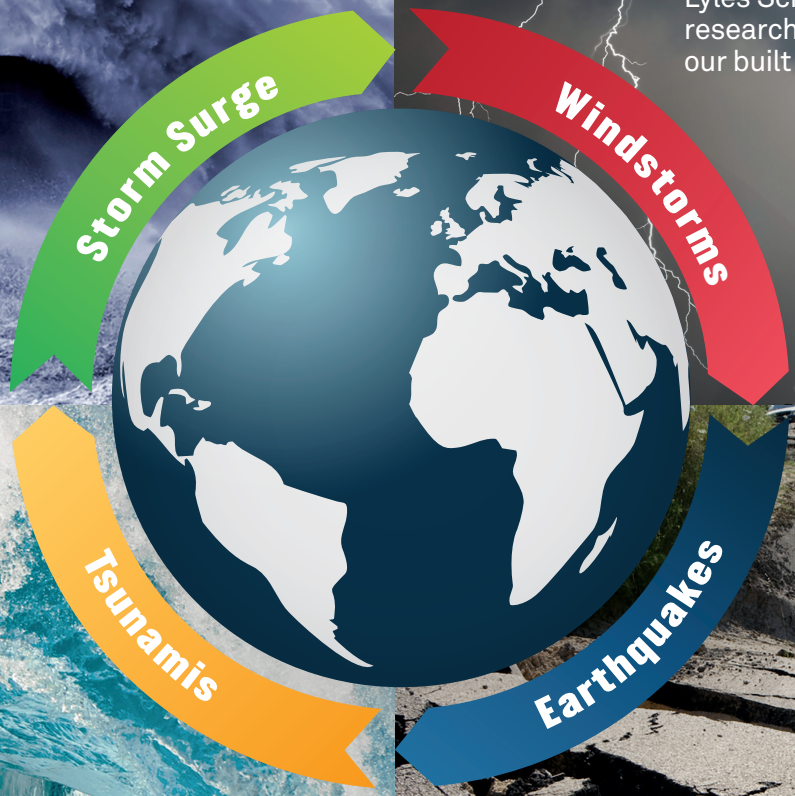
CIVIL

ENGINEERING IMPACT

PURDUE UNIVERSITY | FALL 2016

ENGINEERING SAFE, RESILIENT COMMUNITIES

Lyles School of Civil Engineering researchers work toward securing our built environments



The fall semester is well on its way and the Lyles School of Civil Engineering is already humming with activity. Our students, staff and faculty are all hard at work expanding their knowledge and understanding of civil engineering — and improving the world around us.

It is this hard work and passion that has gained us international recognition as **the best civil engineering school in the world** by ShanghaiRanking for 2016. The top global ranking was based on key areas ranging from research productivity and high-quality research to average global research impact and extent of international collaboration.

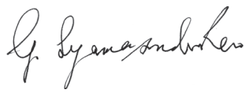
I am both pleased and humbled by this recognition for our program. However, our rankings are more of a byproduct as we strive to amplify our impact around the world — a central theme of our school's strategic plan. It is our goal every year to send out the world's best civil engineers, and these rankings serve as a wonderful success indicator.

In this issue, you will read about research that is just beginning and well under way. This past summer, for example, we received multimillion-dollar grants from the National Science Foundation to improve the United States' structural preparedness for natural disasters and to study how communities can better recover when a disaster strikes.

We're also beginning the second phase in a traffic research effort that could lead to many lives being saved as we try to better identify unsafe intersections.

Also in this magazine, we have shared a story about one of our incredible PhD students, currently overseas studying sand dams in Tanzania in an effort to improve water quality. We look forward to sharing more about her work and success when she returns next summer.

Thank you all for your continued interest in our school. I encourage you to update us on your accomplishments as well. I also hope you will stop by whenever your path takes you this way. ■



RAO S. GOVINDARAJU
Bowen Engineering Head of Civil Engineering and Christopher B. and Susan S. Burke Professor of Civil Engineering

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On the cover: Research engineers and scientists investigate methods for rendering our civil infrastructure safer and making our communities more resilient to devastating natural disasters.

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TRAFFIC BOWL

The Purdue Institute of Transportation Engineers (ITE) Traffic Bowl Team — consisting of Maggie McNamara, Michelle Mekker, Thomas Hall, and Lucy Richardson — won the National ITE Traffic Bowl competition in Anaheim, California, in August. This annual competition among ITE student chapter teams uses transportation planning and engineering topics for clues, questions and answers.

The team qualified for the national championship after taking first place in the Great Lakes District competition held in July. ■

National Champs! Congratulations to the Purdue ITE Traffic Bowl Team (from left) Thomas Hall, Michelle Mekker, Lucy Richardson and Maggie McNamara.

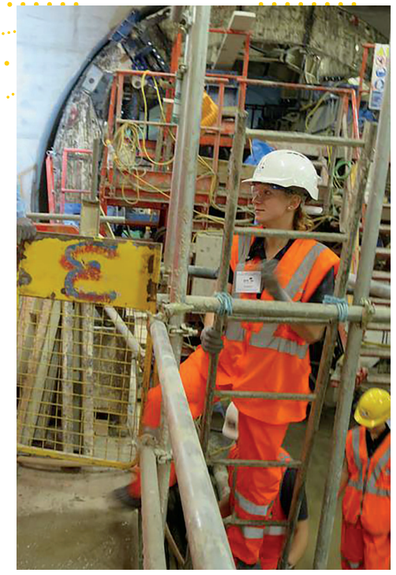
STUDY ABROAD

In May 2016, 19 students from Civil, Mechanical, and Industrial and Construction Engineering embarked on a 12-day European trip. Led by Darcy Bullock, professor of civil engineering, the students studied 21st century European multi-modal transportation infrastructure in London, Paris, Berlin, Hamburg and Munich. The expedition was one of CE's Global Program initiatives.

Active learning opportunities included bike tours of London and Paris, an Eiffel Tower climb, a tour of the Paris sewer museum, technical tours of the new Berlin Brandenburg Airport construction site and the Hamburg Airbus aircraft assembly plant.

A highlight of the trip included London Crossrail site visits to observe the £15 billion (around $20 billion) construction project managed by Bechtel Corp. Bill Dudley, vice chairman of the Bechtel Group Inc., which includes all of the Bechtel companies worldwide, is a Purdue Civil Engineering graduate. Al Dausman, Bechtel project engineer and CE Advisory Council member, joined the students on the trip.

Other highlights included two bike trips, a Segway tour, a boat tour, five airport stops, two overnight trains, as well as countless bus, subway and light rail journeys. The travelers estimate they took about 400,000 steps and 800 flights of stairs during their study abroad trip. ■



Purdue Civil Engineering senior Celia Morin-Kensicki gets some hands-on learning experience at Farringdon station, a London Crossrail station that will open in 2018. Celia, along with more than a dozen other students, took part in the 21st Century European Transportation Infrastructure class this past summer.

ADVISORY COUNCIL

PURDUE LEADS MULTI-HAZARD RESEARCH WITH $4.1 MILLION NSF AWARD

PhD candidate Christian Silva tests a magneto-rheological damping system, which provides variable damping under earthquake loading. The work is part of Professor Shirley Dyke's Intelligent Infrastructure Systems Lab in Purdue's Robert L. and Terry L. Bowen Laboratory for Large-Scale Civil Engineering Research. Photo: Mark Simons, Purdue

In 2015, thunderstorm winds and tornadoes caused 77 deaths and nearly half a billion dollars in damage in the U.S. In 1994, the Northridge earthquake in Southern California caused 57 deaths and about $30 billion worth of damage.

In the face of such natural hazards — and to mitigate their devastation — research engineers and scientists investigate methods for rendering our civil infrastructure safer and making our communities more resilient.

To this end, the National Science Foundation recently named Purdue University as the recipient of the Network Coordination Office (NCO) for its National Hazards Engineering Research Infrastructure (NHERI). The NCO, a $4.1 million, five-year award, will lead the $65 million NHERI network in its goal to minimize damage to our nation's physical civil infrastructure.

> "We want engineers to become multi-hazard in their thinking, to approach resilience of communities as a whole."
>
> — Julio Ramirez, Director, Network Coordination Office for the National Hazards Engineering Research Infrastructure

PURDUE EXPERTISE IN HAZARD ENGINEERING

Julio Ramirez, professor of civil engineering at Purdue, was tapped to direct the NCO. From 2009 through 2014, Ramirez served as director for NSF's George E. Brown Jr. Network for Earthquake Engineering Simulation (NEES), a $105 million grant aimed at mitigating earthquake damage.

By contrast, the new NSF NHERI grant is multi-hazard, combining investigations from the earthquake, wind and coastal engineering, and social sciences communities.

Ramirez says that Purdue's success managing the NEES grant was a key factor in winning the NCO award for NHERI. "Purdue was viewed as the most suitable institution to lead the community, coordinate the large investment of the NSF and to conduct education and community outreach activities of this research infrastructure," he says.

Along with the NCO, the NHERI network consists of eight experimental facilities, a cyberinfrastructure platform for collaboration and a simulation center — components located at universities around the country.

"The NHERI NCO will lead the engineering community into adopting multi-hazard approaches," Ramirez says. "With NEES, our focus was earthquakes and associated damage. With NHERI, we focus on windstorms, too. Things that we've learned in earthquake engineering can be applied to engineering for windstorms and vice versa."

"Most importantly," Ramirez says, "We want engineers and scientists to become multi-hazard in their thinking, to approach resilience of communities as a whole."

Civil Engineering professors Antonio Bobet (left) and Julio Ramirez are heading up the NHERI NCO, headquartered at Purdue. In the Bowen Laboratory, researchers in the Intelligent Infrastructure Systems Lab use a technique called hybrid simulation to test large- and small-scale structures like the one shown. Photo: Mark Simons, Purdue

Other Purdue researchers on the NCO team are Antonio Bobet, professor of civil engineering, who brings extensive geotechnical engineering expertise, and David R. Johnson, an assistant professor with joint appointments in political science and industrial engineering. Johnson will bring experience in interdisciplinary methods and cutting-edge scientific research to inform policymaking and social science research.

Co-principal investigators on the NCO team are JoAnn Browning, dean of the College of Engineering at the University of Texas at San Antonio; Billy L. Edge, professor of civil, construction and environmental engineering at North Carolina State University and head of coastal processes and engineering at the Coastal Studies Institute at the University of North Carolina; and Delong Zuo, associate professor of civil, environmental and construction engineering at Texas Tech University.

MULTI-HAZARD RESEARCH PLAN

The first step for the Purdue-based NCO is to lead the community into developing NHERI's formal research agenda, a five-year science plan. "It's an articulation of the priorities, grand challenges, and the key problems we're going to solve," Ramirez says. "This science plan, developed by the research community, will in turn become the research agenda that NSF and other agencies will fund to make our infrastructure safer against windstorms and earthquakes."

"One of the key goals is to bring together those two very different research communities, people formerly working on the separate paths of earthquake and wind engineering," Ramirez says.

NCO LEADERSHIP

The NCO will serve as the focal point and driving force of a multi-hazards research community focused on mitigating the impact of future earthquakes and windstorms and related hazards such as tsunamis and storm surge on our nation's communities. The NCO team will work with NHERI's experimental facilities to ensure the efficient testing of new technologies within a totally safe environment, to centrally coordinate testing schedules, and to facilitate shared technical knowledge and best practices. Other NCO tasks include leading education and outreach and developing strategic partnerships around the world to form a cohesive, global natural-hazards engineering research infrastructure.

Ramirez encourages fellow researchers to get involved. "NHERI is for anyone interested in improving the resilience of our communities, of our buildings, highways and bridges against earthquakes and windstorms," he says. "This NHERI infrastructure puts all sorts of tools at researchers' disposal: cyber, physical and educational. Get involved. Use it. Take advantage of it. Make your communities safer."

CE UNDERGRAD WINS ASCE Dream Big CONTEST

Purdue Lyles School of Civil Engineering undergraduate Nathan Shellhamer's essay won the ASCE's Dream Big Contest — earning him a trip in May 2016 to Shanghai, China, for the filming of "Dream Big," the ASCE giant-screen movie coming in 2017. Nathan was kind enough to write about his experiences and take photos to share with Purdue University.

Here is an excerpt from Shellhamer's travel blog, describing his visit to Tongji University:

"I never would have believed that a simple dream would lead me to Shanghai, halfway around the world. After many hours of flying, I arrived to what is most certainly the largest city I have ever been to, Shanghai, China.

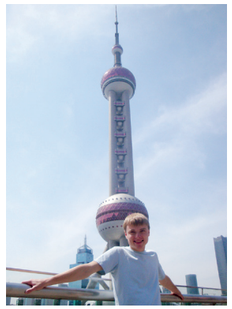
I went to Tongji University, in the northern part of Shanghai, to visit with members of the Tongji University student chapter of ASCE. They showed me a large shake table, where a model of the Shanghai Tower was tested before construction. They had these models outside the building, and many of them were 30 feet tall or more!

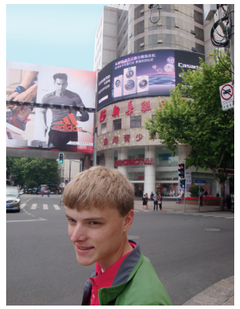
Next, we saw the architecture building, and the students took me to the top of one of the tallest buildings on the campus for a unique view of the Shanghai skyline. The last stop on the tour was their civil engineering building, where they showed me several of their laboratories and work spaces, as well as many of the awards they had won at past competitions. I even got to see their most recent steel bridge.

After the presentation and some photos, we talked about our favorite professional civil engineering classes, and found out that many of us liked the same kinds of classes. While Purdue is done with classes for the summer, Tongji is not yet, so it was time to say goodbye to the students so they could go to class. I must say, I was very impressed with Tongji University.

From traveling on the world's fastest train to visiting the world's second-tallest building, the experience was incredible in every sense of the word. I hope that someday I will be able to return to China on another adventure."

You can read Nathan's full blog entry at **bit.ly/2appSyD**. ■





As part of his trip through China, Nathan Shellhamer rode the Shanghai Maglev, the world's fastest train. In Shanghai, Shellhamer met with the Tongji University ASCE Student Chapter.

PURDUE WINS GRANT FOR INVESTIGATING, IMPROVING DISASTER RECOVERY

> "We want to learn why some communities recover faster than others, while some never recover at all."
>
> — Satish Ukkusuri, Professor of Civil Engineering

Purdue University Civil Engineering researchers are leading an effort to determine how communities can better, and more quickly, recover after a natural disaster strikes.

The National Science Foundation issued a $2.5 million Critical Resilient Interdependent Infrastructure Systems and Processes (CRISP) grant to a research team with Professor of Civil Engineering Satish Ukkusuri serving as principal investigator. The team will research how the U.S. can more efficiently allocate resources, better prepare, and reduce the time and cost of recovery when a community is struck by a disaster.

In addition to Ukkusuri, the multi-university and multi-disciplinary team consists of Purdue professors Shreyas Sundaram of the School of Electrical and Computer Engineering, Seungyoon Lee of the Brian Lamb School of Communication, and professor Laura Siebeneck from the University of North Texas Department of Emergency Management and Disaster Science. Ukkusuri says this eclectic group was chosen because he wants to study how a disaster affects a community from all angles.

STUDYING DISASTER RECOVERY DATA

"We want to learn why some communities recover faster than others, while some never recover at all," Ukkusuri says. "If we can find the answers to these questions, then I think the project is well-served."

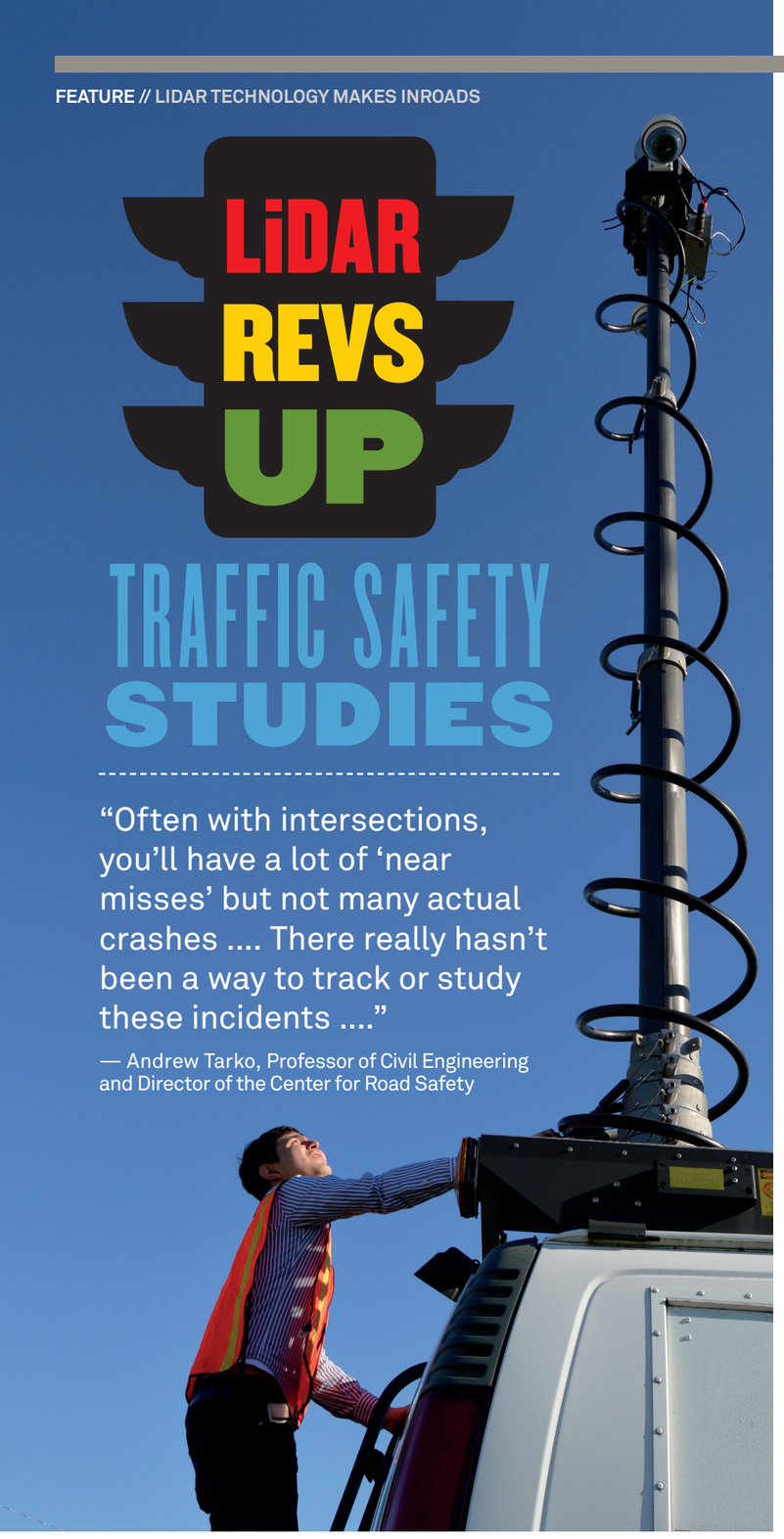
Ukkusuri's team will begin the four- to five-year study in January 2017 by collecting data from communities impacted by Hurricane Sandy in New York and New Jersey. The team will create and test modeling approaches for improved knowledge of social factors (such as how one's involvement in the community affects one's willingness to return to the neighborhood) as well as physical factors (such as road and infrastructure repair) that lead to recovery.

MODELING, PREDICTING RECOVERY

First, researchers will collect data pertaining to the interdependencies of factors that influence post-disaster recovery and decision-making. Second, the project will leverage insights gleaned from the data to identify utility functions that influence the decision-making of households, and to then formulate mathematical techniques based on game theory and network science for modeling and analyzing the tipping points that lead to recovery across social and physical networks.

Ukkusuri says that his team's goal is to allow governmental and emergency agencies to take actions that will accelerate system recovery and enhance the resilience of communities. ■

LiDAR REVS UP TRAFFIC SAFETY STUDIES



"Often with intersections, you'll have a lot of 'near misses' but not many actual crashes .... There really hasn't been a way to track or study these incidents ...."

— Andrew Tarko, Professor of Civil Engineering and Director of the Center for Road Safety

In an era when data gathering methods continually evolve to yield faster and more accurate results, traffic safety analysis remains a laborious and reactive process. However, research currently taking place at the Purdue Lyles School of Civil Engineering aims not only to improve the speed and quality of safety studies, but make them more predictive as well.

"Often with intersections, you'll have a lot of 'near misses' but not many actual crashes," says Andrew Tarko, professor of civil engineering and director of the Center for Road Safety. "There really hasn't been a way to track or study these incidents, and so we will sometimes have to wait years to collect enough data from crashes to determine if there is actually a problem at an intersection."

Through his research, however, Tarko has found a way to solve this issue using LiDAR (Light Detection and Ranging) technology. LiDAR is a surveying system that measures distance by illuminating a target with a laser light.

Mapping companies use LiDAR to create 3-D images of roads and cities, but Tarko's team is able to digitally remove the backgrounds entirely from 3-D images, retaining only the information created by moving objects, such as vehicles and pedestrians.

Although the raw data is not easy to decipher, the schools of Civil Engineering and Mechanical Engineering came together to transfer it into usable information. With software created by mechanical engineering graduate student Vamsi Krishna, the countless dots on a black screen can be combined with an overview map.

The result shows vehicles and pedestrians — fully mapped — with data points, detailing speeds of the objects, their exact proximities to each other, at any given time and in any conditions.

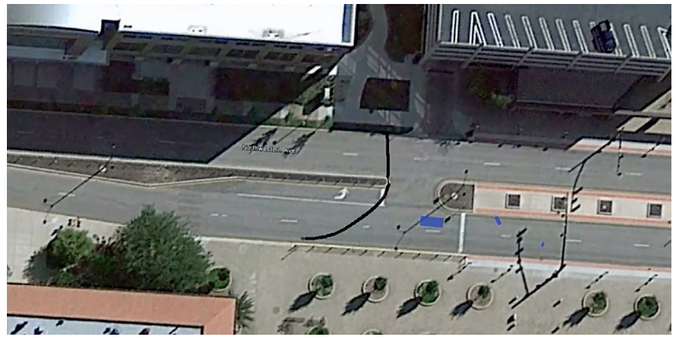
From the data collected, and in a short time period, new safety measures — such as repositioning pavement markings, adjusting traffic signal timing, correcting geometry, or enhancing enforcement — can be implemented before a real crash ever takes place.

Tarko's team successfully completed Phase 1 of the project in August as a proof of concept. It was jointly funded by the Federal Highway Administration and the Indiana Department of Transportation (INDOT) via NEXTRANS and the Joint Transportation Research Program (JTRP) for $450,000.

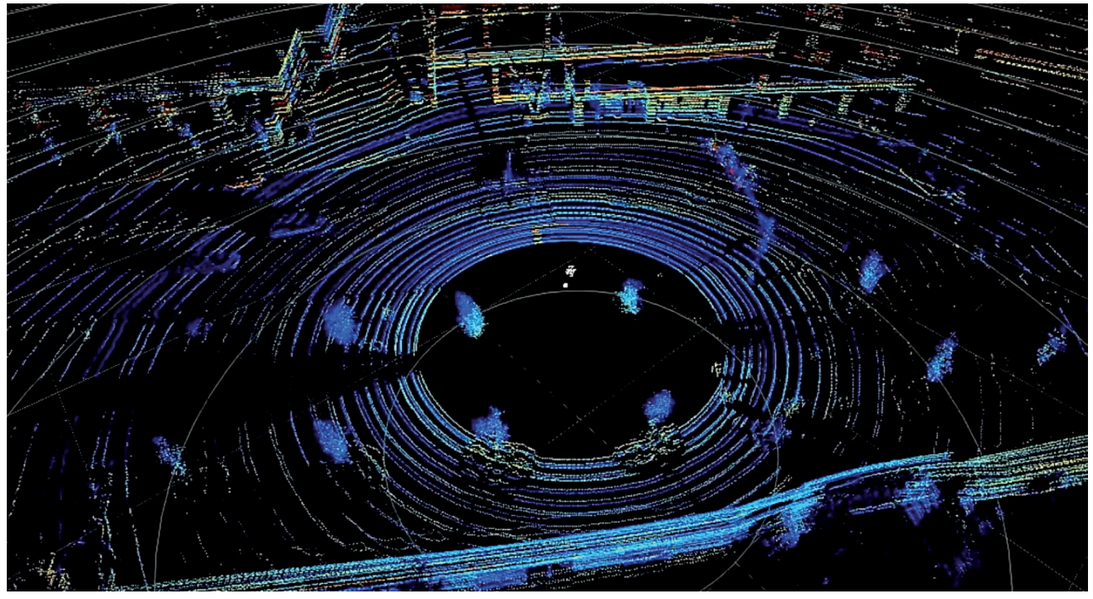
Phase 2, expected to run from August 2016 to August 2018, is funded through JTRP for $420,000 and includes two sub-periods. In the first year, a prototype trailer-based TScan unit will be built for INDOT field-test use across the state over the second year. Phase 3, funded at $270,000, may follow up with a second INDOT TScan unit for integrated use with the prototype to cover large areas.

Brad Steckler, director of traffic engineering for INDOT, says he is optimistic about the system's potential to generate immediate, practical value to reduce risk of severe crashes at intersections and other highway locations such as horizontal curves.

"So far, it's been wonderfully promising," he says. "The notion of observing close calls has been around for a while, but it's always been a manual and time-consuming task. This automated method removes that obstacle." ■



Purdue civil engineering researchers are developing a new method of traffic data collection by attaching a Light Detection and Ranging (LiDAR) device to a mast. With the new, automated system, researchers could collect information in days instead of years, enabling new safety measures to be implemented much more quickly and before a crash ever takes place — potentially saving lives.



Purdue's School of Mechanical Engineering is assisting in the study. Through a software program ME created, the raw data collected from the LiDAR technology is translated from countless dots on a black screen to a fully mapped traffic area, complete with data points that detail the speed of objects and pedestrians and their proximities to each other.

HIGH-ACHIEVING GRADUATE STUDENT SEEKS TO AID DEVELOPING NATIONS

Jessica Eisma says she is thankful for the support she continues to receive from the faculty and staff at the Lyles School of Civil Engineering. In addition to encouraging her efforts, faculty and staff members also reviewed her grant applications.

Eisma analyzes GRACE satellite data to determine the trends in total water storage in East Africa. Jessica says she intends to use the data gathered to aid in her study of sand dams in Tanzania.

PhD student Jessica Eisma doesn't see Purdue Civil Engineering only as a smart career path, but as a way to shape the world for the better.

In 2016, Eisma (MSCE '15) was awarded a pair of prestigious research grants — totaling more than $45,000 — from the Fulbright U.S. Student Program and the U.S. Borlaug Fellows in Global Food Security Program to study the ecological impact of sand dams in Tanzania. She flew to Africa in August and will spend 12 months studying overseas.

In 2015, she was awarded a National Science Foundation Graduate Research Fellowship to further pursue her graduate degree. The fellowship paid her tuition to Purdue University and provided a $34,000-a-year stipend for three years.

SAND DAMS AND WATER QUALITY

Eisma, whose focus is in hydrology, says her desire to study sand dams stems from wanting to help create sustainable life for all people — and one of the keys to maintaining a stable society is through a safe and reliable source of water.

"I want to create knowledge that will guide development in the future," she says. "My hope is that those who use these structures in the future will benefit from the added data I've found."

Specifically, Eisma's research will involve assessing the water quality around the dam by studying the water insects that eat the nearby algae and other vegetation.

"This will be a less expensive way to study and determine the water quality," she says. "By studying the macroinvertebrates, we'll be able to study the water quality. It's very exciting research, especially since there's been very little done so far, and sand dams have been around for hundreds — maybe even thousands — of years."

A sand dam is a reinforced rubble-cement wall built across a seasonal sandy river. It is a simple, low-cost, low-maintenance technology that retains rainwater and recharges groundwater. Sand dams also are the most cost-effective method of water conservation in dryland environments.

Other sand dam quality factors Eisma is studying include the local water table and ground levels, vegetation around the dam and erosion.

"It's a different way to assess the water quality of a dam, and it gives you a different look at how a stream has been impacted," Eisma says.

OVERSEAS PASSION

This is Eisma's second time helping and studying overseas. In 2011, she studied for six months in the Philippines at the University of the Philippines Los Baños. While there, she also interned with the Peace Corps and planned the building of a youth rehabilitation center. It was her time there, Eisma says, that galvanized her interest in using her civil engineering education to improve developing nations.

FACULTY SUPPORT

Eisma says her efforts and interests have been greatly encouraged by Professor Dulcy Abraham and her advisor, Associate Professor Venkatesh Merwade.

"Not only is she very smart, but I felt this study she intends to do will be applicable in a number of other countries," Merwade says. "She has a very unique idea, and I wanted to encourage that."

"I first met Jessica through CESAC (Civil Engineering Student Advisory Council), and I was just so impressed with her," Abraham adds. "Her striving toward excellence and her thinking about the bigger picture and the world around her makes her stand out."

You can follow Eisma's work in Tanzania through her website at **jessicaeisma.com**.

In Tanzania, Eisma is advised by Dr. Karoli Njau, dean of the School of Materials, Energy, Water, and Environmental Sciences at the Nelson Mandela African Institution of Science and Technology. For the next year, she will study sand dams in Tanzania, Africa. She is researching ways to test water quality around the dams to ensure a better quality of life for the region.

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GLOBAL RANKINGS
PURDUE'S CIVIL ENGINEERING IN THE TOP SPOT

WEST LAFAYETTE, Ind. — ShanghaiRanking's Global Rankings of Academic Subjects, released June 15, 2016, lists the College of Engineering's Lyles School of Civil Engineering as the No. 1 civil engineering institution in the world.

Rao Govindaraju, the Bowen Engineering Head of Civil Engineering and Christopher B. and Susan S. Burke Professor of Civil Engineering, said the ranking is an honor for the school.

"This recognition is a testament to the incredible work and accomplishments of our students, faculty and staff of the Purdue Lyles School and our CE alumni and friends," he said. "Their continued pursuit of excellence is what drives our school, and I am very proud of all our efforts and achievements."

Schools earned the global rankings based on a number of areas ranging from research productivity and high-quality research to average global research impact and extent of international collaboration. Significant academic achievements and recognition of an institution's researchers also are measured as part of the rankings. ■