such as bridge settlements and displacements, roadway surface deformations, geohazards and sinkhole detection, historical analysis of problematic sites, etc. In this study, the feasibility, and effectiveness of use of satellite remote sensing technology for pavement and infrastructure monitoring were evaluated. A cost benefit analysis for a possible SAR-based monitoring system was performed. It was found that SAR-based methods are useful as a complementary tool rather than a replacement for current technologies and practices, specifically in the sense of state of good repair.

PROBLEM

Pavement condition surveys provide an indication of physical condition of the pavements and consist of data collection, pavement condition rating and quality management elements. Two great challenges in pavement management are timely detection of problems for the application of preventive measures and frequency of pavement condition data collection.

Traditional pavement inspection techniques, e.g., manual distress surveys, semi- or automated condition surveys using specially equipped vehicles, offer a method of determining pavement condition through observing and recording, which causes this pavement survey work to be cumbersome and inefficient. In fact, some of these periodic inspection-based monitoring efforts are redundant and some of them cause late-detection of the problems. This effort consequently increases the overall cost of monitoring and management of transportation infrastructure systems and cause money and energy loss.

Therefore, any contribution towards network-scale monitoring tools that facilitate the early detection of the problems, reduce the unnecessary vehicle-based inspection trips to the sites, enable detection of slow-moving settlements on and around the transportation infrastructure, and help build more robust infrastructure data systems increase the effectiveness of the monitoring programs. Such tools will benefit state and federal agencies to prioritize their investment strategies that will yield economic and other benefits.

SOLUTION

In the last two decades, SAR technology and interferometric synthetic aperture radar (InSAR) applications have been widely investigated by the research community for large-scale monitoring studies. Recently, availability of high-resolution SAR images and developed advance processing methodologies have gained the attention of transportation research community. With the high-resolution SAR images, extracting information about the identity and quantity of the targeted scene became possible for relatively small areas, which makes the technique useful for pavement and infrastructure studies.

A satellite-based continuous monitoring system might help build more robust pavement and infrastructure monitoring and reduce/prioritize routine vehicle-based inspection trips and associated monitoring cost. Considering most agencies perform routine inspections for pavement and infrastructure elements in different cycles (1-3 years), monthly monitoring with satellite imagery is expected to contribute routine monitoring efforts by providing more frequent data in network-level.

METHODOLOGY

SAR imagery is produced by measuring the distance and transmitted/backscattered radiation of the target scene, and contains both amplitude and phase in each pixel. Amplitude is the measure of the radiation backscattered by the objects in each pixel and phase includes information about the distance between radar and scene proportional to wavelength, which is successfully used for detection of surface

deformations. Cloud-penetrating capability, day and/or night operating flexibility and all-weather working ability give SAR superiority over other imaging techniques especially on tough climate locations. SAR Interferometry (InSAR) uses two or more SAR images acquired at different times to derive more information about the scene by co-registering them in an appropriate order.

Since the InSAR and developed advanced deformation detection techniques upon InSAR are able to measure the millimetric surface deformation over an area , and high-resolution satellite images can significantly increase the number of detected points; satellite based infrastructure monitoring could be possible for deteriorating roadway infrastructure such as bridge settlements and displacements, large-scale deformations in roadway infrastructure and sinkhole detection or detailed analysis of targeted areas that are already known problematic by previous studies.

APPLICATION

Investment on a new technology or method such as satellite remote sensing requires a careful evaluation of costs and benefits associated with it, especially if the technology is not designed for a specific purpose and could be used in a broad range of disciplines. In order to accurately quantify the benefits and costs, it is crucial to evaluate wide range of parameters. It is considered that there are direct and indirect benefits and costs to both responsible agency such as DOTs and society.

Applicability of satellite remote sensing technology is evaluated for all bridges and federal-aid highways in the New Castle County, Delaware. This will help understand the costs and benefits associated with SAR-based pavement and infrastructure monitoring. In the case study, only direct benefits to the agency, which is reduction in routine vehicle based inspections accounted in calculations as benefits. The cost estimates were developed by calculating rough quantities and applying unit costs. Costs were then translated into per mile or per category costs. All adjusted cost values were normalized to a base year of 2016. Inflation factors were developed

based on Producer Price Index for Highway and Street Construction from the 1986–2010 data to convert unit costs from 2016 levels to the build year.

In this study, cost alternatives are investigated based on three options and three resolution levels as follows:

Option 1: Purchasing data & in-house data processing

Option 2: Purchasing data & outsourcing data processing

Option 3: Outsourcing data collection & data processing

H: High-resolution (7x7 km, 1m resolution)
€ 9,450 (new)   € 4,725 (archive)

M: Medium-resolution (10x10 km, 1m resolution)
€ 6,150 (new)   € 3,075 (archive)

L: Low-resolution (40x40 km, 5m resolution)
€ 3,600 (new)   € 1,800 (archive)

Estimation of the costs in this study involves several assumptions, including:

Costs are based on standard facilities constructed in the United States and are represented in year 2016 dollars (1 Euro equals to 1.11 USD). They may change due to future economic conditions.

Discount rate=5%, with a standard time horizon of 20 years (2016-2035).

	Size	Resolution	Option 1 Purchasing data & in-house data processing	Option 2 Purchasing data & outsourcing data processing	Option 3 Outsourcing data collection and data processing
H	7x7 km	1m	0.43	0.39	0.41
M	10x10 km	1m	**1.34**	1.24	1.31
L*	40x40 km	5m	18.53	23.25	25.76

Table 1. Summary of B/C ratio.
* Despite the fact that low-resolution (40x40 km, 5m resolution) has highest B/C ratio, it is only useful for detection of sinkhole formations. Low-resolution images cannot be used to clearly identify the distress type in pavement surface).

Investigation of B/C ratios (Table 1) presents that SAR-based monitoring systems could be cost-effective and quickly pays back for 10*10 km and 40*40 km products. Considering the spatial resolution and high B/C ratio, purchasing the SAR imagery and in-house processing option would be a good option for SAR-based monitoring.
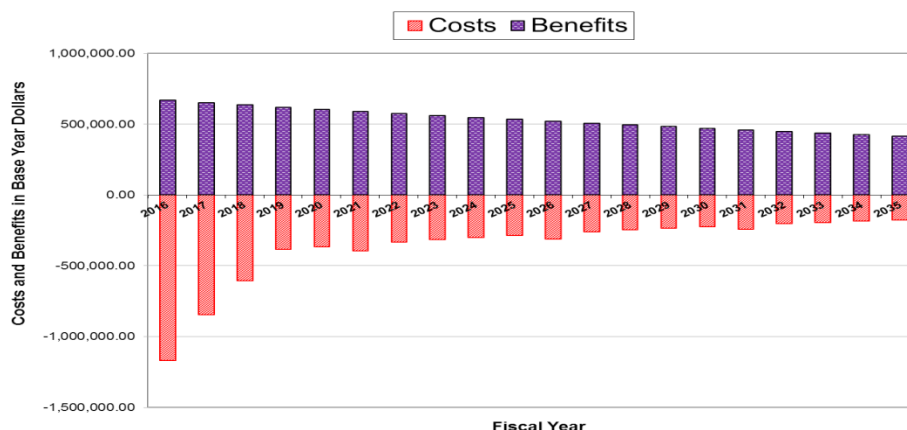
Fig. 1 shows the discounted cash flow in different periods and the estimated discounted payback period. This option pays back in five years considering 20 year time horizon. As shown in Table 2, B/C ratio equals to 1.31, which means that this scenario leads to appealing results for investments.

Benefit (present value)	Value ($)
Reduced costs	16,891,509
TOTAL BENEFIT	16,891,509
Costs (present value)	
Computer and software purchase	40,000
Data storage cost	60,000
Training personnel	200,000
Image purchase	10,205,618
Image processing	0
Total budget costs	10,505,618
Tax-cost factor, 20% of budget costs	2,101,124
TOTAL COST	12,606,741
Benefit/cost ratio	1.34

Table 2. Benefit and cost components of investments 1M (2016-2035)
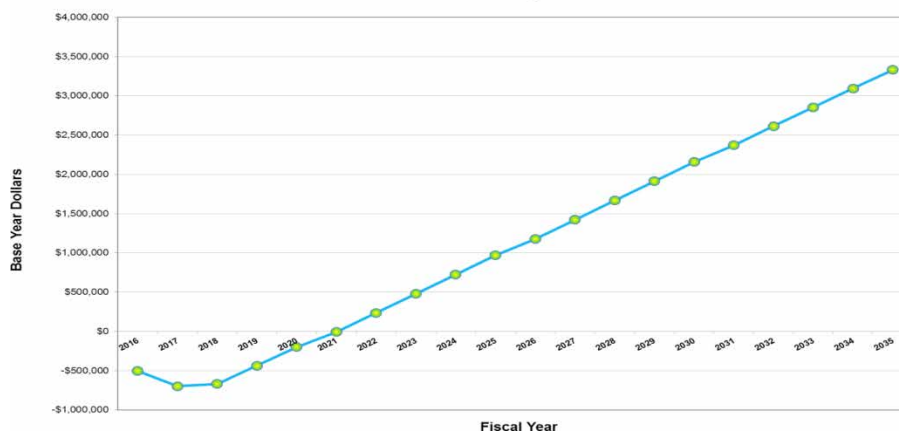
a)

b)

Fig.1. a. Discounted cash flow (Discount rate=5%); b. Estimated discounted payback period

TECHNICAL BENEFITS

Many studies and experiences of agencies show that early detection of problems treated with preventive measures increase the service life of the assets and reduce the total maintenance cost while maintaining the safety and quality. SAR-based monitoring can result in valuable benefits for responsible agencies:

One of the main advantages of satellite-based monitoring is the ability to cover very large areas with frequent revisit times to make it possible even monitoring daily and/or weekly changes. It is also expected that vehicle-based routine inspection trips may decrease and prioritized based on SAR-based network level monitoring, and better allocation of staff hours achieved.

SAR-based methods are highly effective for detection of surface deformations and determining deformation velocities with millimetric accuracy. Recent high-resolution SAR imagery has significant impact on the accuracy of the results and number of detected point in relatively small areas (such as less than 100 ft^2).

The promising satellite remote sensing technology is expected to play a crucial role for reducing the cost of network-scale pavement and infrastructure monitoring for state and federal agencies in near future as the high-resolution satellite imaging become more available and less costly, and analysis methods and algorithms become more mature.

Delaware T²/LTAP

Build a Better Mousetrap Contest

Hint — It has nothing to do with mice or traps.

Tools...Gadgets ...Even Phone Apps!

We're looking for transportation-related projects that you've designed and built. Need some examples? Go to http://www.ltap.org/resources/mousetrap.php for the links to the 2009 through 2015 national competition results; you'll see descriptions and photos of entries from across the nation; not just the winners. A few are shown here.

The competition is limited to Delaware only. Submit entries to us and we will pick a state winner. First prize will receive two Delaware MUTCD-compliant Stop/Slow paddles for flaggers. The winning entry from Delaware will be automatically submitted into a national competition where both you and we here at the Center will compete for prizes, and more importantly, bragging rights! Winners will be announced at the annual LTAP/TTAP National Conference in Madison, WI (July 2016).

Road Saw Hitch Receiver

Pennsylvania

To enter please visit our website for an entry form and return it to us by April 4, 2016.

Don't be shy – we know there have been some great innovations in Delaware and we look forward to reviewing all of your fantastic entries!

http://sites.udel.edu/dct/

The mission of the Delaware Center for Transportation is to improve the movement of people, goods, and ideas, and be viewed as a valuable resource for transportation-related issues and challenges within the state, the mid-Atlantic region and beyond.

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Director's Message

Our partnership with CAIT at Rutgers is now in its fourth year. In addition to the funding we receive as part of the consortium we have collaborated on a number of projects and initiatives. This newsletter outlines the progress and products of some of these projects, as well as the awards and publications of our faculty and students.

Most recently, I helped Dr. Ali Maher, CAIT director, and Dr. Gordana Herning, CAIT Research Engineer, organize a workshop on "Resiliency of Transportation Infrastructure." The workshop, held in December, brought together consortium members from academia, government and industry to develop a research roadmap for the Center that targets priority infrastructure needs within communities and agencies that can lead to improved resilience of transportation systems. Interest in resilience has increased as stakeholders are acutely aware of disruptions to the transportation system and their related costs. These disruptions may be due to the failure of aging infrastructure, the need to repair and improve infrastructure, and the increasing frequency and severity of extreme weather events. This increasing interest in resilience was evident in the transportation legislation, Moving Ahead for Progress in the 21st Century - MAP-21, and the current legislation, Fix America's Surface Transportation (FAST) Act that adds the concept of resilience to the existing requirement that agencies develop Asset Management Plans. Furthermore, the concept of resilience is complex as it can be applied at the project, corridor, and network or community level. This relatively recent interest in the concept of resilience has resulted in many definitions, and widespread use of the term in infrastructure monitoring, material characterization, data acquisition and data driven decision making, and all phases of infrastructure maintenance. This initiative is particularly relevant for UD as the theme our Tier 2 University Transportation, UD-UTC, was "Resilience of Transportation Corridors" and much of our work serves as a foundation for future work.

Dr. Ali Maher, Director of CAIT, opens the Resilience Workshop at Rutgers, December 2015.

Once again this spring there are opportunities to engage with our UTC through a request for preproposals for new research projects, a graduate student fellowship for the 2016-2017 academic year, undergraduate summer internships, graduate student participation in the Annual Interuniversity Symposium on Infrastructure Management (AISIM) and Advanced Infrastructure Management Bootcamp, and student (grad and undergrad) participation in the WTS Annual Conference. Each opportunity has a deadline, so please make note of the deadline and consider applying!

Sue McNeil
Professor, Department of Civil & Environmental Engineering

Household Decision Regarding Housing Recovery – A CAIT Tier I Project

The project Understanding the Relationships between Household Decisions and Infrastructure Investment in Disaster Recovery: Cases from Superstorm Sandy surveyed residents of Oakwood Beach, New York and Sea Bright, New Jersey in 2014 to better understand household decision related to rebuilding and relocating. Reports summarizing the responses to the 2014 survey were prepared, vetted and sent to respondents who asked for summaries. The reports are also available online:

McNeil, S., J.Trainor, A. Greer and K. Mininger, (2015). "Household Residential Decision-Making in the Wake of Disaster: Report Prepared for Oakwood Beach Residents," Disaster Research Center Miscellaneous Report #76. http://udspace.udel.edu/handle/19716/17210

McNeil, S., J.Trainor, A. Greer and K. Mininger, (2015). "Household Residential Decision-Making in the Wake of Disaster: Report Prepared for Sea Bright Residents," Disaster Research Center Miscellaneous Report #77. http://udspace.udel.edu/handle/19716/17211

In Oakwood Beach the majority of questionnaire participants were full-time residents of Oakwood Beach and lived in single-family homes. Most of the residents that participated in the study that the state offered the buyout accepted it. Many of the residents that the state did not include in the buyout process wanted to be included. Beyond the buyout offer, we found that a number of factors influenced how residents decided where to live after Sandy, including their financial situation, how attached they felt to Oakwood Beach, how much damage their home sustained from Sandy, the level of travel disruption in the area, and how concerned they were about future storms.

In Sea Bright, like Oakwood Beach, the majority of questionnaire participants were full-time residents of Sea Bright. They lived in single family homes, condominiums or townhomes, and had completed any necessary repairs on their homes. A portion of residents still had ongoing repairs, and others had plans to make their homes safer in the future that they are still working to finance. We found that a number of factors influenced how Sea Brighters decided where to live after Sandy, including their financial situation, how attached they felt to Sea Bright, how much damage their home sustained from Sandy, how concerned they were about future storms, and their experiences during the recovery process.

In the Fall of 2015, we launched a CAIT funded mini-project titled Tracking Housing Recovery in Sea Bright, NJ and the Relationship to Infrastructure Renewal. This project conducted follow up surveys in Sea Bright. The survey was prepared and mailed to 1017 residents of Sea Bright in December. To date 131 responses have been received, a 12.9% response rate. The first survey conducted in late summer 2014 and the December survey provide us with a unique data set that tracks housing recovery in a small coastal community. We are looking forward to analyzing the results and relating housing recovery to the need for investments in transportation infrastructure.
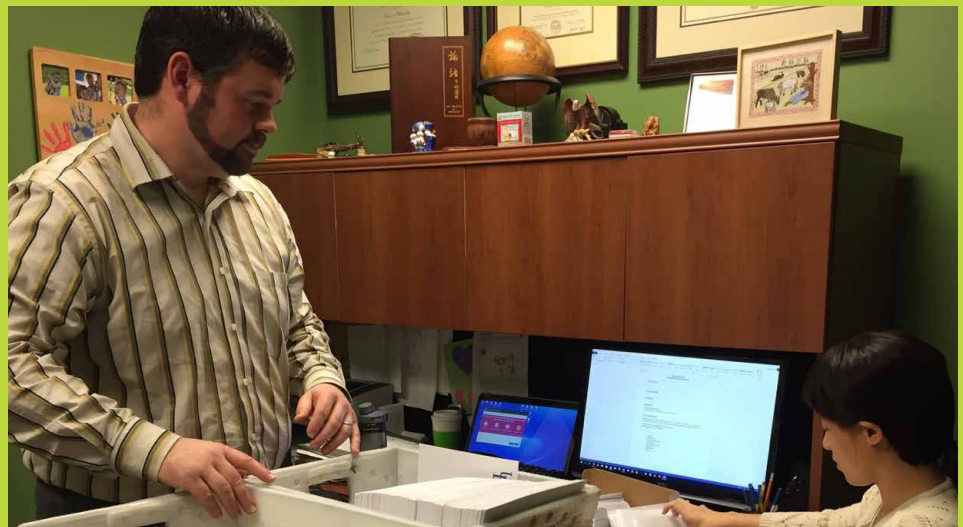
Professor Joe Trainor and graduate student Qiuxi Li prepare surveys for mailing to residents of Sea Bright, New Jersey

CAIT at UD National UTC Projects

Three new projects are starting in the spring semester, 2016. These projects are summarized in the following table:

Title	PI and Co-PI (Graduate student)	Client
Multi-Scale Condition and Structural Analysis of Steel Bridge Infrastructure (starting February 1, 2016)	Jennifer McConnell	Richard Dunne, Michael Baker International and Tom Macioc, PennDOT
Lean Construction Applications for Bridge Inspection (starting February 1, 2016)	Abigail Clarke-Sather and Jennifer McConnell	Daniel Clem, Pennoni Associates
Long-Term Monitoring of a Geosynthetic Reinforced Soil Integrated Bridge System (GRS-IBS) (Began September 1, 2015)	Chris Meehan	Jason N. Hastings. DelDOT

Brown Bag Seminars and Webinars

Arsha Tabrizi, Masters student in Civil and Environmental Engineering, presents a Brown Bag Seminar.

The fall semester again provided an opportunity for students and faculty to provide project updates for the CAIT at UD projects. Three brown bag seminars were presented:

Arde Faghri, Ming Li and Kadir Ozden, "Satellite Assessment and Monitoring for Pavement Management", September 9, 2015.

Abigail Clarke-Sather and Arsha Tabrizi, "Bridge Retrofit or Replacement Decisions: Tools to assess Sustainability and Aid Decision-making", October 14, 2015.

Sue McNeil, Israt Jahan and Joseph Trainor, "Using information at different spatial scales to estimate demand to support asset management decision making", November 11, 2015.

Recent CAIT at UD Related Publications, Presentations, and Posters

Final reports submitted:

Faghri, Arde and Mingxin Li and Kadir Ozden, "Satellite Assessment and Monitoring for Pavement Management," Final Report, October 2015.

Imhoff, Paul T., and Pei C. Chiu, "Biochar as a Rechargeable Geobattery to Promote Nitrogen Removal in Stormwater from Roadways," Final Report, December 31, 2015.

Papers:

Saquing, J. M., Yu, Y.-H. and Chiu, P. C. (2016) Wood-Derived Black Carbon (Biochar) as a Microbial Electron Donor and Acceptor, Environmental Science & Technology Letters, in press, DOI: 10.1021/acs.estlett.5b00354 (http://pubs.acs.org/doi/abs/10.1021/acs.estlett.5b00354).

Shariati, A., Schumacher, T., and Ramanna, N. (2015). Eulerian-Based Virtual Visual Sensors to Detect Natural Frequencies of Structures. Journal of Civil Structural Health Monitoring. Vol. (5)4, pp. 457-468. DOI: 10.1007/s13349-015-0128-5.

Shariati, A. and Schumacher, T. (2015). SHM Using Eulerian-based Virtual Visual Sensors: Introduction of a New Black-and-white Target for Improved SNR. Structural Health Monitoring 2015 (Proceedings of IWSHM. Palo Alto, CA. September 1-3, 2015). DOI: 10.12783/SHM2015/203.

Presentations:

Greer, Alex. "Household Residential Decision-Making: Findings and Future Research." Presented at Oklahoma State University as part of seminar series Let's Talk Disasters. September 24, 2015. Stillwater, Oklahoma.

Greer, Alex. "Issues in Disaster Recovery II: Household and Community Recovery." Panelist at 40th Annual Natural Hazards Center Disasters Hazards Researchers Meeting, July 19-22, 2015. Broomfield, CO (panel presentation).

Jin, Jing, Paul Imhoff, Jing Tian, and Pei Chiu, American Geophysical Union (AGU) 2015 Fall Meeting, San Francisco, CA. "Biochar Addition to Stormwater Treatment Media for Enhanced Removal of Nitrogen."

Shariati, A. and Schumacher, T. (2015). SHM Using Eulerian-based Virtual Visual Sensors: Introduction of a New Black-and-white Target for Improved SNR. 10th International Workshop on Structural Health Monitoring (IWSHM). Palo Alto, CA. September 1-3.

Poster:

Goldschmidt Conference 2015, Prague, Czech Republic. Poster presentation. "Black Carbon (Biochar) as a Rechargeable Electron Donor and Acceptor for Microbial Metabolism."

WTS Scholarship Winners Announced

Congratulations to Sarah Doggett and Rachel Chiquoine. Sarah received the Suzanne Axworthy Undergraduate Scholarship and Rachel the Sylvia Alston Graduate Scholarship from the Philadelphia Chapter of WTS. They received the scholarships at the 2015 Awards Banquet in Philadelphia on December 10. Sarah is a senior in Civil and Environmental Engineering. She is currently working on a senior thesis titled "Characteristics of Transit-Friendly Cities". She plans to pursue a graduate degree in transportation. Rachel is an MS student in Civil and Environmental Engineering. She is working on her thesis "Analysis of the Effects of a Public Health Point of Dispensing on a Regional Transportation Network" and plans to continue to work at the interface between transportation and disasters pursuing a PhD program in the Disaster Science and Management Program at University of Delaware.

Sarah Doggett and Rachel Chiquoine, WTS Scholarship Winners, at the Awards Banquet

UD Presentations at the TRB Annual Meeting

Several UD faculty, researchers, graduate students, and former students made presentations or presented posters at the 2016 Annual Meeting of the Transportation Research Board. These included:

Workshop: Big Data Analytics and Applications: Role of Artificial Intelligence and Machine Learning
Data Science Ontology in the Era of Deep Learning
Dr. Nii O. Attoh-Okine, Professor, Department of Civil and Environmental Engineering, University of Delaware

Workshop: Structural Health Monitoring for Bridge Infrastructure Management: What Owners and Practitioners Should Know
Implementing SHM Solutions and Post-Implementation Issues

Yi Zhou, AECOM
Harry Shenton, University of Delaware

Session 595

Rail Safety IDEA Program
Rail Safety IDEA Project 28: Field Validation of Inspection Gauges for Wheel Climb Safety at Switch Points

Allan Zarembski, University of Delaware

Session 715

Innovative Work in Infrastructure Management: Best Papers from AISIM
Comparison and Analysis of Manual and Automated Pavement Condition Data Collection Methods

Rachel Chiquoine, University of Delaware
Sue McNeil, University of Delaware

Markov Chain Monte Carlo in Rail Track Defect
Silvia Galvan-Nunez, University of Delaware
Nii Attoh-Okine, University of Delaware

Session 776

Current Research on the Marine Environment: Liquefied Natural Gas as Marine Fuel
Assessment of Potential Emissions from LNG as a Marine Fuel in the Inland Rivers

Edward Carr, University of Delaware

James Corbett, University of Delaware

Session 789

Diversity of Roundabouts (9)
Simplified Roundabout Network Design Problem for Hurricane Evacuation: Georgetown, Delaware

Sepideh Eshragh, University of Maryland, College Park
Ardeshir Faghri, University of Delaware

Opportunities

Faculty and Researchers: 2015-2016 Research Grants

A call for preproposals for UTC research funding for 2016-2017 has been issued. Consistent with the focus of the National UTC the preproposals will address State of Good Repair in the following areas:
- Advanced Infrastructure Monitoring
- Innovative Materials
- Large Volume Data
- Construction Maintenance

For a preproposal template, please email ud-utc@udel.edu.
Our base funding will support three projects. Subject to reviews being completed in a timely manner, the timeline is as follows:
- March 15, 2016: Pre-proposals due – submit to ud-utc@udel.edu
- March 31, 2016: Invitation to submit full proposals
- April 30, 2016: Full proposals due (by invitation only) – submit to ud-utc@udel.edu
- May 31, 2016: Project funding announced.

Graduate Students and Faculty: CAIT at UD Graduate Fellowship

The CAIT at UD graduate fellowship is awarded to a student pursuing a master's and PhD degree in an area of relevance to the theme of our National UTC – state of good repair. Applicants may be either new students to the University of Delaware or continuing students. New students must be nominated by a faculty member willing to advise the student. Continuing students may be self-nominated or nominated by their advisors. Applicants must be U.S. citizens. Fellowships are awarded on the basis of academic qualifications, and relevance to the CAIT at UD theme and goals.

The fellowship may be used for the 12 months beginning in Fall 2016. Fellowships pay a stipend of $2000 per month for 12 months, and include a $500 allowance for travel and supplies and a $1000 allowance for computing. Tuition will be covered assuming CAIT at UD is able to negotiate an arrangement with your college.

Fellowship recipients are required to participate in the activities of the center, including brown bag seminars, distinguished lectures and the research showcase, and conduct research in transportation; however, the fellowships do not directly support specific projects.

Applications consist of the following:
- Application form (obtained by emailing ud-utc@udel.edu)
- Transcript.
- At least two recommendation letters.

Statement of research interests, previous research experience (if any), particular interests and career plans, and how the fellowship will contribute to the student's academic and professional development. Statements are limited to two pages (double-spaced, 12-point font). New students may draw their statements from their graduate school applications.

Application due date is March 1. Please send applications to ud-utc@udel.edu

Graduate and Undergraduate Students: WTS Annual Conference

The annual WTS Conference provides opportunities for networking and professional development. Each year CAIT at UD sends at least one student to the annual conference which means registration, airfare and hotel are covered! In 2016 the conference will be held in Austin, Texas from May 18-20. (See https://www.wtsinternational.org/events/2016-wts-annual-conference-in-austin/)

If you are interested, contact Professor Sue McNeil (smcneil@udel.edu), or simply send her a resume and a one paragraph email indicating why you would like to attend the WTS Annual Conference by March 7!

Graduate Students: AISIM12

The 12th Annual Interuniversity Symposium on Infrastructure Management (AISIM) will be held in conjunction with the 4th Advanced Infrastructure Management Bootcamp at Oklahoma State University in Stillwater Oklahoma from June 10th to June 11th.

AISIM is a student-run symposium to advance the infrastructure management body of knowledge and applications by providing a forum for information exchange and for professional conversations about ongoing research. Engineers, scientists, and administrators around the world continually analyze state-of-the-art and best practices in this field, seeking innovative solutions in managing assets. The exchange of information and knowledge in infrastructure management is critical to this search for more effective and efficient methods of retaining initial investment.

If you are interested in participating in the organization of AISIM or presenting at the conference please contact Sue McNeil (smcneil@udel.edu)

Graduate Students: Advanced Infrastructure Management Bootcamp

University of Oklahoma will host a two-week long intensive Advanced Civil Infrastructure Management course from June 6 through June 17, 2016. The course is a graduate class that brings together students and instructors from University of Oklahoma, Virginia Tech, Georgia Tech, University of Texas at Austin, University of Waterloo, University of Delaware and other universities and colleges with Infrastructure

Management programs. Our objective is to provide an opportunity for students to gain in-depth knowledge, develop a mini-project and network with other students with similar interests. The "Bootcamp" provides an opportunity for students and practitioners to have an immersion experience in an advanced Infrastructure Management course.

Topics covered include:

- Performance Management and Level of Service
- Data Management (archiving, mining, analyzing, interpreting, documentation, etc.)
- Deterioration Modeling and Condition Assessment
- Sensors and Instrumentation
- Economics and Finance (asset valuation, PPPs)
- Risk Analysis and Reliability
- Optimization
- Research Methods

If interested contact Sue McNeil (smcneil@udel.edu)

Undergraduate Students: Summer Internship

CAIT at UD is supporting an intern at DelDOT or WILMAPCO for summer 2016. The internship would be for 10 weeks and is intended to provide a student with practical experience. The student would be paid through CAIT at UD, at an hourly rate of $10 per hr. The placement within DelDOT or WILMAPCO and responsibilities will be based on the student's interests and skills, the organizations needs and the focus of CAIT.

To apply for the internship, please send a brief cover email, names and contact information of two references, and a resume to ud-utc@udel.edu by 5pm Tuesday March 1, 2016.

TranSearch

Contact Us

Want to learn more about the UTC?

Watch for our new website – there will be a link from: http://www.ce.udel.edu/UTC/index.html

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

To be added to the email distribution list, send an email to Marikka Beach (marikka@udel.edu)