CIVIL

ENGINEERING IMPACT

PURDUE UNIVERSITY | FALL 2015

MAPPING IN THE MODERN AGE

As I write this, the campus is humming again after the summer break. This is an exhilarating time of the year — students are reacquainting themselves with the campus, the faculty and each other. They also are intimately involved in the process of discovery — of new knowledge, their capabilities and ideas that are bound to change our world.

As one example of venues for new knowledge, Satish Ukkusuri, professor of civil engineering, along with researchers from Purdue, Virginia Tech and North Dakota State University, recently received a National Science Foundation Hazards Science, Engineering and Education for Sustainability (SEES) grant to understand the role of uncertainty in hurricane evacuation decision-making. Ukkusuri and his interdisciplinary team will develop tools to capture and reduce uncertainty hazards. Natural disasters demonstrate the importance of developing new scientific methods in hazard mitigation. Hurricane Sandy is estimated to have caused more than $70 billion in losses, and Hurricane Katrina caused significant loss of life. Professor Ukkusuri's research will develop approaches that leverage advancements in data gathering techniques to ultimately improve evacuations, leading to lower evacuation costs, stress, and loss of life. And in so doing, change our world. We will feature this project in a future issue of this magazine.

Another venue for discussing discoveries, new knowledge and the impact civil engineers have on our world is invited talks from leading experts. Our school is fortunate to have four named lectures: the Dennis & Leslie Drag Distinguished Lecture Series, the G.A. Leonards Lecture, the C.W. Lovell Distinguished Lecture and the Leonard E. Wood Lecture Series. You can learn more, including schedules and speakers, by visiting www.purdue.edu/CE/Academics/Lectures.

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I invite you to enjoy this issue of *Civil Engineering Impact* magazine and to reach out if you have questions, need more information or if you have news of your own to share.

Thank you for being a part of our School. Please stay connected, and plan on visiting us whenever the opportunity presents itself. ■

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

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COVER PHOTO: DJI Phantom 2 Vision unmanned aerial vehicle

MILTON HARR RECEIVES
FRENCH LEGION OF HONOR

At 17, Milton Harr enlisted in the Navy and crossed the Atlantic Ocean on the tank landing ship LST-287 during World War II. He landed on Omaha Beach on D-Day with his unit, Foxy 29, and ferried wounded prisoners from Normandy to England. Harr, a native of Chelsea, Massachusetts, later was transferred to the Marine Corps and shipped to Guam. He served on Iwo Jima with Company B, 3rd Marine Division, Fleet Marine Force. After the war, Harr earned a PhD in civil engineering from Purdue University (1958) and served on the CE faculty in the geotechnical area for 43 years. He now lives on Longboat Key, Florida, with his wife, Florence, of 69 years. ■

RIGHT: U.S. Navy veteran Milton Harr listens to the French national anthem after receiving the French Legion of Honor medal in Miami, Florida, on Feb. 27, 2015. ©Diego Urdaneta (AFP)

PURDUE TEAM WINS
ITE TRAFFIC BOWL
GREAT LAKES DISTRICT

The Purdue Institute of Transportation Engineers (ITE) Traffic Bowl Team won the Great Lakes District competition. This annual competition among ITE student chapter teams uses transportation planning and engineering topics for the clues, questions and answers. Of the ITE student chapters in the United States and Canada, a total of 98 chapters, or 66 percent of all student chapters, have participated in at least one traffic bowl since 2009. The Purdue team, consisting of Jijo Mathew (left), Maggie McNamara, Michelle Mekker and Thomas Hall, also competed against eight other district winners at the national-level Grand Championship on August 3 in Hollywood, Florida, and took home third place. ■

ADVISORY COUNCIL

MAPPING IN THE MODERN AGE

Using unmanned aerial vehicles for data acquisition

Unmanned aerial vehicles (UAV) are emerging in many technological fronts and their use is growing quickly.

According to marketing researchers at *marketsandmarkets.com*, the UAV market was estimated to be worth $6.8 billion in September 2014 and is anticipated to reach $10.6 billion by 2020. One significant use of this technology is as a mobile-mapping platform, providing practical and economic advantages to civil engineers.

A UAV, commonly known as a drone, is an aircraft without a human pilot. Its flight is controlled either autonomously by onboard computers or by the remote control of a pilot on the ground or in another vehicle.

The ability of UAVs to fly at lower elevation and slower speed than manned systems allows them to capture data with higher resolution. Moreover, these systems can be economically stored and deployed. By way of example, the **POINT-CLOUD** graphics included in this article were produced using a UAV that cost less than $1,000.

Professor Ayman Habib and other researchers within the geomatics area of the Lyles School of Civil Engineering are working to address the challenges surrounding the manipulation of acquired data by digital imaging systems onboard these low-cost UAVs.

DJI Phantom 2 Vision unmanned aerial vehicle

Two such challenges include the calibration and stability analysis of imaging systems, which were not really designed for mapping purposes. Geomatics investigators also are working to establish pre-acquisition best practices as well as post-acquisition guidelines to ensure the validity of the collected data in meeting the needs of intended applications while reducing the required level of technical expertise.

Additionally, this group is studying different areas that could benefit

A POINT CLOUD is a set of data points in some coordinate system. In a 3-D coordinate system, these points are usually defined as X, Y and Z coordinates, and often are intended to represent the external surface of an object. They can be used for many purposes, including the creation of 3-D CAD models for manufactured parts, metrology/quality inspection and a multitude of visualization, animation, rendering and mass customization applications.

from data collected by UAVs, such as infrastructure monitoring, transportation, landslide hazard analysis, precision agriculture and building-model generation.

"The realization of our research goals will have a tremendous impact on the diversity of areas that could benefit from geospatial data collected by UAVs," Habib says.

APPLICATIONS IN ENERGY

Purdue recently received $6.5 million from the U.S. Department of Energy for research aimed at producing superior strains of sorghum suitable for growing as a biofuel. The research team from Purdue includes Ayman Habib as well as Melba Crawford, professor of agronomy, professor of civil engineering, and associate dean for research in the College of Engineering. This group, along with a team from IBM, will use digital imaging systems onboard UAVs as well as wheel-based mobile mapping systems for accurate derivation of detailed and precise measurements of plant characteristics, referred to as phenotypes, that relate to growth, development and water tolerance. The phenotype characteristics (e.g., plant height, leaf area, biomass) will be correlated with the genetic structure of the plants to identify the structure that produces the highest crop yield for biofuel production. ■

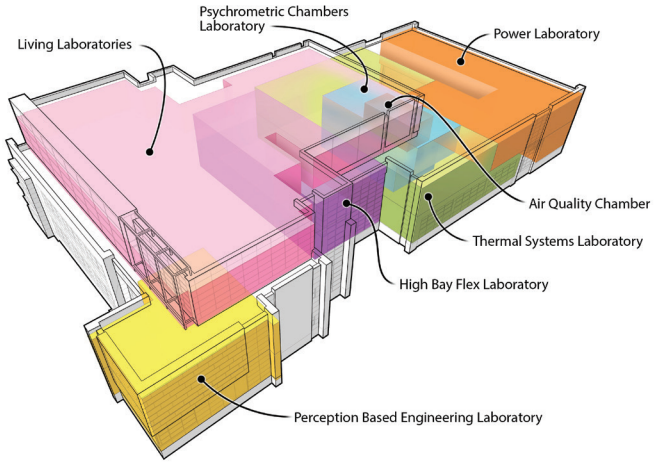
A sample point cloud over a building that has been derived from imagery collected via UAV.

A sample point cloud over an area that is prone to soil creep derived from imagery collected via UAV. Such point clouds, together with the original imagery, can be used to derive accurate measurements and change detection applications.

To see a UAV at work, visit youtu.be/jRCwgum0eS0. This video shows how UAVs may be used to inspect bridges and other structures.
Video provided by Jim Bethel, associate professor of civil engineering.

THE FUTURE OF ARCHITECTURAL ENGINEERING IS HERE TODAY

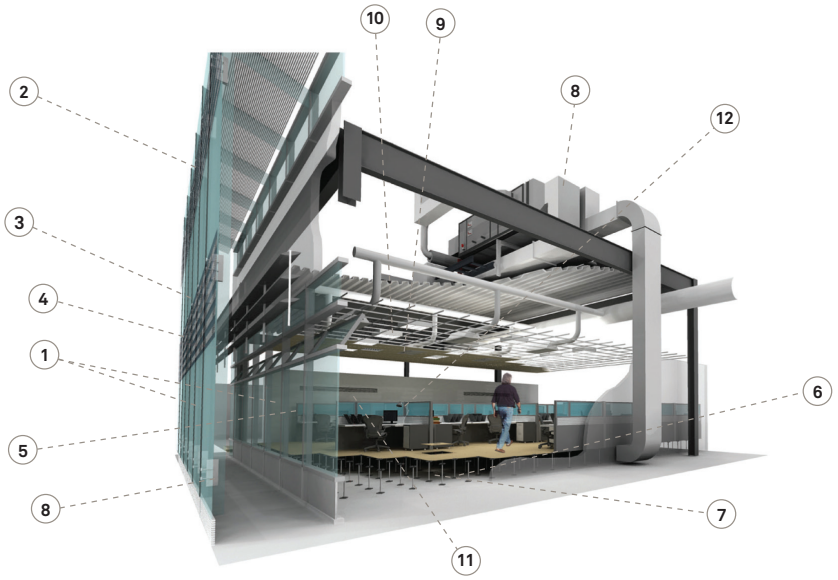
Purdue's Center for High Performance Buildings



Researchers working at Purdue in the field of engineered environments had a vision for a facility with a fully instrumented living laboratory: offices with reconfigurable facades, multiple comfort delivery modes and primary equipment enabling controlled testing. They also imagined a perception-based engineering (PBE) facility to study the combined effects of lighting, acoustics, air quality, vibration, temperature, humidity and air flow on occupant perceptions and performance. They dreamed of creating a center to house these unique facilities along with more traditional laboratory-scale test facilities that are useful for controlled testing of building envelopes, lighting and facades, air distribution, cooling and heating equipment, heat exchangers, compressors and more.

TWO PARTS OF THE LIVING LABORATORY

"The living laboratories allow CHPB researchers to evaluate new systems and concepts within a real-world setting in terms of energy performance and occupant response," said Jim Braun, Herrick Professor of Engineering, professor of mechanical engineering, professor of civil engineering and director of the center. "These real-world test beds, along with specialized equipment, envelope and occupant test facilities, give us unique capabilities that cannot be found elsewhere."



AIR LIVING LABORATORY

These grand aspirations have been realized at Purdue's Center for High Performance Buildings (CHPB), located in the School of Mechanical Engineering's Ray W. Herrick Laboratories. The facility was dedicated in November 2013.

Faculty and students from Purdue's Lyles School of Civil Engineering (particularly those in architectural engineering), School of Mechanical Engineering, and School of Electrical and Computer Engineering and the Department of Psychological Sciences can now collaborate to consider a wide range of applications.

Although similar research centers exist, they tend to focus on very specific aspects of components, equipment or comfort. In contrast, Purdue's CHPB offers an enviable range of test beds and includes two state-of-the-art facilities designed to test full-scale building features.

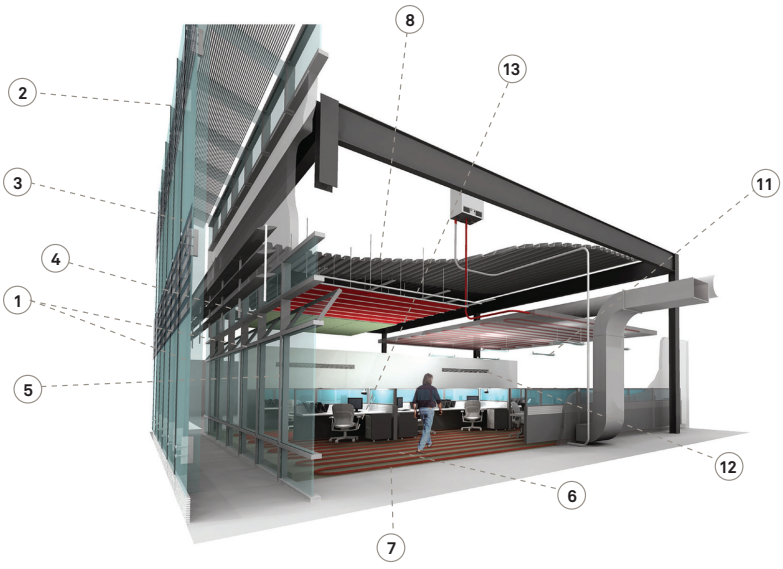
According to Amir Sadeghi, a civil engineering graduate student, "The Integrated Building Management System in Herrick Lab gives us the opportunity to thoroughly investigate human-building interactions and better understand occupants' thermal and visual preferences in office areas."

Established through a construction grant from the National Institute of Standards and Technology, the center has a mission to partner with industry to develop, demonstrate and evaluate new technologies and analysis tools that can enable dramatic improvements in the performance of buildings.

Center administrators are developing a member-based program to partner more closely with industry. This mutually beneficial program will provide enhanced access for corporate partners while offering students valuable connections to companies in fields they are studying.

The center is headquartered in the Herrick Laboratories expansion (HLAB) on Russell Street. Here, researchers have the ability to adjust, or completely change, the lighting, heating, air conditioning, windows and acoustics in four nearly identical office spaces, each housing about 20 graduate students. Comfort-delivery options alone include air supply from ceiling, floor or side-wall diffusers, along with radiant floor heating and radiant chilled beam cooling. This degree of variability allows full operational assessments of new and emerging building technologies.

For Iason Konstantzos, another CE grad student who uses the space, "The flexibility of reconfigurable envelope elements gives the potential to investigate the impact of different setups in terms of energy consumption and comfort. The lab lets us focus on specific details, such as efficient control algorithms for maximizing comfort and productivity, material requirements for shading devices, and other things. Direct feedback from individuals that occupy the space is essential in order to confirm hypotheses and also direct the next steps of comfort-related research."



HYDRONIC LIVING LABORATORY

Hydronics is the use of water, or other liquid, heat transfer medium in heating and cooling systems.

RECONFIGURABLE FEATURES WITH OPPORTUNITIES FOR:
1. Double Skin Facade 2. Integrated Photovoltaics 3. Advanced Glazing Materials 4. Natural Ventilation 5. Controllable Glazing: Visible Light Transmittance and Thermal Performance 6. Underfloor Air Distribution (Air) or Radiant Floor Heating (Hydronic) 7. Personnel Ventilation Control (Air) or Integrated Thermal Mass (Hydronic) 8. Primary Air System with Broad Delivery Range (Air) or Radiant Ceiling Panels (Hydronic) 9. Overhead Air Distribution (Air) or Active and Passive Chilled Beams (Hydronic) 10. Overhead Light Fixtures (Air) or Displacement Ventilation (Hydronic) 11. Wall Light Fixtures (Air) or Overhead Light Fixtures (Hydronic) 12. Task Fixtures (Air) or Wall Light Fixtures (Hydronic) 13. Task Fixtures (Hydronic)

HLAB has a Leadership in Energy & Environmental Design gold classification; nevertheless, the primary goal was to design a facility that will allow research on technologies that go well beyond LEED standards.

The architectural engineering laboratories at the Robert L. and Terry L. Bowen Laboratory are also a component of the CHPB. In the Bowen Lab facilities, graduate students conduct research related to building envelopes, lighting and daylighting, smart and predictive building controls, hybrid ventilation, mechanical systems, as well as renewable energy technologies — such as photovoltaic-thermal systems and solar heating and cooling systems.

Students in the Lyles School of Civil Engineering have the opportunity to study the integration of different building systems and to learn how to design for sustainability and energy efficiency. This new facility and its associated programs provide amazing flexibility for studying energy and comfort issues related to buildings and the design and application of electrical and mechanical systems.

Graduate research assistant Jaewan Joe said, "Strong opportunities exist with this interdisciplinary approach from faculty and researchers from diverse departments to lead this up-to-date research." ■

Thanos Tzempelikos (top left), associate professor of civil engineering; Iason Konstantzos (at computer), graduate student and Tzempelikos advisee; and Amir Sadeghi, graduate student and advisee of Panagiota Karava, associate professor of civil engineering. The group is discussing the results of experiments conducted in HLAB regarding human interactions with lighting and thermal systems in buildings.

GETTING DATA ON DRIVERS

The NEXTRANS Driving Simulator Laboratory

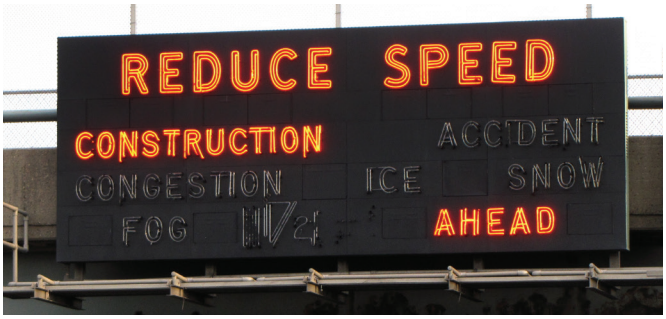
Advances in roadside signage technology, smartphones and in-vehicle navigation devices have led to increased, and increasingly personalized, communications to travelers en route. In fact, recent reports suggest that the number of automobiles with in-vehicle navigation systems will quadruple in North America by 2019, growing to nearly 13 million new systems annually. Regrettably, this rise in information available to travelers can lead to increased distracted driving.

Until now, there has been little research into how travelers process real-time information, what and how much information travelers can safely process and absorb while driving and how much information should be provided to drivers for effective information-based traffic management.

Funded through the NEXTRANS Center, the Purdue Driving Simulator Laboratory (DSL) is a quasi-living laboratory where investigators seek to discover the benefits of real-time information for travelers.

Srinivas Peeta, professor of civil engineering and director of the NEXTRANS Center, says, "The Purdue DSL is a unique facility in that the driving simulator is integrated with a real-time microscopic traffic simulator. This enables us to reflect on driver decisions, road capacity changes (for example, due to accidents) or demand fluctuations seamlessly as drivers travel to their destinations."

Graduate student Dong Yoon Song operates the Purdue Driving Simulator, which replicates automobile, traffic and weather conditions in and around Indianapolis. The DSL is located in the Purdue Technology Center. [Photo provided]



Early style of variable message sign (VMS) still in use on the New Jersey Turnpike will be replaced by new LED VMS signs. [Photo by Ben Schumin / Wikimedia Commons / CC-BY-SA-3.0]

This facility can mimic the multi-tasking environment in which drivers maneuver their vehicles, interact with other vehicles under surrounding traffic conditions and analyze how drivers respond to real-time information.

NEXTRANS is the U.S. Department of Transportation Region 5 Regional University Transportation Center and encompasses Indiana, Illinois, Ohio, Michigan, Wisconsin and Minnesota. Established in 2007, the center is based on an award from the USDOT Research and Innovative Technology Administration and supports a multidisciplinary program of transportation research, education and technology transfer.

NEXTRANS is led by Purdue University. Its partners are The Ohio State University, Central State University, Chicago State University, Illinois Institute of Technology, Trine University, University of Michigan and University of Wisconsin-Madison.

In addition to simulating traffic, signal timing, weather and other conditions, the simulator and lab are unique in that they enable researchers to quantify the value of real-time information on a network under regular or extreme traffic conditions. Using a simulation of the Indianapolis road network, researchers expect their project will contribute to the development of better methods of providing information to travelers and enhancing the quality and safety of the travel experience.

For Shubham Agrawal, a graduate student working on this project, understanding the role of technology that people use in their daily lives is rewarding. He says, "I get the opportunity to work with a sophisticated system, which is very challenging and interesting."

Dong Yoon Song, also a graduate student, says, "Our research is designed to capture driver perception of information in addition to revealing behaviors under realistic travel contexts. For policymakers, our work justifies investing in an advanced network for disseminating real-time traffic information." ■

WHERE DID CIVIL ENGINEERING TAKE YOU?

Alum Brian Harlow: From the farm to the boardroom

Brian Harlow grew up on a family farm near Kokomo, Indiana. When he left home to attend Purdue in the mid-1970s, he never dreamed his journey would take him much beyond that farm. Forty years later, he is the vice president - manufacturing for the North American arm of the seventh-largest automaker in the world, Fiat Chrysler Automobiles (FCA).

Harlow was one of about 80 graduates from his high school, and at Purdue University he found himself in a place he could not have imagined, learning things of which he previously only dreamed. His affinity for flowing water originated from boyhood when he used to play in the irrigation sluices that watered his great-grandmother's garden in Albuquerque, New Mexico. This led him to concentrate his studies on environmental engineering and to earn a minor in structures.

Graduating from college — the first in his family to do so — he had all but decided on a position at a "traditional" CE firm, one specializing in engineering, architecture and planning. But fate intervened when Harlow learned Chrysler needed an environmental engineer at the Kokomo Transmission Plant. He has worked for Chrysler ever since, succeeding and advancing despite corporate bankruptcy, mergers and acquisitions.

> "SUCCESSFUL LEADERS MUST BE ABLE TO COMMUNICATE IDEAS TO PEOPLE, GET ALONG WITH PEOPLE, HAVE THE ABILITY TO CONVINCE PEOPLE OF A COURSE OF ACTION — AND THROUGHOUT ALL OF THAT, HAVE INTEGRITY IN EVERYTHING THEY DO."

Harlow credits the size and nature of the company as reasons for longevity with a single employer, saying, "In a company the size of Chrysler, I had many opportunities to grow my skill set and continue to find new challenges."

One of Harlow's most significant accomplishments was helping convince management in 2009 that it would be a better business decision to develop and produce more of its own transmissions. This led to the retooling of the four Kokomo facilities, plus the addition of a new plant in Tipton, with a total infusion of nearly $2 billion and job security for more than 8,000 workers.

Brian Harlow, vice president - manufacturing for FCA North America, speaking during the State of Manufacturing & Logistics event on June 11 in Indianapolis, Indiana. Brian shared his thoughts on how the company's private and public partnerships are preparing the next-generation of advanced manufacturing workforce.

"When I am asked about lessons learned in this industry, my answer is that everything is people-oriented," Harlow said. "Successful leaders must be able to communicate ideas to people, get along with people, have the ability to convince people of a course of action — and throughout all of that, have integrity in everything they do." ■

STUDY ABROAD
SWEDEN

In May of this year, 17 Purdue civil engineering students visited Stockholm, Sweden, to study environmental sustainability across multiple sectors. The weeklong session was led by Inez Hua, professor of civil engineering and professor of environmental and ecological engineering, and Jill Churchill, undergraduate international programs coordinator in the Global Engineering Program.

During the students' stay in Stockholm, made up of 14 islands in the Baltic Sea, Purdue students participated in lectures at KTH Royal Institute of Technology, toured industry sites, observed water treatment plants in action, and visited energy-generation facilities. Students experienced firsthand how Sweden has achieved greater independence from fossil fuels because of its widespread district heating systems, some of the world's largest. For instance, by using cold seawater from the Baltic Sea, central Stockholm has fulfilled most of its cooling needs since 1995. Students who toured the facility remarked they have a newfound appreciation for the principles of thermodynamics.

Students also toured the Parliament House, learned about the Swedish monarchy and participated in cultural activities.

"Learning in the classroom gives a good theoretical background on how sustainability can be implemented," said Julie Woodworth. "Visiting Sweden to be able to see and understand the successful application of innovative technologies was an unbelievable learning experience. I am now motivated to make a difference in our community with respect to environmental practices. I look forward to making a positive impact in the U.S., as so many of the people we met in Sweden have had on their country."

Annual Maymester and other study abroad programs give students the opportunity to think and act locally and globally and to enhance critical thinking skills. The school hopes to grow this program for its students. ■

Purdue students touring a district heating plant in Jarfälla, Sweden. During the visit, students were able to see the equipment and principles they studied being put into action.

Master's student Angela Ortiz (left, since graduated), shows two residents of Las Canas, Dominican Republic, how to measure chlorine concentration in their water.

STUDY ABROAD
THE DOMINICAN REPUBLIC

A dozen Purdue students from seven different academic units, including Civil Engineering, traveled May 9-15, 2015, to the Dominican Republic to take part in a service-learning project related to a course titled Water Supply in Developing Countries.

Since its inception in 2012, the course has taken an interdisciplinary, holistic approach to water quality and water supply problems in developing countries. Specifically, course participants design and implement community-scale water treatment systems for use in small towns in the Dominican Republic, such as Las Canas, a remote village on the northern side of the island.

Work on this project has been shaped with the assistance of Aqua Clara International, a nonprofit organization working to provide affordable safe water solutions for communities in developing countries. Financial support comes from Purdue's Study Abroad program and from the academic departments and schools involved, which include Agricultural Economics, Biology, Civil Engineering, Environmental and Ecological Engineering, Food Science, Industrial Engineering and Nursing.

Though this spring's trip was mainly one of reconnaissance, Ernest (Chip) Blatchley, professor of civil engineering and environmental and ecological engineering, adds, "We identified several other communities in the Dominican Republic to begin working with, and we worked closely with the community of Las Canas to help residents better utilize the potable water system we helped install during a previous visit. A key feature of our project is that the systems installed are owned and operated by the communities they are in."

Plans are moving forward for future trips, and the group is especially excited about a potential partnership it is exploring with the Lafayette Rotary Club and Rotary International. ■

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