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Bernard M. Gordon Learning Factory sponsors weigh in on the benefits of working with Penn State students:

“Not only do my colleagues and I observe firsthand the energy, enthusiasm, and technical knowledge the students demonstrate throughout the projects, we come away with a renewed sense of the same at the conclusion of the project, culminating at the project showcase.”

— Perry Morrissette, Senior Manager – MSE Engineering, The Boeing Company

Watch and read more on page 11 >>

ABOUT THIS ISSUE

Enjoy our enhanced digital version of Engineering Penn State. This issue highlights the College of Engineering’s five-year strategic plan and our faculty and student efforts in accomplishing the goals.

To sign up for digital delivery of our magazine, email communications@engr.psu.edu.
Innovation only thrives in empowering ecosystems. Concurrently, deliberate and purposeful management of complex organizations requires guided path finding and consistent strategy implementation. Nowhere more than in academia do these two poles interact and sometimes even collide.

How does our college manage to empower its professoriate while accomplishing convergence towards impactful and contextual research? Through the concept of ‘guided debate’: debate that is inclusive, flexible, adaptable, and is still ‘guided.’

Our four research thrusts — cyberenvironments, advanced manufacturing, resilient infrastructure, and energy-food-water — have been derived through intense consultations and community engagement. We started the conversation by assessing the world’s grand challenges, the expertise and interests of our faculty, and our research infrastructure. At the intersection of these three streams, we found our niche: the grand challenges that our faculty are interested in addressing, using our research infrastructure. We then formed brainstorming teams to articulate specific focus areas under these topics. These teams have gone to a finer granularity in defining the research topics, resulting in the following sub-topics:

**Cyberenvironments:** Network design/optimization, cybersecurity, data analytics, and cyber-ethics.

**Advanced Manufacturing:** Multi-material integration, analysis, modeling, and optimization, and digital and intelligent manufacturing.

**Resilient Infrastructure:** Network autonomy, adaptation, supply chain, cyber-physical systems, health monitoring, adaptive decision-making, and interdependencies.

**Energy-Water-Food Nexus:** Physics-based analysis and simulation of the tri-system interactions; new technologies for supply and demand optimization; data-intensive resources management; and conservation, and environmental impact stewardship.

We have concentrated our internal resources on these topics, and are in the process of wrapping up the launch of these research thrusts through workshops with national and international participation. The outcome will be coherent teams with a common technical vocabulary, ready to successfully compete at the highest level for research projects, centers, and center-type funding opportunities. In the meantime, the reports developed by the working groups have been, and continue to be, the basis for internal resource allocations including frontier faculty hiring, graduate research fellowships, and innovation grants.

In addition to the four research topics, the college continues to address a fifth and exceptionally important challenge: developing innovative engineering education techniques. Our ongoing effort focuses on introducing new instructional technologies and pedagogy both in-class and online; implementing ethics, leadership, and entrepreneurship into courses; developing interdisciplinary majors and minors to address societal challenges; and promoting global engineering education and experiences.

With the expansion of our research leadership through the appointment of an associate dean for research and an associate dean for innovation, Penn State Engineering has the vision, energy, technical breadth and depth, the human and capital resources, and the management structure to play a pivotal role in addressing the pressing challenges facing the global community, in propelling forward economic development, and in improving the quality of life for current and future generations.

Amr Elnashai, FREng
The Harold and Inge Marcus Dean of Engineering
Penn State hosts largest-ever Engineering Ambassadors Network Conference

More than 210 participants, including current and future Engineering Ambassadors and their advisers, attended the Engineering Ambassadors Network Conference September 9 to 11 on the University Park campus.

The event provided new engineering ambassadors with presentation skills they will need to be successful in their roles. In addition, more than 40 returning ambassadors mentored the incoming cohort by sharing best practices and lessons learned.

“It was an honor to host this year’s Engineering Ambassadors Network conference at Penn State,” said Erik Orient, director of Penn State’s Engineering Ambassadors program. “We are doing tremendous things here, and we were happy to share what we’re doing with others.”

George Lesieutre and Chris Rahn named associate deans

In June, George Lesieutre and Chris Rahn were appointed to associate dean positions in the college.

Lesieutre, who previously served as head of the aerospace engineering department, was named associate dean for research, and Rahn, professor of mechanical engineering, became the college’s new associate dean for innovation.

They are working collaboratively with leadership within the college and in other units at the University to advance the college’s research and innovation priorities.
Jennifer Wu named director of data analysis and assessment

Jennifer Wu joined the college in June as the inaugural director of data analysis and assessment. She is responsible for collecting and managing data that will be used to assess the college’s progress toward its 2014-2019 strategic plan and to help enhance the college’s and departments’ rankings.

Priya Baboo joins college as director of industry innovation and development

Priya Baboo was named the college’s inaugural director of industry innovation and development, in August. She is primarily responsible for building and fostering strategic industry partnerships; stimulating entrepreneurial ventures; increasing graduate student internship, co-op, and full-time job opportunities; and helping secure corporate donations.

Prestigious awards recognize faculty accomplishments

Akhlesh Lakhtakia, Charles Godfrey Binder Professor in Engineering Science and Mechanics, was admitted as a Fellow of the Royal Society of Chemistry. He was also named the recipient of Sigma Xi’s 2016 Walston Chubb Award for Innovation for his theoretical and experimental innovations in electromagnetics.

Andrew Scanlon, professor emeritus of civil engineering, received the Canadian Society for Civil Engineering (CSCE) Fellow Award and his son, Mark A. Scanlon, a 2010 Penn State civil engineering alumnus, was honored with the CSCE Young Professional Achievement Award during the society’s annual awards gala on June 3 in London, Ontario.

Michael Tonks, assistant professor of mechanical and nuclear engineering, was one of two recipients of the 2015 American Nuclear Society Materials Science & Technology Division’s Special Achievement Award. The other recipient is Richard Williamson, a researcher at Idaho National Laboratory who, along with Tonks, developed the BISON-MARMOT fuel performance codes.

Kenji Uchino, professor of electrical engineering and director of the International Center for Actuators and Transducers at Penn State, received the 2016 International Ceramic Prize. The prize is awarded by the World Academy of Ceramics in Italy every four years to recognize recent important achievements in ceramics science and technology. Only 20 people internationally, have received this honor.

A record 24% of first-year women students enroll in the College of Engineering at University Park.
Several faculty have received funding from the National Science Foundation to enhance their efforts in the classroom and in the laboratory.

- **Enrique Gomez**, associate professor of chemical engineering; **Scott Milner**, William H. Joyce Chair Professor of Chemical Engineering; and **Ralph Colby**, professor of materials science and engineering and chemical engineering, received $1.2 million for a proposal which aims to identify the key polymeric properties of conjugated polymers used to develop flexible electronics.

- **Darrell Velegol**, Distinguished Professor of Chemical Engineering, and **Ayusman Sen**, Distinguished Professor of Chemistry, were awarded $388K to develop catalytic motors that can function in salty environments.

- **Hui Yang**, Harold and Inge Marcus Career Associate Professor of Industrial Engineering, is leading a team that was awarded $299K for research focused on improving health care delivery to patients who have had cardiac surgery.

- **Qian Wang**, professor of mechanical engineering; **Ted Reutzel**, head of the laser process technology department at Penn State’s Applied Research Laboratory and an affiliate faculty member in the Department of Engineering Science and Mechanics; and **Pan Michaleris**, a former professor in the Department of Mechanical and Nuclear Engineering, will use a $277K grant for research on an integrated paradigm of modeling and advanced control for additive manufacturing of critical metal components.

- **Enrique del Castillo**, Distinguished Professor of Industrial Engineering and professor of statistics, will use a $270K grant to develop statistical methods that will improve the formulation and manufacturing of drugs used to treat some of the world’s deadliest diseases.

- **Necdet Serhat Aybat**, assistant professor of industrial engineering, received $235K to design smart power grids that factor in uncertainty in energy demand and renewable energy production.

- **Guodong (Gordon) Pang**, associate professor of industrial engineering, was awarded $150K for research that aims to improve discharge predictions within intensive care units and a patient’s subsequent flow through the hospital system.

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**Three faculty appointed to interim leadership roles**

**Philip J. Morris**, Boeing/A.D. Welliver Professor of Aerospace Engineering, has been appointed interim head of the Department of Aerospace Engineering. He succeeds **George Lesieutre**, who was named the college’s associate dean for research in June.

**M. Kevin Parfitt**, professor of architectural engineering, was named interim head of the Department of Architectural Engineering. He takes over for **Chimay Anumba**, who accepted a position as dean of the University of Florida’s College of Design, Construction and Planning.

**Matthew Parkinson**, associate professor of engineering design, was appointed interim director of the Bernard M. Gordon Learning Factory. He agreed to serve in the role following the announcement that Maggie Slattery, who had been director of the facility since January 1, 2016, was named interim director and assistant dean of Penn State’s Office for General Education.
Students get second win(d) in Collegiate Wind Competition 2016

The Penn State Wind Energy Club blew away the competition at the U.S. Department of Energy Collegiate Wind Competition 2016, held at the end of May in New Orleans.

Competing against 11 teams from universities across the nation and Puerto Rico, the Penn State team, comprised of 21 students from various majors, was the competition’s overall winner, claiming its second consecutive title. The team also took first place in the Business Plan and Turbine Testing contests.

“I’m so proud of our students for winning the overall competition,” said Susan Stewart, lead strategic adviser of the team and senior research associate and assistant professor of aerospace engineering. “They worked extremely hard, and the contests they won were the ones they were gunning for.”

Chemical engineering graduate program named in honor of John and Jeanette McWhirter

Longtime supporters and advocates of the chemical engineering department, John “Jack” McWhirter (‘61 M.S. CH E, ’62 Ph.D.) and Jeanette Dachille McWhirter (‘69 SCI), (right) committed $20 million to help support the future success of the chemical engineering graduate program.

“Jack and Jeanette have been extraordinarily generous to our department, and we are delighted that our graduate program will bear their names,” said Phillip Savage, department head and Walter L. Robb Family Endowed Chair Professor of Chemical Engineering. “Their support has transformed our graduate program and enhanced the overall student experience in chemical engineering, and it will continue to do so for years to come.”
In 2014, college administrators, faculty, and staff worked together to craft a five-year strategic plan that would enable the college to strengthen and broaden its educational programs, modernize its research portfolio, and expand the faculty in emerging areas.

In addition to outlining the college’s values, vision, and mission, the plan identifies five critical institutional thrust areas that synthesize the priorities of Penn State Engineering with the priorities of the University:
When the Engineering Ambassadors put out their first call for applications in 2009, Melissa Marshall, then director of the program, realized that more students applied than she could accept. Not wanting to disappoint these talented engineering students, she approached Michael Alley, associate professor of engineering communications, to brainstorm solutions.

“At the time, I was overwhelmed with requests to teach one of my new communications courses, so I had this idea that students might be able to help out,” Alley recalled.

He tested his idea by inviting a few ambassadors to teach the course. According to Alley, they did such a phenomenal job that he established Utree (Undergraduate Teaching and Research Experiences in Engineering) in 2010.

Initially, the grassroots student organization was composed of seven engineering students who helped Alley teach his assertion-evidence approach in various technical courses.

As Utree evolved, members came up with new ways to involve even more students. One example is the Leonhard Center Speaking Contest, which challenges students to give the best 10-minute presentation that explains an engineering solution to a societal problem.

Today, the organization’s membership has nearly tripled. Besides organizing the speaking contest, Utree members present the assertion-evidence approach and teamwork skills to approximately 25 classes per semester, including sections of EDSGN 100: Introduction to Engineering Design, and junior- and senior-level design courses. They also serve as teaching interns for Communication Arts and Sciences (CAS) 100A for Engineers.

“I remember I was nervous and hated public speaking when I was in CAS 100, and now I am the one who’s teaching people,” said Stephanie Howard, chemical engineering senior and Utree student lead on class teaching.

Utree has expanded its offerings to include presentations at Penn State Hershey, the University of Pittsburgh, the University of Massachusetts Medical School, Northeastern University, and Shanghai Jiao Tong University (SJTU) in China.

In summer 2016, Utree members made a 10-day trip to SJTU to teach 50 graduate students at Shanghai School of Mechanical Engineering topics such as technical presentations, English writing, and networking.

Students who went on the trip said it was a life-changing experience.

“It helped me a lot in my teaching skills,” said mechanical engineering junior Kate Ferster. “We got to explore Shanghai with other graduate students. They are the most hospitable people I have ever met, always making sure it was the best experience for us.”
Alley, who still serves as Utree’s adviser, reflected on how far the organization has come. “In the beginning I didn’t realize the effect Utree had on students. But through the years, I’ve heard many students say their involvement has boosted their confidence,” he said.

All engineering students are welcome to apply for Utree membership after they complete CAS 100A, especially the sections that target engineering presentations.

“I remember I was nervous and hated public speaking when I was in CAS 100, and now I am the one who’s teaching people.”

— Stephanie Howard, chemical engineering senior and Utree student lead on class teaching

Bringing the real world into the classroom at the Bernard M. Gordon Learning Factory

Engineering students gain hands-on experience through industry-sponsored and client-based capstone design projects.

“The students go above and beyond the expectations of the sponsor. It truly amazes me to see the successful outcome of a student project!”

— Thomas Kapelewski, Environmental Health and Safety Manager, Sekisui Polymer Innovations, Sekisui SPI

“The Penn State students that we have worked with have had excellent technical abilities, are well prepared to manage the project, and have a passion for success. The students have a strong support network between themselves and the faculty that facilitates collaboration resulting in optimal solutions.”

— Bill Grauer, Enterprise Capability Leader, Boeing Aerodynamic, Noise, & Propulsion Labs

“I enjoy working with the students because of the energy and enthusiasm they bring to the project. Their strong desire to learn, their drive to deliver viable solutions, and their creativity reassure me that the future of engineering is in good hands.”

— James Sorokes, Principal Engineer, Research & Development, Dresser-Rand Company
In order for students to understand the complexities of the design process, it is essential to create an environment where they can practice product analysis, statistics, fidelity prototyping, and innovative design techniques.

The College of Engineering’s EDSGN 548/IE 548 Interaction Design course provides graduate students with an integrative perspective on the types of human-centered design techniques used to analyze existing consumer products and develop innovative solutions to real-world problems.

Taught by Scarlett Miller, assistant professor of engineering design and industrial engineering, the course reimagines graduate student teams as mini design firms. Miller uses a rapid-fire teaching style, allowing students to immediately apply design and analysis concepts to projects.

“Our whole goal is to develop products that are usable,” she said. “We define usability to be efficient, effective, and invoke some kind of emotion.”

During the spring 2016 semester, four teams of engineering and information sciences and technology graduate students worked on user-centered projects sponsored by Penn State faculty members:

Supported by Jason Moore, assistant professor of mechanical engineering, the dynamic haptic robotic training system project focused on developing a user-interface for a Central Venous Catheter insertion training system. The completed interface and training modules were implemented at the Penn State Milton S. Hershey Medical Center over the summer.
The team for the Penn State Operating Station, a project sponsored by the Penn State Institute for Natural Gas Research (INGaR) and spearheaded by Monty Alger, director of the INGaR and professor of chemical engineering, and Sven Bilén, head of the School of Engineering Design, Technology, and Professional Programs and professor of engineering design and electrical and aerospace engineering, focused on designing an online, real-time monitoring system to display the use of sustainable energy at the University Park campus.

The Kids About Town platform, sponsored by Meg Small, assistant director for Innovations and Social Change; director, Prevention Innovation Lab; and research associate, Bennett Pierce Prevention Research Center for the Promotion of Human Development, investigated the integration of social-emotional learning opportunities in retail spaces. The team worked to develop a mobile application based on MyPlate, the new food pyramid model, that engages children and parents.

About Face, a project supported by Frank Ritter, professor of information sciences and technology, investigated how sensors can reduce the spread of infectious disease. The team determined user needs, develop a prototype, and research patents in the infectious disease sensor space. A research and design patent is currently being pursued.

To design solutions to these problems, students learned to elicit customer wants and needs by conducting and analyzing user interviews. These are used to foster initial designs and low fidelity prototyping — a step where engineers and programmers work to fix product flaws or identify design obstacles.

Jian Chen, an engineering design graduate student, said he learned that as designers, engineers need to personally identify the problem in order to solve it.

“The interview is a very useful, powerful method to help figure out the problem,” he said.

After creating initial design concepts, teams developed medium fidelity prototypes and began usability testing. At this point, designs were taken to potential users for product effectiveness and satisfaction testing.

This feedback was used to develop a design plan for project stakeholders. Project supporters were presented with the opportunity to continue sponsoring the class or to work with Integrated Design Solutions (IDS) to bring the product to life.

Miller said it is rewarding, especially for engineering design graduate students, to work with IDS because it is almost impossible to take an idea from plan to implementation in the course of one semester.

“I think something unique we have [at Penn State] is that we are able to take these well-developed design plans and hand the idea off to IDS to implement,” she said.

These opportunities not only allow students to add to their design portfolio, but also provide them with opportunities to leave a lasting impact on the University — and potentially the world.

“We are looking into the broader scope of what is motivating us and what will have a long-term impact,” Niranjana Sundaresan, an engineering design graduate student on the operating station team, said.

To identify potential design obstacles or flaws in their user-centered projects, EDSGN/IE 548 students tested low fidelity paper prototypes via peer review. Assistant Professor Scarlett Miller (opposite page) and EDSGN/IE 548 classmates served as product testers for each team’s project. Teams used feedback from their product testers to develop medium fidelity prototypes for product effectiveness and satisfaction testing.
Time and (wind) energy well spent:
Susan Stewart talks innovating online education

By Chris Spallino

Engineering Penn State sat down with Susan Stewart, senior research associate and associate professor of aerospace engineering, to shoot the breeze about her innovative and successful teaching methods for the online graduate certificate in Wind Energy.

Engineering Penn State: Obviously, teaching online classes is different than standing in front of a classroom of students. What’s the biggest difference for you?

Susan Stewart: The interaction takes a different form. With online courses, you generally don’t have the opportunity to have live, in-person conversations with your students as you would in a classroom.

EPS: So you lose an important part of the educational process?

SS: I’ve found it’s quite the opposite and is more of an active learning environment that many students seem to prefer and benefit from. Sitting in a lecture, you have one shot at taking in the information. You can get lost quickly and find it hard to catch up. With the online learning format I use, students can review content as many times as they need and pace themselves in a way that adapts to their own learning style.

EPS: How is your format different than a live lecture or one that is recorded and viewed or streamed live?

SS: My goal has always been to provide a highly interactive learning environment that integrates multiple components. From anticipatory questions that get them thinking before they get into the main content, to equations they have to solve, screencast demonstrations, and short YouTube videos, I try and motivate the students to want to understand how to do things themselves versus me telling them how or giving them step-by-step solutions. Thus, the students should be active participants in the lessons.

EPS: With an online course, students aren’t able to have face-to-face interactions. Do you provide any way for them to engage with each other?

SS: I do, because I believe they can learn from each other as much as they can learn from me or any instructor. I incorporate discussion forums into the program, and it has become one of the most important elements. During the forum, I may post a question or ask them to find and summarize an article, but then I require them to respond to each other. Sometimes there are also assignments which require discussion in terms of making appropriate assumptions about how to approach the problem. These assignments are structured intentionally to encourage students to communicate with each other. It’s no different than what happens in the working world—you’re not always the expert or have the answer, so you have to dig for it.

EPS: Do you incorporate any “real world” elements into the courses?

SS: More recently, I integrated several industry-derived case studies to provide more project-based learning and give students the opportunity to interact with wind industry personnel. Using Adobe Connect, I set up webinars with company representatives that allowed the students to discuss how to handle real-world scenarios that were relevant to their assignments. It taught them how to use their own professional judgment in approaching problems.

EPS: What does the future of this program look like? Will you add any new components?

SS: The wind energy industry is constantly evolving, so it’s important to me to keep the material fresh and relevant. We get students from diverse backgrounds, so having more content variety, especially with the case studies and demonstration videos will be a priority. I also think there is the potential to collaborate with other universities that are part of the North American Wind Energy Academy to offer additional courses or content.

Read about Stewart’s success with her students in the Collegiate Wind Competition on page 8
Leading the way in security and networking research at Penn State

During its 13-year history, the Institute for Networking and Security Research (INSR), formerly the Networking and Security Center until 2013, has been incredibly successful.

Created in 2003 by Thomas La Porta, Evan Pugh Professor, William E. Leonhard Chair and Director of the School of Electrical Engineering and Computer Science (EECS), INSR has become the focal point of security and networking research at Penn State. Now directed by Patrick McDaniel, Distinguished Professor of Computer Science and Engineering in EECS, the institute is made up of world-renowned researchers who are leading the nation’s highest priority research efforts in security and network science. >>

Graduate students in the School of Electrical Engineering and Computer Science work on security solutions in the INSR lab. By Rebekka Coakley

Nicolas Papernot explains machine-learning and solutions to the vulnerabilities as shown through his work with Ian Goodfellow on Cleverhans

Read more about their collaboration with Elon Musk’s OpenAI tool to prevent hacking.

Optimal and Secure Cyberenvironments
“Over the last 13 years INSR has evolved with the increasing impact of networking and security on the technical sector and public at large,” McDaniel said. “These changes have allowed the faculty and students to pursue a vast array of topics from sensing to smartphones, and even the security of presidential elections.”

Members of INSR actively consult with industry partners like Microsoft, Google, and IBM, and participate as partners on funded projects. Since 2006, the team has been awarded more than $27 million in new funding from leading science and technology agencies such as the National Science Foundation, the Defense Advanced Research Projects Agency, Army Research Laboratory, Air Force Research Laboratory, and Defense Threat Reduction Agency.

“I hope that the coming years allow us to expand that broad agenda to other areas, and to extend our effort beyond the College of Engineering,” McDaniel said. “This will allow us to foster interdisciplinary research that will inform and guide industry and society at large.”

INSR’s research is extensive, covering internet security, policy, secure operating systems, secure programming languages, access controls, mobile networking, protocol design, performance analysis and simulation, wireless communication, networked applications, and large networking software systems.

“I see the next step in INSR as building further bridges to other colleges and institutions, and to expand the scope and impact of our research,” McDaniel said. “In this way, we can shape future systems and technologies and inform the society that uses them.”

From Tom La Porta, director of the School of EECS:

1. What are cyberenvironments?
2. What subjects are being studied in the School of EECS?
3. What aspects of security are the focus of research in the School of EECS?
As a graduate student researching cryptography, Adam Smith (above) wanted to study problems that required new theoretical insights, but whose solutions would actually affect people’s lives in a positive way. The issue of privacy and data collecting particularly piqued his interest.

“The phrase ‘big data’ wasn’t around yet, but it was a thing and it was becoming clear that if technology didn’t think carefully about this, we would get to a stage where data would be shared widely without regards to privacy,” said Smith, professor of computer science and engineering in the School of Electrical Engineering and Computer Science (EECS). “I wanted to help find a way to get the benefits of this data without the cost to privacy.”

In 2006, Smith co-wrote a paper that was a major breakthrough in privacy protection for companies like Google, Apple, and the U.S. Census Bureau. The paper introduced the world to differential privacy and provided a solid mathematical foundation for a vast body of subsequent work on private data analysis.

“The term [differential privacy] refers to a class of techniques, many of which were developed at Penn State, that will help organizations aggregate information about users’ behavior while ensuring that the raw information is never collected or stored,” Smith said.

Smith’s work started a large and growing area of research on algorithms for analyzing a sensitive data set while preserving the privacy of the individuals whose data it contains.

“The work we are now doing at Penn State will help organizations aggregate information about consumer behavior while ensuring that the raw information is never collected or stored by the company,” Smith said.

In addition to Smith, other researchers in Smith’s group at Penn State, including computer science and engineering associate professors Sofya Raskhodnikova and Dan Kifer in the School of EECS and statistics professor Aleksandra Slavkovic in the Penn State Eberly College of Science, are doing research in this area.

In 2013 and 2015 Google awarded Penn State researchers two grants, one to Kifer and one to Smith and Vitaly Shmatikov at Cornell, to investigate what deep learning systems can leak about sensitive inputs, as well as to develop a system for privacy-preserving deep learning.

Smith said some of this is funding differential privacy research that investigates false discovery, addressing the problem where some scientific findings seem valid but cannot be reproduced. There’s an assumption that the more privacy is implemented into the data, the less valuable it is, but Smith said algorithms can be used to adjust to the noise distraction, which would allow privacy to make the data more useful.

Kifer’s research, with help from the grant, focuses on making sure bugs cannot get into the software that companies are using to decipher big data. He is on sabbatical this semester helping the U.S. Census Bureau implement this and disclosure control. This area of research requires him to write a program that respects the constraints the agency needs when looking at data on various populations, but also makes sure the information being released is differentially private.
3D printing produces cartilage from strands of bioink

By A’ndrea Elyse Messer

Strands of cow cartilage substitute for ink in a 3D bioprinting process that may one day create cartilage patches for worn out joints, according to a team of engineers.

“Our goal is to create tissue that can be used to replace large amounts of worn out tissue or design patches,” said Ibrahim T. Ozbolat, associate professor of engineering science and mechanics. “Those who have osteoarthritis in their joints suffer a lot. We need a new alternative treatment for this.”

Cartilage is a good tissue to target for scale-up bioprinting because it is made up of only one cell type and has no blood vessels within the tissue. It is also a tissue that cannot repair itself. Once cartilage is damaged, it remains damaged.

Previous attempts at growing cartilage began with cells embedded in a hydrogel — a substance composed of polymer chains and about 90 percent water — that is used as a scaffold to grow the tissue.

“Hydrogels don’t allow cells to grow as normal,” said Ozbolat, who is also a member of the Penn State Huck Institutes of the Life Sciences. “The hydrogel confines the cells and doesn’t allow them to communicate as they do in native tissues.”

This leads to tissues that do not have sufficient mechanical integrity. Degradation of the hydrogel also can produce toxic compounds that are detrimental to cell growth.

Ozbolat and his research team developed a method to produce larger scale tissues without using a scaffold. They create a tiny — from 3 to 5 one hundredths of an inch in diameter — tube made of alginate, an algae extract. They inject cartilage cells into the tube and allow them to grow for about a week and adhere to each other. Because cells do not stick to alginate, they can remove the tube and are left with a strand of cartilage.

The researchers reported their results in the current issue of Scientific Reports.

The cartilage strand substitutes for ink in the 3D printing process. Using a specially designed prototype nozzle that can hold and feed the cartilage strand, the 3D printer lays down rows of cartilage strands in any pattern the researchers choose. After about half an hour, the cartilage patch self-adheres enough to move to a petri dish. The researchers put the patch in nutrient media to allow it to further integrate into a single piece of tissue. Eventually the strands fully attach and fuse together.
“We can manufacture the strands in any length we want,” said Ozbolat. “Because there is no scaffolding, the process of printing the cartilage is scalable, so the patches can be made bigger as well. We can mimic real articular cartilage by printing strands vertically and then horizontally to mimic the natural architecture.”

The artificial cartilage produced by the team is very similar to native cow cartilage. However, the mechanical properties are inferior to those of natural cartilage, but better than the cartilage that is made using hydrogel scaffolding. Natural cartilage forms with pressure from the joints, and Ozbolat thinks that mechanical pressure on the artificial cartilage will improve the mechanical properties.

If this process is eventually applied to human cartilage, each individual treated would probably have to supply their own source material to avoid tissue rejection. The source could be existing cartilage or stem cells differentiated into cartilage cells.

Also working on this project were Yin Yu, recent Ph.D. from the University of Iowa now at Harvard University; Kazim K. Moncal, graduate student in engineering science and mechanics and member of the Huck Institutes, Penn State; Weijie Peng, visiting scholar in engineering science and mechanics, Penn State; Iris Rivero, associate professor of industrial manufacturing and systems engineering and Jianqiang Li, former student, Iowa State University; and James A. Martin, associate professor of orthopaedics and rehabilitation, the University of Iowa.

The National Science Foundation, Grow Iowa Values Fund, and the China Scholarship Fund supported this work.

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TRANSFORMING WEARABLE TECH
Platforms aim to protect devices, provide consumer comfort

By Stefanie Tomlinson

By 2020, the wearable market will be worth $34 billion, according to industry analyst firm CCS Insight.

As the wearable tech industry booms, Huanyu (Larry) Cheng, assistant professor of engineering science and mechanics, and his team are developing a platform that will help ensure these devices are durable and robust.

“The challenge of linking electronics and the human body is that the forms are dramatically different, said Cheng. “Human tissue is soft and flexible while electronics are rigid, so we need to think about how to combine these together.”

Cheng’s team addressed this challenge by figuring out a way to make their platform stretchable.

“Basically, we put a thin layer of silicon on top of a pre-stretched rubber band. When we release the tension, the rubber band goes back to its original shape however the silicon becomes wavy, like a spring,” explained Cheng.

Alternatively, the silicon is cut into small pieces — about the size of several hundred microns — that are then connected together by wavy metal interconnects. Once this design platform is applied to a device, the device is more flexible, and thus hopefully more comfortable, for the consumer. >>
Another important consideration for the team as they develop their platform is mechanical robustness. “We don’t want the device itself to be easily damaged or break, but at the same time we want to make sure our platform can be used in a variety of situations,” said Cheng.

In order to enhance the device’s durability, a wavy fiber is included in their platform. “As the wavy fiber is stretched straight, it gets stiffer and more difficult to stretch. This property will help the device resist potential damage,” said Cheng.

In order to enhance the device’s durability, a wavy fiber is included in their platform.

Since their platform is still in early phases of development, Cheng and his team plan to start simple. “At first, our platform may be used for temperature sensors or biopotential monitors for the heart. The measurements taken by these devices are very useful for diagnosing diseases and delivering treatment,” said Cheng.

Nevertheless, he doesn’t rule out the possibility of someday working on a platform for devices that will allow human-to-machine interaction.

“For example, we have designed a platform for a wearable device that allows the user, via muscle movement, to send a signal to a helicopter that can control its takeoff, rotation, flying forward, and landing,” he said.

In fact, Cheng predicts that someday, wearable devices might be as sizable and functional as the attire worn by a favorite DC Comics superhero. “Right now we’re focused on sensors, which monitor a variety of signals, but the actuators we use may provide the same capabilities as Superman’s suit,” Cheng said.

Cheng’s research is funded by the American Society of Mechanical Engineers and Penn State’s College of Engineering. Larry Cheng joined Penn State’s College of Engineering in August 2015. He and his team are building upon a product that he developed with funding that his previous teams received from the Defense Advanced Research Projects Agency, the National Science Foundation, and the National Institutes of Health while he was a Research Fellow at Northwestern University and a Visiting Research Fellow at the University of Illinois at Urbana-Champaign.
Advancing medical aid for wounded soldiers

Biofoam pad shows potential to improve trauma care

By Stefanie Tomlinson

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Shortly after the September 11 attacks, Scott Armen made the decision to join the United States Army Reserve. Since then, he has been deployed multiple times as an Army trauma surgeon. Because of Dr. Armen’s experiences as a citizen soldier, and his role as Chief of the Division of Trauma, Acute Care and Critical Care Surgery at the Penn State Milton S. Hershey Medical Center, he knows firsthand the importance of improving surgical combat care.

Armen is working collaboratively with Melissa Linskey, surgical resident at the Penn State Hershey Medical Center, and Jeffrey Catchmark, professor of agricultural and biological engineering, to develop a biofoam pad for wound and trauma care.

The pad, which closely resembles cotton, is compressed and then inserted directly into a wound. Once inside, the resilient material expands back to its original shape and fills the void. Within seconds, the area is stabilized and the bleeding stops.

“The pad we have developed absorbs blood and other body fluids, so it swells and conforms to the pattern of the wound, which provides compressibility that helps in hemorrhage control in the clotting agent as well as the compressibility of the material,” explained Armen.

Catchmark said the pad is safe to remain inside the body because it is made of starch and chitosan, which are both natural food products.

“Our bodies’ cells produce enzymes which digest starch, degrading it to sugar which is then metabolized by the body,” he explained.

In addition to providing hemorrhage control inside of a wound, the pad can also effectively stop bleeding when applied to a wound’s surface. 

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Advancing medical aid for wounded soldiers (cont.)

“Many competing products are made from cellulose or cellulose derivatives. So, for example, if you put cellulose gauze on a cut and leave it on long enough, the tissue will start to grow into the gauze, causing tissue damage when the gauze is removed,” said Catchmark. “Our pad degrades as the cells grow and the pad eventually turns into a harmless gel, because it essentially becomes sugar and solution.”

Armen said there is also potential to inject an antibiotic into the pad, which would be ideal if the pad was to be left in or on a wound for an extended period of time.

Linskey has been conducting preliminary tests of Catchmark’s biofoam pad in her lab, comparing it with standard materials used in prehospital and battlefield settings.

“Dr. Catchmark’s pad showed a significant improvement in amount of blood loss and survival time,” she said.

This is positive news for Armen, who said his “ultimate goal is to use this pad in a variety of applications around the world on wounded American soldiers, to potentially help save more lives.”

The trio’s research has been funded by TechCelerator@StateCollege and a RAIN grant from the College of Agricultural Sciences Entrepreneurship and Innovation Program. A patent is pending for the biofoam pad.

Self-healing textiles not only repair themselves, but can neutralize chemicals

By A’ndrea Elyse Messer

Someday, chemically protective suits made of fabric coated in self-healing, thin films may prevent farmers from exposure to organophosphate pesticides, soldiers from chemical or biological attacks in the field, and factory workers from accidental releases of toxic materials, according to a team of researchers.

“Fashion designers use natural fibers made of proteins like wool or silk that are expensive and they are not self-healing,” said Melik C. Demirel, professor of engineering science and mechanics. “We were looking for a way to make fabrics self-healing using conventional textiles. So we came up with this coating technology.”

The procedure is simple. The material to be coated is dipped in a series of liquids to create layers of material to form a self-healing, polyelectrolyte layer-by-layer coating.

This coating is deposited “under ambient conditions in safe solvents, such as water, at low cost using simple equipment amenable to scale-up,” the researchers reported online in ACS Applied Materials & Interfaces.

Polyelectrolyte coatings are made up of positively and negatively charged polymers, in this case polymers like those in squid ring teeth proteins.
“We currently dip the whole garment to create the advanced material,” said Demirel, who is also a member of the Huck Institutes of the Life Sciences. “But we could do the threads first, before manufacturing if we wanted to.”

During the layering, enzymes can be incorporated into the coating. The researchers used urease — the enzyme that breaks urea into ammonia and carbon dioxide — but in commercial use, the coating would be tailored with enzymes matched to the chemical being targeted.

“If you need to use enzymes for biological or chemical effects, you can have an encapsulated enzyme with self-healing properties degrade the toxin before it reaches the skin,” said Demirel.

Many toxic substances can be absorbed through the skin. Organophosphates, for example, which are used as herbicides and insecticides are absorbed through the skin and can be lethal. Some of these chemicals have also been used as nerve agents. A garment coated with a self-healing film containing an organophosphate hydrolase, an enzyme that breaks down the toxic material, could limit exposure. The squid ring teeth polymer is self-healing in the presence of water, so laundering would repair micro and macro defects in the coating, making the garments rewearable and reusable.

“The coatings are thin, less than a micron, so they wouldn’t be noticed in everyday wear,” said Demirel. “Even thin, they increase the overall strength of the material.”

For manufacturing environments where hazardous chemicals are necessary, clothing coated with the proper enzyme combination could protect against accidental chemical releases. Future use of these coatings in medical meshes could also help patients minimize infections for quick recovery.

“For the first time we are making self-healing textiles,” said Demirel.

Also working on this project from Penn State were Srinivas Tadigadapa, professor of electrical engineering and affiliate of the Materials Research Institute; David Gaddes, graduate student in bioengineering; and Huihun Jung and Abdon Pena-Francesch, graduate students in engineering science and mechanics.

Outside the university, Genevieve Dion, assistant professor and director, Shima Seiki Haute Technology Lab, Drexel University; and Walter J. Dressick, U.S. Naval Research Laboratory, Washington, D.C. also worked on the project.

The Army Research Office and the Office of Naval Research supported this work.

“We were looking for a way to make fabrics self-healing using conventional textiles. So we came up with this coating technology.”

— Melik Demirel, professor of engineering science and mechanics
Every day, millions of Pennsylvania motorists drive on or under one of the commonwealth’s more than 22,000 bridges without ever thinking about its safety and durability. Researchers at Penn State, in collaboration with the Pennsylvania Department of Transportation (PennDOT), however, are thinking about it and are trying to improve the bridges in the process.

Aleksandra Radlińska, assistant professor of civil engineering, along with associate professors Farshad Rajabipour and Gordon Warn, recently conducted a study to identify the key factors that contribute to premature cracking in concrete bridge decks. The team also assessed the effects of the cracks on the long-term durability of the bridges.

“When the current infrastructure was built in the 1950s under President Eisenhower, it was built for current times and traffic demands, with little focus on maintenance,” Radlińska said. “Few, if any, expected the number of vehicles in the nation to increase by 300 percent and the nation’s population to increase by 91 percent.”

The result is an aging infrastructure in need of major repair. According to the Federal Highway Administration’s 2015 National Bridge Inventory, of the 22,783 bridges in Pennsylvania, 21 percent are classified as structurally deficient and another 19 percent are classified as functionally obsolete. The estimated cost to repair those bridges numbers in the billions.

One of the primary causes of early bridge deterioration is the premature cracking of the bridge deck. These cracks significantly decrease the durability and service life of the bridge and enable chlorides and moisture to penetrate into the concrete leading to accelerated corrosion of the steel reinforcement.

Until now, only a limited amount of information has been available as to how premature cracking truly affects long-term performance of bridge decks. In order to improve
In total, 203 Pennsylvania bridge decks were evaluated to identify the main factors that contribute to early-age cracking and to assess the effects of cracks on the long-term durability of bridge decks.

The study, recently published in the Transportation Research Record Journal, determined that higher concrete strength was associated with higher deck crack density; lower total cement-based materials and higher Portland cement replacement with supplementary materials resulted in less cracking; decks constructed with half-width procedures cracked four times more than decks constructed with full-width procedures; and epoxy-coated rebar was effective in resisting corrosion, even in cracked concrete and at the location of cracks.

Additionally, the researchers were able to create a deck performance database to enable a more extensive and detailed data collection process and better monitoring of Pennsylvania bridge decks over time.

“One of the project tasks was focused on creating a database for PennDOT to record all the relevant bridge deck information in one central location and have it available for ongoing and future research needs,” Radlińska said. “The database will store key information related to bridge design and construction, including the type of bridge, along with the support, span, length, and traffic pattern during its construction.”

The database will also allow the development of detailed deterioration models that will help predict the future performance and service lives of concrete bridge decks and improve the maintenance costs over their lifespans.

“There is no one solution to fix it all,” Radlińska said. “Every bridge is different, so we have a lot of data points that connect to specific models which will allow PennDOT to determine the best remediation strategies for these deteriorated bridges.”

Additional researchers in this study included graduate students Travis Hopper and Amir Manafpour and collaborators Parisa Shokouhi, associate professor of civil engineering, and Ilgin Guler, assistant professor of civil engineering. Partners included Quality Engineering Solutions’ Dennis Morian, director of engineering, and Shervin Jahangirnejad, senior project manager. Technical advising was provided by Robert Watral of PennDOT.

The Pennsylvania Department of Transportation funded this work.
Shutting down a bridge for repair can be extremely expensive and time consuming, and disruptive and frustrating for the public. It’s also labor-intensive and usually involves heavy equipment.

Researchers at Penn State are now gaining more insight into a more efficient and effective reinforcement solution that is gaining greater acceptance for strengthening, rehabilitating, retrofitting, and repairing reinforced concrete structures in civil infrastructure applications such as bridges and buildings—bonded fiber-reinforced polymer (FRP) reinforcement systems.

For more than 20 years, Charles E. Bakis, Distinguished Professor of Engineering Science and Mechanics, along with Thomas E. Boothby, professor of architectural engineering, has been investigating the long-term performance of bonded FRP systems that incorporate highly oriented carbon fibers and epoxy polymers that, when bonded to concrete, provide structural reinforcement eight times greater than steel reinforcements on a unit weight basis.

Dry carbon fibers have exceptional strength-to-weight and stiffness-to-weight ratio, making them extraordinarily strong; however, they lack the ability to adhere to each other. Epoxies, on the other hand, do not have great strength but can provide a matrix of “glue” to hold the carbon fibers together and bond them to concrete.

To conduct the research, Bakis first applies these materials in layers to plain concrete beams to form a composite material—applying an epoxy primer that soaks into the concrete’s pores, an epoxy “putty” that fills in holes and levels the surface, and aligned carbon fiber sheets saturated with a third type of epoxy. All of this is done in much the same way paint is applied. He then bends the beams to form cracks in the concrete and to get the load into the composite, where it acts as the only tensile reinforcement for the beam.

By placing the entire specimen under sustained bending load and various environmental conditions for several years, he is able to evaluate how the degree of cure of the epoxies and the bond strength between the FRP and concrete vary over time.

“Despite the increased popularity of bonded FRP reinforcement systems, data on their long-term bond and tensile behavior has been scarce,” said Bakis. “What we’ve found after seven years of loading under aggressive indoor and outdoor conditions is that the bond strength holds up amazingly well, and the composite materials prevented cracks from growing. There was also very little change in bond behavior in either environment.”

With rapid installation time, carbon FRP reinforcement systems can now provide bridge and building owners a quick, low-labor, cost-effective, and easy method for repairing and rehabbing degraded or damaged bridges and buildings. They also allow the structures to recover their original strength and margin of safety they lost, and even handle higher loads than originally designed for.

Bakis said bonded FRP reinforcement systems won’t ever replace steel rebars in concrete beams as the primary source of tension support. But, if there is a need to quickly and safely strengthen a bridge or retrofit and change the use of a building to handle greater loads, they are the preferred method.

By Chris Spallino

At any point in time, a bridge can have hundreds of cracks in its concrete beams. These are expected and don’t pose a risk to the bridge’s structural integrity or public safety. However, if there is significant damage due to environmental degradation or external forces, safety becomes a major concern and repairs become necessary.

Above: Charles Bakis, Distinguished Professor of Engineering Science and Mechanics, along with Jeffrey J. Kim, undergraduate student, inspect the FRP system on a concrete beam.
For the past three years, Barbara Shaw, professor of engineering science and mechanics (ESM), and several groups of undergraduate and graduate students from her corrosion classes have been monitoring the corrosion of an underground gas pipeline outside the Earth and Engineering Sciences Building.

What they found wasn’t good — but something good would come out of it.

The students determined that the pipeline’s cathodic protection system had degraded to the point where it no longer offered the required level of corrosion protection. After alerting Penn State’s Office of Physical Plant (OPP), OPP hired a commercial contractor, and accompanied by the students, conducted an official inspection which corroborated the initial testing results by Shaw’s groups.

What Shaw saw in this collaboration between industry and academia was a huge opportunity.

“It was a valuable, real-world learning experience for the students to observe the contractor conducting a certified inspection that validated their monitoring efforts. It was also a great opportunity for them to actively participate,” said Shaw. “It made me realize we have an opportunity to do something that’s never been done at an academic institution — establish a state-of-the-art pipeline ‘living laboratory’ for research, education, workforce development, and STEM outreach.”

The vision for a living lab at Penn State is to establish the University as a worldwide leader in pipeline structural health monitoring by introducing project-based learning that will link research and education with operational experience and streamline the technology transition from the laboratory to the field.

The installation of a test bed facility would incorporate an operational gas pipeline, as well as additional buried pipes with the unique ability to seed defects on them and alter the corrosivity of the environment. The test bed would enable the collection of valuable, unprecedented data for both research into new and improved methods for identifying pipeline degradation and improvements in protection methods. It would also serve as a valuable training resource to students at all levels.

With an estimated asset replacement cost of $1.1 million per mile of pipeline*, the need for maintaining pipeline infrastructure integrity is increasing exponentially. And the demand for qualified pipeline monitoring personnel continues to grow. Through collaboration with the National Association of Corrosion Engineers, the lab would also provide a unique training facility for utility pipeline engineers and inspectors to obtain corrosion certification.

The ESM department will also explore a partnership with the ASM Materials Education Foundation to provide materials camps for teachers to provide tools and training for inspiring high school students’ interest in science, technology, engineering, and math.

*According to a recent Det Norske Veritas report on the state of pipeline infrastructure.
Aerospace engineering researchers are going to new heights to improve the intelligence and autonomy of robotic aircraft to enable new science, military, and civil missions.

By Chris Spallino

Look, up in the sky! It’s a bird, it’s a plane…no, it’s an unmanned aerial vehicle (UAV)! And it’s starting to have a mind of its own, and an ethical one at that. At least that’s what Jack Langelaan, associate professor of aerospace engineering, and Alan Wagner, assistant professor of aerospace engineering, are working toward.

There’s no denying UAVs have soared in popularity and interest as of late, and they’ve seen unprecedented growth in their role with the military and governmental agencies. But what if they could do more—with less human intervention and more intelligence?

A bird’s eye view

Soaring birds employ flight strategies and techniques that make use of atmospheric conditions, such as thermal updrafts, to harvest energy and sustain flight. It’s energetically less expensive than flapping and enables long migrations (Golden Eagles migrate using the updrafts found along the slopes of the Appalachian Mountains). These birds have evolved flight strategies that help them overcome the aerodynamic limitations imposed by flight physics.

By mimicking the knowledge and actions of these animals through advanced autonomous soaring systems that can search for, locate, map, and exploit thermals, Langelaan and his research group have seen significant improvements in both the range and endurance of small robotic aircraft.

Recent test flights conducted at Aberdeen Proving Ground demonstrated fully autonomous flights of several hours in duration, with the motor only running for a few minutes during the flight.

“With the goal of long endurance at low altitudes, the system extends flight times and missions far beyond what is possible with stored energy, such as batteries,” said Langelaan. “We can now take an aerial vehicle that would fly for 45 minutes and keep it aloft for as long as the weather cooperates by exploiting energy from the environment.”

Such a sophisticated system might also help you trust your local meteorologist, too. More intelligent UAVs could sample the atmosphere over a longer period of time and aid meteorology research by collecting more, and more accurate, temperature, pressure, and relative humidity data to improve weather models and forecasting. Equipped with a camera, the systems could also be used to conduct more extensive ground surveys for mapping services.

Flying in formation

Langelaan is also investigating using teams (or flocks) of autonomous multi-rotor UAVs to cooperatively carry heavy payloads.

“Using several smaller, less-expensive vehicles that can cooperate is more cost effective than building a heavy-lift vehicle,” said Langelaan. “A properly configured system of cooperating vehicles should also be more resilient to failures.”
Decisions, decisions, decisions

As robotic aircraft gain more autonomy, what decisions and actions humans should allow UAVs to make becomes increasingly important.

“If we offload more of what used to be a human’s job in operating a robotic aircraft, how we interact with the vehicle has to change dramatically,” said Wagner, who works in conjunction with the Penn State Rock Ethics Institute on the ethical dimensions of human-robot socialization and its applications to interactions between pilots and UAVs.

Safety will also be a major concern as UAVs gain more autonomy.

“If you’re carrying loads with UAVs, you don’t want to drop them on the people below or have them run into each other,” said Wagner. “You want to operate them in a way that safety, as well as the perception of safety, covers people and property on the ground and all the other vehicles in the air.”

The surface is just being scratched when it comes to autonomous UAVs and their practical applications, whether it’s using them for search and rescue missions, landing on a ship deck, or inspecting infrastructure. One thing is for certain, though, the sky is the limit.
The use of Cyber-Physical Systems (CPS) will allow for monitoring and assessing the safety of temporary structures used on construction sites, according to research being completed in Penn State’s Department of Architectural Engineering.

The National Science Foundation defines CPS as engineered systems that are built from, and depend on, the seamless integration of computational algorithms and physical components. The agency believes CPS will enable advancements in capability, adaptability, scalability, resiliency, safety, security, and usability in embedded systems being a driving force behind continued innovation and competition in industries such as agriculture, energy, transportation, building design, healthcare, and manufacturing.

While the implementation of CPS in the manufacturing, transportation, and healthcare industries has occurred, its benefits to the construction industry are still being explored.

A study completed by Xiao Yuan, an architectural engineering Ph.D. candidate, focuses on enhancing the monitoring of temporary structures through the use of CPS. It investigates how linking sensors to structures and virtual models can better ensure the safety of the more than 75 percent of construction workers who work on or around temporary structures.

Yuan’s research investigates how CPS can be used to promote safer construction and prevent failures of temporary structures through the use of CPS. It investigates how linking sensors to structures and virtual models can better ensure the safety of the more than 75 percent of construction workers who work on or around temporary structures.

This allows for real-time inspections, remote interaction, early warnings of potential failures, and immediate notification to workers through a mobile application available on the mobile platform.

“The once there is a problem, our virtual model will know,” Yuan said. “It’s just like when we feel something if it hurts — the virtual model will feel if there is a problem.”

The bidirectional workflow of the CPS allows for sensors located on the temporary structures to collect and send data to LabVIEW, the selected data acquisition system, where information on the temporary structure is processed and sent on to the cloud database. Queries every two seconds monitor the structural performance based on predefined values. If no potential safety concern or failure is found, this system monitoring will continue without changes.

If a potential failure is discovered, the hazardous section will be highlighted in the 3D virtual model. Warning notifications and detailed structural deficiencies are sent from the virtual model to the mobile devices used by on-site construction workers, safety inspectors, and project managers. These industry professionals are able to use the virtually delivered information to address any structural failure and preventing injuries or fatalities due to structural deficiencies.

Five different failure scenarios were simulated in the architectural engineering labs in Engineering Unit A on the University Park campus. They include: base settlement of scaffolding system, overloading, severe displacement of scaffolding planks, diagonal brace missing or not in the correct position, and lateral load to the scaffolding system by wind or after being hit by a vehicle.

Yuan said in addition to continuously monitoring the structures and detecting possible failures, the CPS research includes interpreting the system as an “intelligent” virtual model. The investigation is using machine learning technology to develop a self-learning model based on big data analysis.

Now that the concept of the CPS temporary monitoring system has been proven, Yuan said the next step in the research project is to better determine job site costs and installation factors.

Chimay Anumba, former department head and professor of architectural engineering, and M. Kevin Parfitt, interim head and professor of architectural engineering, served as supervisors on the project.
Arthur Motta, chair of the nuclear engineering program, said the Global Nuclear Power Safety (GNPS) Center was established at an ideal time. “We’re really excited about the center because nuclear power in this country has not been developing at the pace that we would like it to, but nuclear power abroad, especially in China, is going very strong,” he said.

Nuclear power is picking up steam in other countries, explained Motta, because it does not emit greenhouse gases and it is able to produce power on a consistent, reliable basis.

The GNPS Center includes groups of faculty who specialize in the various topic areas of interest to nuclear safety, including nuclear fuel and materials, advanced instrumentation and control, innovative cooling enhancement, experimental support, system code development, and education and training.

The center is directed by Fan-Bill Cheung, George L. Guillet Professor of Mechanical and Nuclear Engineering, who has more than four decades of experience in nuclear power research and development, including more than 10 years at Argonne National Laboratory and 30 years at Penn State.

Cheung will coordinate the efforts among the center’s group leaders and faculty members to take advantage of challenges and opportunities in the global nuclear realm. “One advantage of being at Penn State for more than 30 years is that I have learned the capabilities and expertise of the faculty, not only in the college but across other units at the University,” he said. “My responsibility is to leverage their expertise to maximize our efforts at the center.”

Cheung will also explore U.S. and international communities to assess their nuclear research and development needs. He said faculty involved with the center are already working to help ensure that a new high-power reactor being built in China will operate safely and efficiently. “We would like to work with other countries that are developing nuclear power to provide assistance in creating their programs, as well as to ensure that they are generating nuclear power safely and economically,” said Cheung.

The GNPS Center was established in early June, with a kick-off meeting held on June 23. The event was attended by representatives from the U.S. Nuclear Regulatory Commission (NRC), the State Nuclear Power Technology Research & Development Center, and the Shanghai Nuclear Engineering Research & Design Institute, who toured various Penn State research facilities.

The center includes faculty from the College of Engineering, the College of Information Sciences and Technology, the Applied Research Laboratory, the Materials Research Institute, and the Departments of Math and Materials Science and Engineering. The center leverages existing research efforts funded by the NRC, Department of Energy, the Navy, the Electric Power Research Institute, Bettis Atomic Power Laboratory, Sandia National Laboratory, Korea Hydro & Nuclear Power, and UJV Rez, a nuclear research institute in the Czech Republic, in order to enhance future efforts that will be conducted as part of the center.

“We are committing resources to this global effort to help other countries and to use our abilities and expertise to help nuclear power develop around the world. The Global Nuclear Power Safety Center is set to position the college and the University as a pioneer in helping to address global nuclear power safety concerns,” said Motta.
For many college students summer is a time for relaxation, part-time jobs, and internship experiences, but for chemical engineering senior, **Adam Uliana**, the summer of 2016 was filled with international travel ventures and research studies aimed to advance water purification techniques around the globe.

Uliana spent his spring and summer months as a participant in EuroScholars, a program designed to provide motivated undergraduate students from the United States and Canada with international research opportunities. As a EuroScholar, Uliana spent several months at KU Leuven in Leuven, Belgium, where he worked with students and researchers from around the world to discover new water treatment methods aimed to protect the environment against emerging chemical containments.

“I never thought that studying abroad would be something I would do. It seemed a little out of my comfort zone — but I am so glad that I did,” said Uliana. “As an aspiring chemical engineer, I feel the need and desire to help protect our environment. There is often a misconception that individuals in the chemical industry only contribute to the world’s mounting pollution challenges rather than offering solutions to solve them. My personal goal is to correct those mistakes and change the conversation.”

At KU Leuven, Uliana collaborated with nearly 20 researchers hailing from virtually every continent. He conducted research aimed to innovate new membranes using nanomaterials to enhance water purification. Throughout the summer, his work was highly revered, being published in multiple scholarly journals.

As if the experience at KU Leuven was not remarkable enough for the young researcher, Uliana was presented with a second research opportunity in May. With a grant provided by the Materials Research Institute at Penn State, Uliana and several Penn State researchers were afforded the opportunity to travel to Kigali, Rwanda, to investigate new methods of sanitizing wastewater.

Uliana, along with **Stephanie Butler Velegol**, undergraduate program coordinator for civil and environmental engineering and instructor in environmental engineering; **Mike Erdman**, Walter L. Robb Director of Engineering Leadership Development and instructor in engineering science and mechanics; and **Emma Clement**, undergraduate researcher in civil engineering, spent one week in the African city flocculating solid contaminants in wastewater to create sanitized water and produce new fuel sources.

“Our research work in Rwanda was a very eye-opening experience. They didn’t have clean running water available so the work processes were much different than what I was used to. It made me realize how privileged we are in that regard,” said Uliana.

Before heading back to Happy Valley to begin his senior year, Uliana was able to enjoy some personal travel time as well. He visited over half a dozen European countries and spent time hiking, sightseeing, and enjoying new experiences — a phenomenal opportunity for the young researcher who revealed that he had never traveled outside of the United States before.

Committed to expanding his research mission, Ulia has plans to earn a Ph.D. and continue his work in water purification and environmental remediation, preferably in a research or academic setting. He is hopeful that he will stay in contact with his international peers and collaborators and one day return to the sites that have inspired his career path.
Necdet Serhat Aybat has received $235,852 in funding from the National Science Foundation to design smart power grids that factor in uncertainty in energy demand and renewable energy production.

Aybat, an assistant professor of industrial engineering, is the principal investigator on the three-year project titled, “Decentralized Power Flow Optimization on Electricity Grids via Distributed Consensus Methods.”

The project is aimed at solving important dynamic problems with uncertain parameters that currently exist in energy production and distribution. The grids are intended to run efficiently in a decentralized manner while respecting the data privacy requirements of each grid note.

“There are millions of smart meters deployed through the United States that sit idle over 90 percent of the time; thus, we know there is sufficient computation power without occupying additional land or powering and cooling new server farms or data centers,” said Aybat. “Knowing all of this, it is my hope to develop techniques to enable greater renewables penetration while maintaining grid resiliency through dynamic decentralized control of energy storage and regulator devices.”

The techniques developed in this project will help maintain grid reliability without having to burn more fossil fuel as backup, and in effect turn the smart grid into its own backup via intelligent control of the capacitor banks. This will lead to deeper integration of renewables and contribute to the reliable, robust and privacy-enabled operation of a stable power grid through the development of scalable computational tools for control and optimization.

Industrial engineering graduate students Erfan Yazdandoost Hamedani, Zi Wang, and Jinwei Zhang are assisting on the project.

Aybat awarded NSF funding to design smart decentralized power grids

By Pam Wertz

Necdet Serhat Aybat has received $235,852 in funding from the National Science Foundation to design smart power grids that factor in uncertainty in energy demand and renewable energy production.

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Aybat (left) explains some of the challenges in the current design of power grids to industrial engineering students.
Growing ties and FEEDING NATIONS

Chemical engineering faculty member combines his love of plants and expertise in engineering to improve agricultural practices around the world

By Mindy Krause

Agriculture and chemical engineering may seem like two divergent areas of study, yet Wayne Curtis, professor of chemical engineering, has found a niche in combining the two that may offer the potential to aid an entire population.

Curtis, who has been a faculty member in the Department of Chemical Engineering for the past 27 years, has dedicated his career to the study of bio-product engineering, which combines his love of agriculture and botany with his expertise in the production of chemical commodities. Recently, he was awarded funding through a collaborative grant issued by the National Science Foundation’s Basic Research to Enhance Agricultural Development (BREAD) program, in which he will have the opportunity to use his skill set to assist African farmers with the production of agricultural food staples.

The grant, titled “Advancing Technologies to Get Improved Yams in Farmers’ Hands,” is sponsored by the Bill and Melinda Gates Foundation — the world’s largest private philanthropic organization that seeks to improve the quality of life for individuals around the world. It aims to institute low-cost plant propagation technology to improve the cultivation of African yams (the region’s most economically relevant cash crop) and promote greater economic and food security, particularly in Africa. The proposed work also includes intermediate research for cassavas (tapioca) and bananas, which may have the potential to benefit millions more around the globe.

“I have always felt a strong desire to improve agriculture practices and help sustain food supplies throughout the world,” said Curtis. “Whether that need is in my own backyard or in an African village, the end goal is not that different. I feel it is my obligation to use my skills to fulfill a greater need in society — wherever that may be.”

The inspiration for Curtis’ most recent endeavor was sparked during an annual meeting of the Society for In Vitro Biology, a community that specializes in the study of cells, tissues, and organs of both plants and animals. At that time, he was introduced to the work of Morufat Balogun, senior lecturer and tissue culture specialist at the University of Ibadan, Nigeria, and the two became involved in a project designed to propagate chocolate trees. After discussing shared interests and a need for agricultural aid and intervention in Africa, the duo teamed with Leena Tripathi, plant biologist at the International Institute of Tropical Agriculture, who is based in Nairobi, Kenya, and the project was born.

“One of the most interesting aspects of the BREAD grant has been the concept of community that the Gates Foundation has encouraged. When my team was notified that we had been awarded funding, we were invited to attend a convening that included contributors from all over the world. It was a great opportunity to meet critical members of our team and start discussions with other teams related to the overall food security initiative,” said Curtis.
Curtis’ work on the project focuses on developing low-cost methods of cultivating African root crops by creating reactor systems and leveraging molecular biology techniques. Currently, African farmers are faced with a myriad of obstacles when growing crops that include factors such as drought, dormancy, soil nutrient deficiencies, pests, and disease. Curtis will work to induce cultivation of superior plants by a process known as somatic embryogenesis, which denotes the generation of plant embryos from somatic cells rather than seeds or pollen.

“The easiest way to think about somatic embryogenesis is to take a plant [leaf, root, petal, etc.] and give it biochemical instructions on how to become a new plant; this can be done at the cellular level. We will be taking cells and turning them into baby embryos just like a seed, which will eventually create a system to propagate disease-free plants,” explained Curtis.

The major difference between previous research and Curtis’ current approach is the strong engineering perspective that he and his team will contribute. Rather than focusing on standard tissue culturing practices, they will implement precise control over the plants’ physical, chemical, and biological environment to ensure that mass propagation is scalable, and thereby, successful.

Other factors unique to the project include the open source website dioscorea.org, that was developed as part of the grant as a place for farmers, researchers, and other stakeholders interested in yam propagation to interface and share resources. In addition, a distinct aspect of the project is the amount of undergraduate research support and enthusiasm it has received. Curtis notes that since the inception of the relatively young project, over a dozen undergraduate researchers have contributed their time and ideas.

As the grant develops over the next three years, Curtis plans to travel to Africa (both Kenya and Nigeria) approximately half a dozen times to study crops on site and set up training workshops to teach local farmers about new methods and techniques.

“Ultimately, my goal is to get these methods into the hands of African farmers,” he said. “My hope is that the work will lead to enhanced crop production, gains in economic prosperity, and an overall improvement to the lives of people around the world.”
Linking Industry with Real-World Solutions
Ben Noah ('16 Ph.D.) talks about partnering with industry to complete his research as a student at Penn State

Water Heroes Camp
Protecting our water so it is safe to drink and swim in

16 New Master’s Programs in 18 Months

What Can a Penn State Engineering Student Do Each Year? See the Possibilities...

New Building Approved for Chemical and Biomedical Engineering

Read About Our New Engineering Faculty
Improving Golf Clubs through Acoustics
The Daily Planet came to Penn State to talk to Daniel Russell about his work with sports equipment, specifically golf clubs.

Digging Deeper: PlantVillage
President Barron explores how Penn State researchers are helping to protect the world’s food supply.

3D Printed Robotic Arm Improves Manufacturing Efficiencies

Penn State Center for Engineering Outreach and Inclusion
Headquartered at Penn State at The Navy Yard in Philadelphia, Pennsylvania, the Energy Innovation Leadership Experience program provides students with the opportunity to work with leading companies and research teams to create innovative solutions to challenging real world problems. Open to both undergraduate and graduate students, the program includes topics that focus on the fields of energy efficiency, sustainable energy technologies, and leadership. The immersive nature of the program combines coursework with internship experience.

Learn more about the Energy Innovation Leadership Experience at Penn State at The Navy Yard.
A group of students traveled to Montana to install solar panels on a Native American reservation. Students helped to advance research and learning resources for solar and distributed energy technologies.

Students worked to develop a new education and training program focused on energy storage for engineering and electrical worker audiences.

Students assessed building energy through knowledge of building energy systems, client engagement, and diagnostic measurements.
Global Engineering Education Photo Contest

1ST PLACE ($75 Amazon gift card)

2ND PLACE ($25 Amazon gift card)
Emma Clement, junior, civil and environmental engineering. Program: Moringa Research in Kigali, Rwanda. The research team traveled to Akagera National Park to experience a Rwandan safari. Here the team is pictured in front of the Akagera entrance.

3RD PLACE ($25 Amazon gift card)
Rachel Diamond, senior, mechanical and nuclear engineering. Program: Melbourne - The University of Melbourne, Australia. Feeding kangaroos (even an albino one!) at Maru Koala and Animal Park.

RUNNERS UP

Adam Huffman, sophomore, electrical engineering technology. ENGR 118 Impact of Culture on Engineering in China. Just hanging out at “The Birds Nest” in Beijing, China.
Bill Warren named Penn State Alumni Fellow

Bill Warren ('86 E SC, ‘90 Ph.D. ESMCH) has been selected to receive the Penn State Alumni Association’s 2016 Alumni Fellow Award. This year, 24 alumni received the award, the highest bestowed by the alumni association.

Warren is vice president and leads innovation for research and development at Sanofi Pasteur, the vaccines division of the multinational pharmaceutical company, Sanofi.

He began his career as a principal member of the technical staff at Sandia National Laboratories. In 1997, he took a position as a program manager at Defense Advanced Research Projects Agency (DARPA), where he directed a diverse portfolio of research and development programs. Warren joined Sciperio Inc. in 2001 as a managing partner, coordinating state-of-the-art water desalination and water-from-air technologies.

In 2004, Warren founded VaxDesign Corporation and served as president and chief executive officer for six years.

The Alumni Fellows were honored during a dinner October 26 at the University Park campus.

Pre-game fun for a great cause

The College of Engineering Tailgate raised more than $5,800 to support the Penn State Engineering Alumni Society Endowed Scholarship.

More than 150 people attended the September 17 event, held at Medlar Field at Lubrano Park. The annual tailgate included food, drinks, and Penn State Berkey Creamery ice cream; a silent auction; and children’s activities organized by the Engineering Ambassadors.

150 PEOPLE ATTENDED
$5,800 RAISED
Two alumni groups lauded for exceptional programming

The School of Electrical Engineering and Computer Science’s (EECS) Alumni Society and the College of Engineering Young Alumni Advisory Board (EYAAB) have been selected to receive Penn State Alumni Association volunteer group awards.

The School of EECS Alumni Society will receive the 2016 Professional Development Award, which recognizes programs that help members continue to grow and advance within their chosen career fields, network with other professionals and/or navigate career transitions.

The society was selected for sponsoring Silicon Happy Valley, an annual conference at Penn State that brings together EECS alumni, students, faculty, and staff members to network, exchange ideas, learn about emerging trends and technologies, and promote and reinforce industry partners’ interest in Penn State’s College of Engineering.

The EYAAB will be recognized with the 2016 Fundraising Award, which honors groups who undertake exceptional fundraising efforts that will support areas outside of scholarships.

The board’s one-month crowdfunding campaign raised $4,300 to help support engineering students who want to travel abroad to study or complete a co-op or internship assignment.

Crowdfunding raises $4,300 for student global experiences
FROM YOUR PRESIDENT

What is new for the Penn State Engineering Alumni Society?

In June of this year, I became your new president of the Penn State Engineering Alumni Society along with the new vice president, Jane Clampitt (’79 CH E). I am excited and extremely honored to represent almost 100,000 strong (and counting!) engineering alumni.

I have been on the board since 2010, so I have had the opportunity to work with our dedicated board of directors, three past society presidents, and outstanding college staff. They have set the bar high by establishing an active and dynamic alumni society.

When I first came back to Penn State in 2008, many of our alumni and students were not even aware that the college had an alumni society and department affiliate program groups (APGs). Over the past eight years, I have seen the society create programs to reach out to engineering alumni and students, increasing their awareness of the society and focusing on fellowship among alumni, faculty, staff, and students. We grew our department APGs to twelve and added new opportunities for volunteering not only on campus but in the community.

I plan to build upon the successes of past leadership by continuing initiatives that engage our alumni and promote a meaningful identity for PSEAS and the twelve APGs within the Penn State community. I also plan to continue to develop programs that will enhance our society’s role in engaging young alumni. I hope to meet many of our engineering alumni and I welcome your thoughts and suggestions about how we can better serve the alumni community.

As Jane and I step into our new leadership roles within the Penn State Engineering Alumni Society, we ask for your continued support of the college and the alumni society.

Dale T. Hoffman ’72 E E
President, Penn State Engineering Alumni Society
dhoff128@comcast.net
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