PURDUE ENGINEERING | WINTER 2013

IMPACT

NEIL A. ARMSTRONG

1930-2012

LEAH H. JAMIESON

The John A. Edwardson Dean of Engineering

Ransburg Distinguished Professor of Electrical and Computer Engineering

DEAN'S MESSAGE

In 2009, we launched our strategic plan to achieve preeminence through societal impact around the world. The stories in this edition of Impact magazine demonstrate some of the ways that we are achieving this goal.

By thinking more broadly, taking valuable, measured risks, and stepping outside traditional disciplinary boundaries, Purdue Engineering's extraordinary people are addressing today's pressing challenges. Faculty, staff, students, and alumni, whose stories you'll read here, are contributing to our progress.

Our cover story pays tribute to perhaps the most famous Purdue Engineering alum, astronaut Neil Armstrong, who passed away in August. Always a humble hero, Armstrong's "small step for a man" has forged a path for so many seeking knowledge of our universe.

Also in this issue we explore interdisciplinary approaches being taken to address one of the most urgent challenges facing the world today — the need for safe, efficient, green energy. One example is our Hoosier Heavy Hybrid Center of Excellence that is engaged in innovative research to advance energy efficiency through fuel-flexible buses and trucks.

You can also read about the work of alumni Douglas Adams and Eugene Bonfiglio, and Steve Schneider, professor of aeronautics and astronautics. They contributed to NASA's successful mission to land "Curiosity," the Mars Science Laboratory, on the surface of Mars in August. As they did their work, one of our undergraduates working as an intern at the Jet Propulsion Laboratory developed an iPhone app that solved problems encountered in maneuvering a Mars rover test double.

On the topic of impact — but a very negative sort — research by the Purdue Neurotrauma Group documenting the number of head blows sustained by high school football players has been getting national attention. The findings are proving pivotal in developing new safety guidelines and gear. They also are providing supporting data for the argument being made by 2,000 former NFL players accusing the league of ignoring brain injuries resulting from the game.

And finally, I encourage you to join us in celebrating the global impact of the School of Civil Engineering, which is marking 125 years of excellence.

The Four Stories depicted within Purdue Engineering's strategic plan, Extraordinary People, Global Impact, are the framework for what is happening within the College and serve as the guiding vision for Engineering Impact magazine. Icons will be used in this and future editions to make the connection to our Four Stories.

Always@Purdue Engineering. Create and sustain the human, intellectual, and information infrastructures that connect people and Purdue for life.

OurPeopleOurCulture. Engage our people to transform our culture, because empowered people radiate passion that energizes them to change the world.

Innovate@PurdueEngineering. Build an innovation ecosystem and nurture a culture of creativity that takes us far beyond where we are today.

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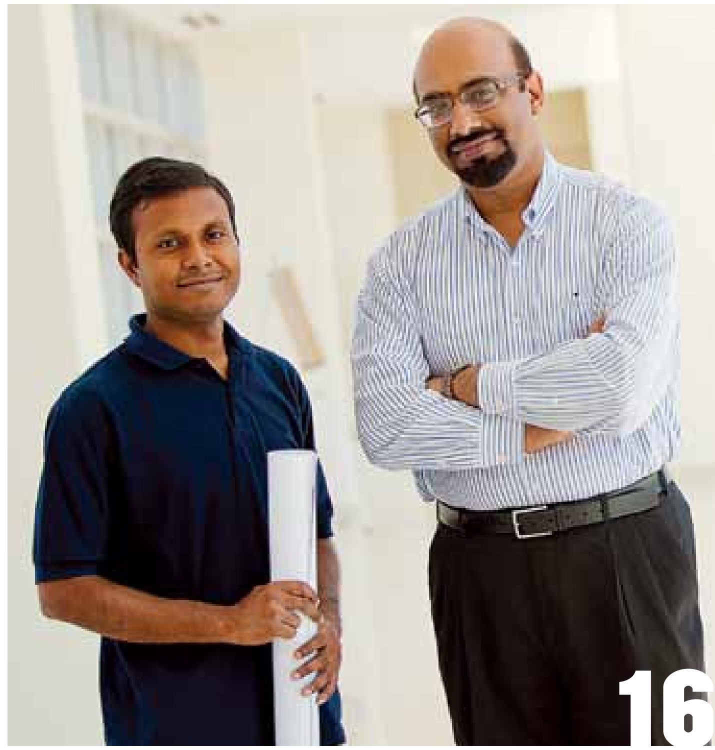

Editor's note: No story in recent memory has generated as much discussion as our feature on the future of nuclear power. Here are a few excerpts from letters received.

Thank you for addressing some of the misconceptions people have about the dangers of radiation from nuclear power plants and their likelihood of failure. There are many reasons why we should question the use of this form of energy and explore ways to make the whole system safe, from cradle to grave.

The mining of uranium needed for nuclear power plants causes pollution of soil and groundwater and affects the health of the workers doing the mining. This has lasting effects on the surrounding communities and costs a great deal of money to remediate the soil and water. This is commonly neglected from nuclear power discussions but is a real factor.

The article brought up the point that 95 percent of the fuel is not spent and could be recycled. Currently, the fuel in the United States is not being recycled due to the threat of terrorism, so it is a moot point. Until U.S. policy changes, we need to store the spent fuel somewhere for the next few thousand years.

I do not claim to be an expert in nuclear energy, but from what I have read and researched, there is a great risk involved with using this technology. Indeed, nuclear power plants do not emit carbon dioxide while they are operating, so they are attractive in that regard, but in order to assess nuclear power's total risk, we need to look at the whole system.

Todd Trabert, BSME '06

I was disappointed in the articles on nuclear engineering. As a world we have to get away from nuclear power, as Germany is doing. Haven't the nuclear catastrophes been warning enough: Chernobyl, Fukushima, Three Mile Island? Also, there is no current way to rid ourselves of the spent nuclear waste; hence, we leave it for our children to deal with while these plants output radioactive particles 24/7 into our waters and air.

With all the exciting energy developments and opportunities happening in the sustainable energy field, Purdue should be the leader. It's time to eliminate nuclear energy, strategize an exit and lead the engineering way to a clean, sustainable energy future.

Philip Chipman, AAE '69

WE WOULD LOVE TO HEAR FROM YOU.

Include your name and address and send to:
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We may edit letters for length and clarity.

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"FOR THOSE WHO MAY ASK WHAT THEY CAN DO TO HONOR NEIL, WE HAVE A SIMPLE REQUEST. HONOR HIS EXAMPLE OF SERVICE, ACCOMPLISHMENT AND MODESTY, AND THE NEXT TIME YOU WALK OUTSIDE ON A CLEAR NIGHT AND SEE THE MOON SMILING DOWN AT YOU, THINK OF NEIL ARMSTRONG AND GIVE HIM A WINK."

— The family of Neil Armstrong

July 20, 1969, at 8:17 p.m.

SALUTING A QUIET HERO

Neil A. Armstrong, a Purdue aeronautical engineering alum, will forever be known as the first human to set foot on the moon, but in a 2000 speech he humbly described himself as "a white-socks, pocket-protector, nerdy engineer, born under the second law of thermodynamics, steeped in steam tables, in love with free-body diagrams, transformed by Laplace and propelled by compressible flow."

Armstrong died Aug. 25 following complications from heart surgery. He was 82.

Millions of people around the world still remember July 20, 1969, at 8:17 p.m. Coordinated Universal Time (UTC) when they were transfixed on the flickering black-and-white video images showing Armstrong descending a ladder from the Lunar Module (LM).

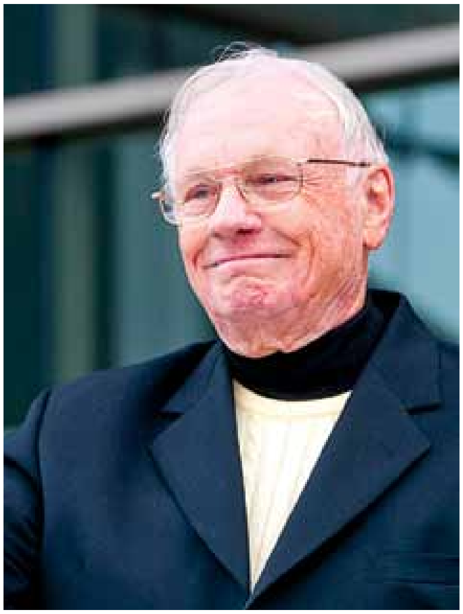
When Armstrong uttered the words, "Houston, Tranquility Base here. The Eagle has landed," a collective sigh of relief had filled the air. As he touched the lunar surface, Armstrong uttered this famous phrase: "One small step for [a] man, one giant leap for mankind."

In his authorized biography, "First Man: The Life of Neil A. Armstrong," Armstrong revealed to his biographer James R. Hansen the personal memorabilia he took with him to the moon: some jewelry for his wife and mother, an old fraternity pin from Purdue and some Apollo 11 medallions. According to the book, however, Armstrong was most proud of safely transporting a piece of the historic Wright Brothers Flyer to and from the moon.

AVIATION IN HIS BLOOD

When Armstrong was born on Aug. 5, 1930, in Wapakoneta, Ohio, aviation was still young. Charles Lindbergh had flown solo across the Atlantic Ocean to Paris just three years earlier.

From a very early age, Armstrong — a future U.S. Navy test pilot, aerospace engineer, and NASA astronaut — was fascinated with aviation. He earned his pilot's license as a teenager and idolized Lindbergh.



After his service in the Korean War, Armstrong took part in the fledgling Boeing X-20 Dyna-Soar human spaceflight program. He joined the NASA Astronaut Corps in 1962.

His first spaceflight was the NASA Gemini 8 mission in 1966, for which he was the command pilot. He performed the first manned docking of two spacecraft with pilot David Scott, preparing for what may be the greatest accomplishment in human history.

Armstrong's second and final spaceflight was as mission commander of the Apollo 11 moon landing in July 1969. On that mission, Armstrong and Buzz Aldrin descended to the lunar surface in the Lunar Module and spent 2-1/2 hours exploring, while Michael Collins remained in orbit in the Command Module.

He epitomized the calm, confident tone astronauts respected. In reporting from the moon, he matter-of-factly told controllers, "It's different, but it's very pretty out here. I suppose they are going to make a big deal of all this."

> "IT'S DIFFERENT, BUT IT'S VERY PRETTY OUT HERE. I SUPPOSE THEY ARE GOING TO MAKE A BIG DEAL OF ALL THIS."

REMEMBERING A HUMBLE HERO

More than 1,000 people gathered near Armstrong's statue at Neil Armstrong Hall of Engineering for a memorial service on Aug. 27.

Joe Rust, president of Purdue Student Government, which organized the service, told the crowd that the astronaut "inspired us to go beyond the classroom, beyond our boundaries and even challenged us to go beyond Earth."

Tim Sands, acting president, says Armstrong is likely the most famous and inspirational alumnus of Purdue, and was an integral part of campus life from his arrival as a young student in the '50s until his death.

"He was a humble and private person, but always willing to talk to students," Sands says. "He was passionate about encouraging young men and women to pursue careers in science and engineering."

Leah Jamieson, the John A. Edwardson Dean of Engineering, echoes Sands' remarks, saying, "He inspired us all. He would say that engineering is about 'what can be' and gave us unforgettable images of just how bold and inspiring the future can be. He was proud of being an engineer, and we have always been enormously proud that he was a Purdue engineer."

President Emeritus France A. Córdova, a former NASA scientist, speaks for many when she recalls the excitement of Apollo 11 heading for the moon with the goal to put two men on its surface.

"Everyone was watching Neil Armstrong take humankind's first step on the moon," she says. "Grainy as black-and-white TV was at the time, you knew it was the real thing. It changed lives, career paths, dreams. For me it was a turning point."

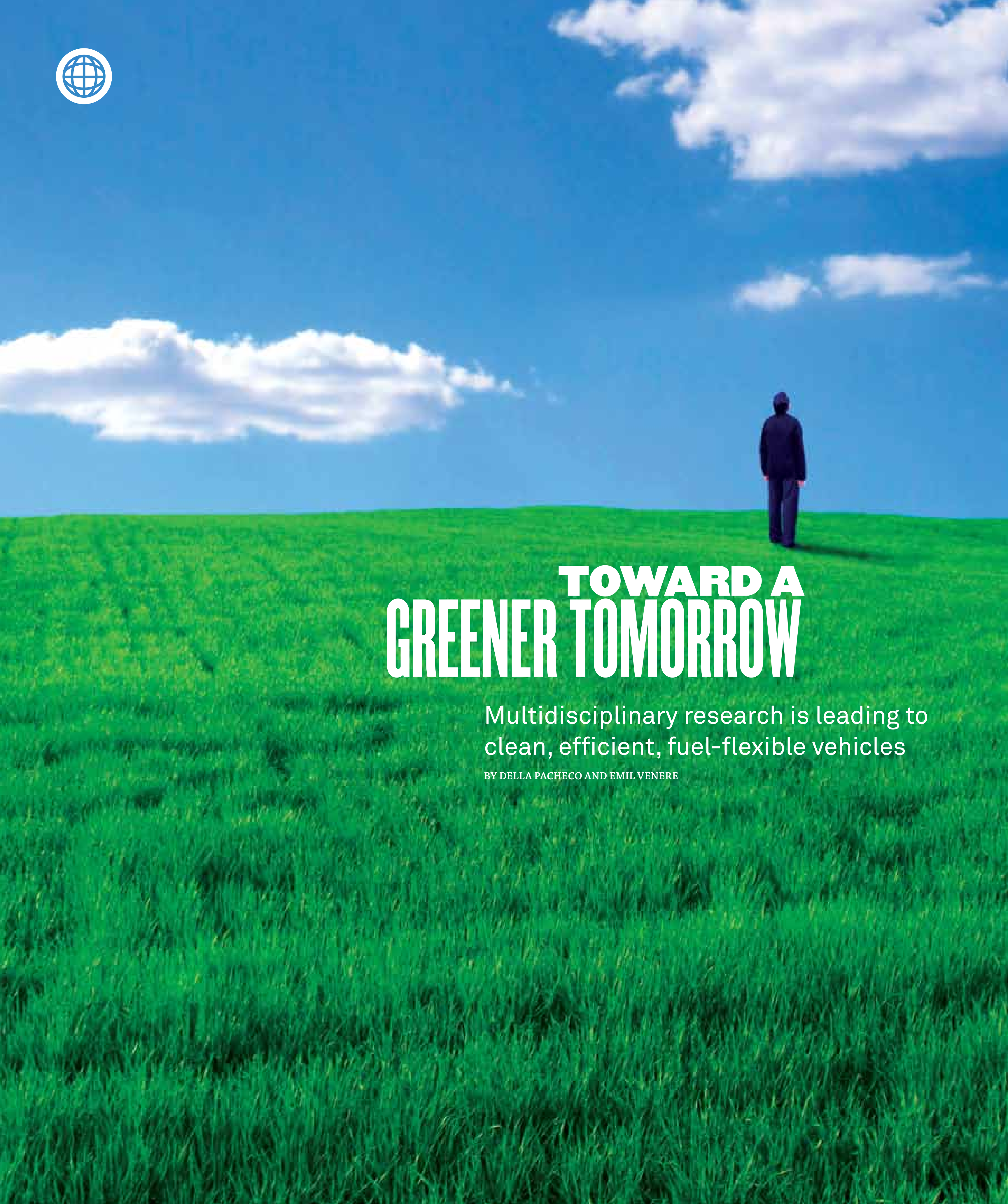
She finally was able to meet Armstrong in person at the opening of Neil Armstrong Hall in October 2008. "He was humble — giving credit to the engineers who put him on the moon," Córdova says.

NASA astronaut Scott Tingle (MSME '88) was 4 years old when Armstrong left his footprint on the moon's surface. Tingle says Armstrong carried "the hopes and dreams of not only one man, one crew or a single country, but of the human race."

"While we have learned about explorers such as Magellan, Columbus, Lewis and Clark, the legend of Neil Armstrong and Apollo 11's epic journey to the moon will forever take center stage in our history lessons."

Retired astronaut Gene Cernan (BSEE '56), the last man to leave his footprint on the moon, remembers his friend as "all that is good and great about this nation," he says. "To Neil it was never about him, it was always about those who a generation and a half ago made it all possible. He truly was a reluctant hero."

To view a video of Neil Armstrong's famous moon walk, scan this code.



TOWARD A GREENER TOMORROW

Multidisciplinary research is leading to clean, efficient, fuel-flexible vehicles

BY DELLA PACHECO AND EMIL VENERE

Tight budgets, environmental pressures and rising energy demand — all challenges facing the world today.

The International Energy Agency (IEA) says the highest priority should be on becoming energy-efficient, as this offers the highest potential for reducing carbon emissions at the lowest cost. In practice, however, it can be challenging to capture these benefits.

Right now, the energy we use doesn't work nearly hard enough for us. The process of transforming energy resources and then using them is so inefficient that we lose most of the potential energy value of our energy resources. Faced with finite fossil fuel supplies and rising demand, this situation is simply unsustainable.

This is why Purdue Engineering researchers are examining ways to make the energy we already use work harder for us while developing new, cost-effective alternatives. By increasing our energy productivity, or efficiency, we can do more with less.

HOOSIER HEAVY HYBRID CENTER OF EXCELLENCE

The Hoosier Heavy Hybrid Center of Excellence (H3CoE) at Purdue was funded with a $1 million grant from the U.S. Department of Energy's Graduate Automotive Technology Education initiative. The goal is aimed at cutting fuel consumption in half for commercial vehicles by perfecting hybrid technologies for the world's burgeoning bus and truck fleets.

Buses and trucks, particularly vehicles used to transport goods, represent a huge percentage of global fuel consumption and tailpipe emissions, says Gregory Shaver, associate professor of mechanical engineering and the center's principal investigator.

"There is a lot of potential to increase the efficiency of these vehicles," says Shaver, who co-directs the center with Maryam Saeedifard, assistant professor of electrical and computer engineering.

Additional faculty making up the project management team include Vahid Motevalli, professor of mechanical engineering technology; James Caruthers, the Reilly Professor of Chemical Engineering; Eric Dietz, associate professor of computer and information technology; and Monika Ivantysnova, Maha Fluid Power System Professor of Mechanical Engineering and Agricultural and Biological Engineering.

The project, which falls under the umbrella of the Purdue Energy Center Advanced Ground Vehicle Power and Energy Storage initiatives, seeks to achieve a 50 percent reduction in commercial vehicle fuel consumption and greenhouse gas emissions. The five-year project began Oct. 1, 2011.

"The savings in energy efficiency is absolutely critical here," says Maureen McCann, director of the Energy Center and professor of biological sciences. "If you can double energy efficiency, you are halving your fuel consumption. That's huge."

Reducing fuel consumption for commercial vehicles by 50 percent would cut petroleum use by about 15 billion gallons per year, corresponding to a reduction of 155 million tons of carbon dioxide.

The United States is the world's largest oil user, consuming nearly 20.7 million barrels per day. U.S. consumption is expected to grow moderately, but consumption in developing countries is expected to skyrocket in coming years. China consumes about 7.6 million barrels per day, and the rate is expected to grow at 9 percent annually.

"This trend in China is due in large part to the increased use of commercial vehicles," Shaver says.

Growth in e-commerce is one phenomenon leading to significant increases in the number of trucks needed to transport goods. Annual e-commerce spending in the United States grew by nearly 100 percent in 2010.

"The explosive growth in e-commerce is a positive outcome for the U.S. and global economies, but requires an increase in the number of trucks to transport goods," Saeedifard says. "This need creates a significant economic opportunity for U.S. companies that are heavily engaged in the commercial vehicle market. Indiana companies can benefit through the global market. The center will work toward solving technical challenges and training engineers and scientists who will be ready to make contributions."

Purdue doctoral students Dan Van Alstine and Karla Stricker, who now works at the Cummins Technical Center, work on a diesel-engine test platform at the Ray W. Herrick Laboratories. The work is related to a new effort aimed at cutting fuel consumption in half for commercial vehicles by perfecting hybrid technologies for the world's burgeoning bus and truck fleets. The new Hoosier Heavy Hybrid Center of Excellence is funded with a $1 million grant from the U.S. Department of Energy's Graduate Automotive Technology Education initiative. (Purdue University photo/Mark Simons)

The work includes industrial partners Cummins Inc., Allison Transmission Inc., Navistar and the Energy Systems Network, an initiative of the Central Indiana Corporate Partnership focusing on clean-energy technologies in Indiana. The project management team is reaching out to additional prospective industry partners, Shaver says.

Commercial vehicles consume far more fuel per vehicle than passenger cars, averaging 6.2 mpg and 74,000 miles per year, compared with 21.1 mpg and between 10,000 and 12,000 miles per year for light-duty automotive vehicles.

“This results in a drastic difference in fuel consumption on an annual basis,” Shaver says. “As the global truck markets continue to grow, fuel consumption and greenhouse gas emissions will increase. Any attempt to significantly reduce fuel consumption and emissions must focus not only on the U.S. truck market, but also on global markets.”

Each commercial vehicle consumes an average of 11,900 gallons of fuel per year, whereas light-duty automotive vehicles consume an average of 570 gallons of fuel annually.

“The greater fuel consumption of commercial vehicles means that fuel reduction associated with technology improvement is much greater for commercial vehicles on a per-vehicle basis,” Shaver says. “For each commercial hybrid vehicle on the road, 20 light-duty automotive hybrids would need to be in operation to achieve a comparable fuel savings.”

HYBRIDS ALSO COULD PROVIDE LARGE ECONOMIC BENEFITS

Shaver says one of the biggest costs for fleet owners and operators is fuel. “If your fuel costs go down, your bottom line improves and you can hire more people.”

Companies operating in Indiana, such as Cummins and Allison, sell vehicle components globally, so solving technological challenges associated with medium- and heavy-duty hybrid vehicles could benefit the local economy.

“If we can help them in the short and medium term with their technology challenges, that’s great for business, and at the same time we’re training students to work in industry,” Shaver says.

The program includes fellowships for students, an annual workshop, seminar series and the creation of a new course on medium- and heavy-duty electric hybrid vehicles. A new certificate program for graduate students in medium- and heavy-duty hybrids has been developed.

“We keep hearing from industry that there is a shortage of engineers, and we’re helping to address that issue,” Motevalli says. “This graduate student research and education grant, along with the Advanced Electric Drive Vehicle Education Program and EcoCar 2 Student Vehicle competition, are putting Purdue in a unique position to play a leading role in the emerging field of hybrid vehicles and powertrain electrification.”

Challenges include learning how to better integrate the various components in the vehicles’ powertrains, encompassing the engine and transmission and other elements.

“Often the major parts of the powertrain are built by companies that don’t make the vehicle itself, so they may not be tailored for the vehicle they are used in,” Shaver says. “For hybrids to be optimized, these components need to be integrated properly.”

PUTTING THE BRAKES ON LOST ENERGY

Another challenge is to design heavy-duty regenerative braking systems, in which electric motors can serve as generators while the vehicle is braking, producing power to recharge the battery pack. Researchers involved in the center also are developing regenerative braking systems that store energy by compressing hydraulic fluid in a tanklike “accumulator.” High-pressure fluid in the accumulator would be used to drive a hydraulic motor, providing torque to the wheels and saving fuel.

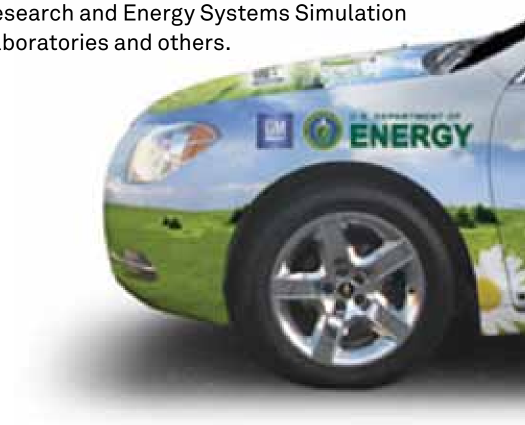
While regenerative braking already is used in hybrid cars, such systems are especially difficult to design for heavy vehicles.

“There are very large braking energy rates in heavy-vehicle stopping and much more energy to capture,” Shaver says. “So, how do you capture the energy and also handle the energy flow?” Saeedifard’s research is focused on using power electronics-based solutions to address these issues.

Another step needed to improve efficiency is recovering waste heat from the exhaust.

“More than half of diesel engine exhaust is lost to waste heat out the tailpipe or radiator,” Shaver says. “If you could better harvest that waste heat, you could make the whole power train more efficient.”

The research will be performed at the Ray W. Herrick Laboratories, Maha Fluid Power Research Center, Energy Conversion Research and Energy Systems Simulation Laboratories and others.



ECOCAR2:
PLUGGING INTO THE FUTURE

The U.S. Department of Energy (DOE) has given students from 15 universities across North America, including Purdue, the chance to show what they can do in the field of automotive technology that looks to reduce greenhouse emissions and improve fuel efficiency.

The goal is to push the envelope of transportation and train young engineers. Entry criteria were simple: Build a highly efficient plug-in hybrid vehicle and use renewable energy sources.

The three-year competition, which began in 2011, is divided into phases that focus on design, construction and refinement. The competition challenges the teams to convert a Chevrolet Malibu to reduce its environmental impact without compromising performance, safety and consumer acceptability.

Each team designed its own drivetrain, which will eventually propel a real 2013 Chevrolet Malibu — provided courtesy of GM, one of the competition's primary sponsors. The winner gets to keep their Malibu and also receives various cash prizes from industry sponsors.

Purdue's team is using Parallel through the Road (PTTR) architecture with its vehicle, which uses electrical energy to power an electric motor on one axle, while an engine drives another axle.

The PTTR architecture is a Plug-In Hybrid Electric Vehicle, which uses an onboard battery to reduce fuel use and can be recharged using a standard wall outlet. Once the plug-in range of the battery is depleted, the vehicle can still operate as a regular hybrid. Purdue will use B20 fuel, which is a blend of 20 percent biodiesel and 80 percent petroleum diesel, to extend the range of the vehicles.

Vahid Motevalli, department head and professor of mechanical engineering technology, is the lead faculty advisor for the Purdue team. Others involved with the project include Gregory Shaver, associate professor of mechanical engineering, leading engine control and overall mechanical systems; Oleg Wasynczuk, professor of electrical and computer engineering, advising the team on power electronics and the electric motor and controller; Haiyan (Henry) H. Zhang, assistant professor of mechanical engineering technology, who is overseeing the modeling and simulation and work on the vehicle's transmission; Peter Meckl, professor of mechanical engineering, overseeing work in powertrain controls and diagnostics; and Eric Dietz, associate professor of computer and information technology, leading work on batteries and computer and information systems.

Purdue's team, composed of more than 50 undergraduate and graduate students, received its car in June and has been testing and troubleshooting its design.

"We are looking at an approach that is unique because of components selected and the integration of them," says Haley Moore, a graduate student in mechanical engineering technology who serves as project manager. "Some things have been done and some tools have been used, but the way all the components work together is different than what has been seen before."

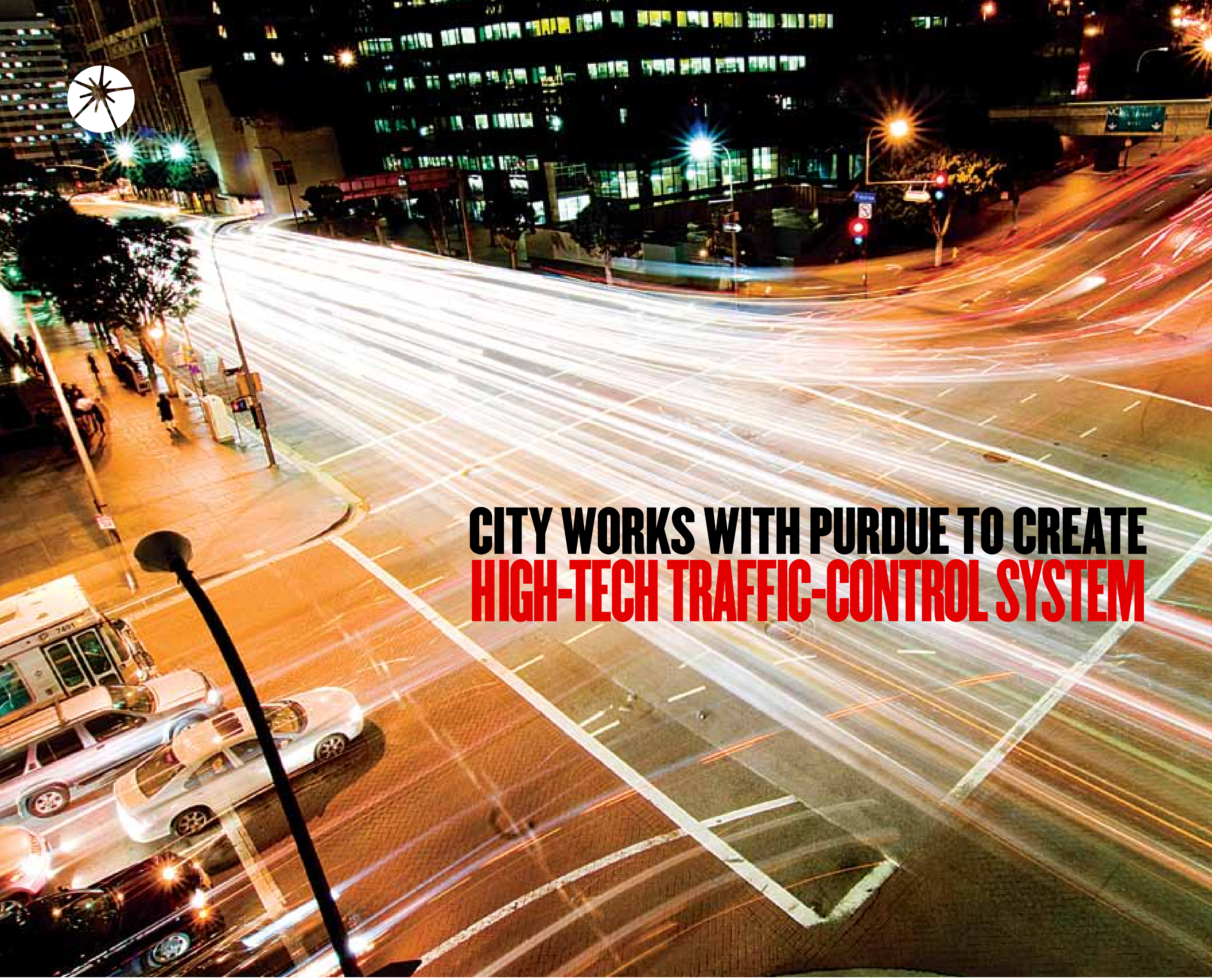
Each team has created a booth, which must include a driving simulator, powered by a control box that has been developed over the past year.

"The simulator is realistic in the sense that we're programming a control box that will go into a vehicle," Motevalli says. "You don't have to take the risks of actually driving a test car. You're driving a simulator. Once all of the bugs are out, you can take the control box and put it into the car."

The program has benefited participants greatly, Meckl says. "It's been demonstrated that people who have worked on the EcoCAR projects have 100 percent job placement. Putting this on their resume not only gives the students more confidence, but they can demonstrate that they've been involved with an actual car and use the exact protocols used at GM to put a car together."

During phase two, the team will work on fabrication, phase three will deal with refinement.

In addition to the vehicle, the team received $25,000 in seed money to help start the project. The colleges of Technology and Engineering have committed to three years' worth of funding for the team.



CITY WORKS WITH PURDUE TO CREATE HIGH-TECH TRAFFIC-CONTROL SYSTEM

Purdue engineers have worked with the city of Lafayette to create a new Advanced Transportation Management System, a network of sensors, computers and software to efficiently control traffic signals and reduce congestion.

The system is one of the first deployments in the country of new traffic signal management techniques developed at Purdue, says Darcy Bullock, a professor of civil engineering and director of the Joint Transportation Research Program.

It allows engineers to attack traffic jams on two fronts: Determine more precisely how to adjust the length of green signals to better match traffic volumes and synchronize signals in series on busy roads so that motorists catch green lights in sequence.

"We have all been at intersections where the green light did not last long enough for all the traffic to pass through and then seen drivers on the opposing side of the intersection get too much green time," Bullock says. "What we are doing enables electronic signal controllers to collect data that can be used to effectively alter this timing to better manage traffic flow."

The system improves signal-timing efficiency, says Lafayette City Engineer Jennifer Miller.

"The ultimate goal is to allow the majority of the travelling public to spend less time stopped at a signal when it is red," she says. "Other potential benefits are improved fuel efficiency and reduced emissions because less time idling reduces fuel usage and the associated emissions. Having fewer starts and stops also reduces fuel consumption and emissions."

The system is integrated into portable signal controllers that are widely used at intersections across the country and uses specialized software algorithms. Data are displayed on a main computer in the city's traffic center, allowing personnel to monitor information and make a change to individual intersection timing.

"It is like a dashboard for signal systems," says Neal S. Carboneau, research manager of the Indiana Local Technical Assistance Program (LTAP) in the school of civil engineering. "You could equate it to the leap from horse-drawn carriages to commercial aircraft. In the past, you had to manually count vehicles and time their progression through the corridors. You would have to come back to the office and do calculations, then return to the signal to make adjustments to improve the flows. Then, in order to verify that the changes were effective you would need to go through the same procedure again. As you can imagine, it was a very inefficient and time consuming process."

Recent advances in technology, including improvements to the reliability and speed of Internet access, as well as greater computer storage and processing ability, have made it practical to use computerized systems that operate signals.

Induction loops buried under pavement near signals indicate that a vehicle is in the turn lane and other locations. These loops, which are ubiquitous in U.S. cities, are connected to a computer in a cabinet at each intersection.

Algorithms in the system use mathematical equations and data from the loops and other sensors to determine whether an intersection's traffic volume is exceeding its capacity, tracking traffic during each cycle of green-amber-red. The resulting information is plotted on graphs that show how many vehicles are unable to get through an intersection before the signal turns red.

Such data enable the system to identify needed changes to signal timing to facilitate the flow of traffic and also to synchronize signals.

"How often have you driven down a corridor and had it go green, green, green, green?" Bullock asks. The answer is, not very often. "The problem is that until now we have not had good measurement tools needed to create patterns of sequential green signals."

Darcy Bullock, from left, professor of civil engineering, and Edward J. Smaglik, a former postdoctoral research associate, discuss information provided by detection equipment at an "instrumented intersection." The engineers are using the system to test specialized detection and control software algorithms designed to help improve the safety and efficiency of traffic flow. (Purdue News Service photo/David Umberger)

The system incorporates new traffic signal performance measures, criteria based on research on traffic flow that enable computers to decide how to optimize signal timing.

"We've married some theory with new data collection practices, performance measures and modern IT technology to come up with a better tool for making decisions about signal management," Bullock says.

The performance measures were developed with funding from the National Cooperative Highway Research Project and the Indiana Department of Transportation.

"The system has been installed and is operational, but since it is the first of its kind, getting it to be fully functional will take some time," says Fred Koning, foreman in the Lafayette Traffic Department.

Having a centralized system is helpful in troubleshooting the network, which is made up of numerous signals and computers and a web of electrical cables and sensors, Koning says.

City officials worked with LTAP to put the system in place. Carboneau says other states and local agencies across the country are modeling their system specifications based upon the system in Lafayette.

The project has involved about a dozen faculty, staff and students from engineering.

Officials in Elkhart County, Ind., assisted the research, and the county is in the process of bringing a similar system online.

City officials received a Merit Award for the new system from the American Council of Engineering Companies, which also recognized Bullock and Carboneau for their contributions.

Previous research has been funded by the Indiana Department of Transportation. A portion of that earlier work, on State Route 37 in Noblesville, Ind., yielded data indicating a potential 20-percent decrease in travel time for drivers. Findings from the Noblesville research show that optimizing signal timing has resulted in an estimated annual cost savings of $472,817, with a reduction in carbon dioxide emissions of 197 tons per year.

■ EMIL VENERE

LEADING THE CHARGE
IN MOTORSPORTS SAFETY

Di Xu, a graduate student in Mechanical Engineering, and Danny White. Photos submitted.

Motorsports is big business in Indiana — $4 billion big. Teams increasingly need highly skilled technicians to engineer cars both for speed and safety. So when Purdue decided two years ago to start a motorsports program, officials sought out someone with strong credentials to lead the effort — Danny White.

White, an Indianapolis west sider, brings more than 30 years of experience in motorsports to the program. He started, as most Ben Davis High School boys did, he says, drag racing on Tuesday nights at Raceway Park in Clermont. Later he worked as a firefighter in the Wayne Township fire department for 10 years before becoming senior safety officer for Boehringer Mannheim, now Roche.

He received an invitation to train as a member of the fire crew at the Indianapolis Motor Speedway. One day, White says, he was sitting on the pit wall when car owner Dick Simon asked if he could look at a problem that none of his engineers could figure out. White identified the problem and fixed it. Simon responded, "Bring me your paycheck stub and I'll give you $10,000 more than whatever your employer is paying you. Come to work for me."

And he did. White spent 20 years in Champ Car, the governing body later known as Championship Auto Racing Teams (CART), and IndyCar. He also worked on the NHRA top fuel team of Kristin Powell, who earned the title of the World's Fastest Teenager.

It was the death of race driver Greg Moore in the 1999 CART season finale race that led White to leave the Player's Forsythe team and take a sabbatical from racing to work for then-Indianapolis Mayor Bart Peterson. Two years later, White returned to the sport, purchasing an Indy Pro Series (now Indy Lights) team with Taylor Fletcher as his driver.

White's extensive experience means he is often sought out to comment on driver and spectator safety. Features like SAFER barriers and Kevlar rope used as tethers to hold racing wheels in place have protected both drivers and spectators. One area needing improvement, White says, is fencing.

The death of race driver Dan Wheldon has prompted White to argue for better design of catch fences at racetracks. "Las Vegas and Texas both have poles on the interior of the fence toward the driver," White says. "As a safety professional, I don't think that's the wisest choice."

He also advocates for research on using Kevlar in the construction of these fences. "If Kevlar rope is that strong, why aren't we considering its use as a primary catch fence?" White says.

White has dual appointments in EPICS and Chemical Engineering. In addition to leading the motorsports program, he also serves as director of race operations and chief steward for the evGrand Prix, an outgrowth of the Indiana Advanced Electric Vehicle Training and Education Consortium (I-AEVtec), which is developing degree and training programs for the electric vehicle industry.

The motorsports program recently launched an aerodynamics online course to give technicians, drivers and mechanics of IRL racing cars the background needed to keep their job skills up-to-date in a quickly changing environment. The course has 11 modules, each 90 minutes, that can be taken anywhere at any time.

■ DELLA PACHECO

Q&A

EDUCATED RACER

If ever anyone was born to race cars, it may be Ryan Newman. A South Bend native and Purdue grad (IDE '01), he got into racing when he was four-and-half years old. He was a member of the Richard Petty Fan Club and his boyhood heroes included the intimidating Dale Earnhardt and the fearless A.J. Foyt.

Still, NASCAR stardom isn't guaranteed to anyone. Long before Newman won the Daytona 500 and compiled 49 starting pole positions, he came up with a backup plan: getting an education. It's a plan he's now helping to build for others.

With all the racing success you had as a youngster, why did you decide to attend Purdue?

Ryan Newman: I didn't know I could become a professional race car driver. I wanted something to fall back on.

How were you able to tailor an interdisciplinary engineering degree to your sport?

Purdue gave me a better understanding of all the engineering areas of study. The interdisciplinary side of being able to create my own path was what interested me after I found that mechanical engineering was not entirely suited to my desire to become a race car driver.

How do you work with the engineers on your crew?

Because of my schooling, I have a common language with the engineers on my team. We understand each other. So when we go to make a change on the race car, we are more likely to do it the right way the first time, and that definitely helps the entire team.

Do you still work on engines yourself?

I love engines and love working with them. But the race car is their [the crew's] responsibility. I just focus on being the driver.

What's been your proudest moment on the track?

My Daytona 500 win in 2008 when my dad spotted for me and called me down to the start/finish line to take the checkered flag. It was the biggest race that I have ever been a part of because it was the 50th running of the Daytona 500, and I won it. And we did it in style — a 1-2 finish with my teammate. I'm very thankful for all the people who helped me get to where I am in my career, and that win was a tribute to all of them.

Talk about the Ryan Newman Foundation. In addition to the focus on animals, there's a strong educational component. What made you and your wife decide to focus your energy here?

I was a recipient of the Rich Vogler scholarship, which gives kids in motorsports a $1,000 grant. I feel like it is important with my career to be able to give back to the scholarship. From my standpoint, I just want to be able to help kids who want to go to school and who need help. It's nice to be able to get your books paid for and enjoy a couple of semesters.

■ WILLIAM MEINERS

The Ryan Newman Foundation
ryannewmanfoundation.org

Doctoral student Biswajit Ray and Muhammad Ashraful Alam, professor of electrical and computer engineering. Purdue University photo/Andrew Hancock.

NEW MODELS POINT WAY TOWARD BETTER SOLAR CELLS

Research provides path to low-cost, more efficient designs and materials

■ BY EMIL VENERE

According to the United States Department of Energy, the amount of solar energy that hits the surface of the earth every hour is greater than the total amount of energy that the entire human population requires in a year.

To put this in perspective, roughly 100 square miles of solar panels placed in the south-western U.S. could power the country.

But placing those panels, which would advance energy independence, involves obstacles including cost. Purdue researchers are working to create a new generation of low-cost solar cells that could transform global energy production.

One project is led by Rakesh Agrawal, the Winthrop E. Stone Distinguished Professor of Chemical Engineering. Also working on the research are Mark Lundstrom, the Don and Carol Scifres Distinguished Professor of Electrical and Computer Engineering; Muhammad Ashraful Alam, professor of electrical and computer engineering; and Eric Stach, a researcher at Brookhaven National Laboratory.

Two major drawbacks exist for commercial silicon solar cells: They are expensive to manufacture and must operate for eight to 12 years just to recoup the amount of energy needed to manufacture them, Alam says.

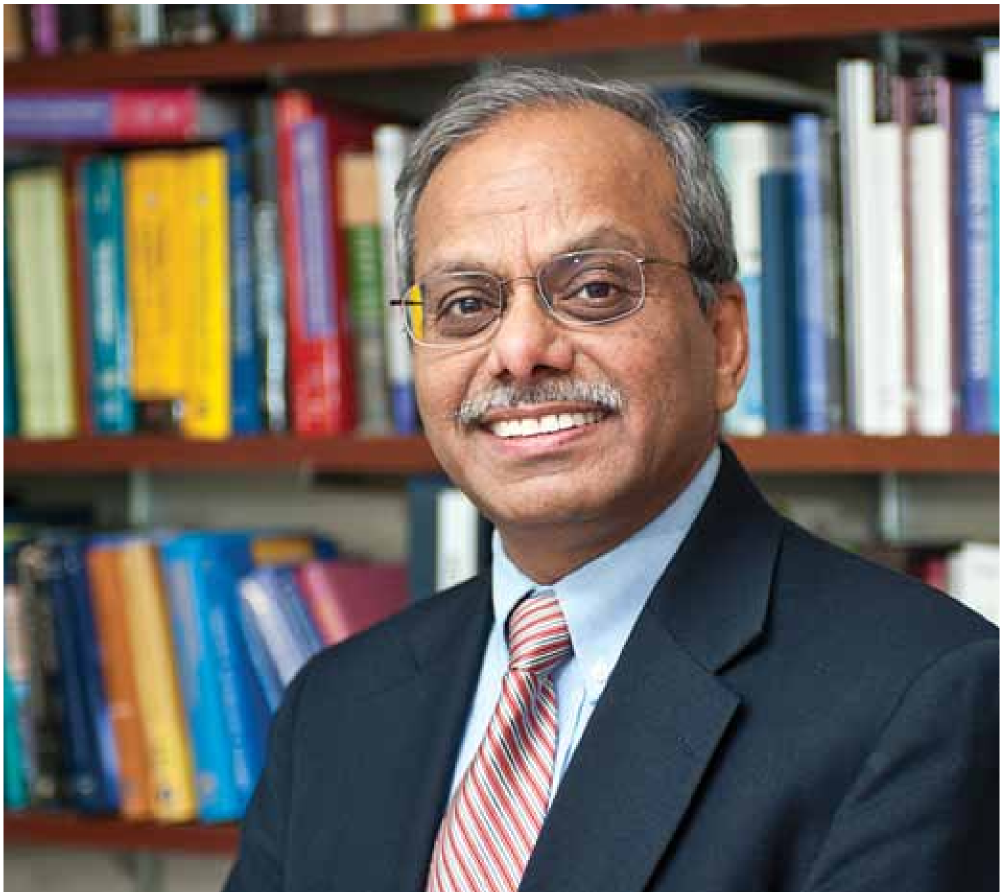
Purdue research funded by the U.S. Department of Energy strives to achieve critical requirements not met by other solar technologies: It should be mass-producible at low cost and not limited by the availability of materials.

"To date, none of the photovoltaic technologies simultaneously meets all these constraints," says Agrawal, who received the National Medal of Technology and Innovation — the nation's highest honor for technological achievement — from President Barack Obama in September 2011.

He is working on new solar cells that hinge on developing an ink using tiny "nanocrystals" made of a material called copper zinc tin

…"ONCE YOU HAVE AN INK YOU CAN PRINT PHOTOVOLTAIC CELLS VERY FAST, SO THEY BECOME VERY INEXPENSIVE TO MANUFACTURE."

– Rakesh Agrawal



Rakesh Agrawal, the Wintrop E. Stone Distinguished Professor of Chemical Engineering. Purdue University photo/Andrew Hancock.

sulfide, or CZTS. Because the materials are abundantly available, the CZTS technology poses no resource hurdles, Agrawal says.

Agrawal's lab was the first to make CZTS nanocrystals, which enabled creation of a light-absorbing ink.

"The concept is that once you have an ink you can print photovoltaic cells very fast, so they become very inexpensive to manufacture," Agrawal says.

In other work led by Alam and doctoral student Biswajit Ray, researchers are developing plastic solar cells by mixing two liquid components and annealing, or heating the mixture, which solidifies into a thin polymer film. The cells are portable, lightweight and transparent. The flexible cells might be attached to windows to light buildings, or coated onto laptops and other portable electronics as a power source.

However, although the plastic solar cells are far less expensive to produce than silicon cells, they have a low efficiency and currently break down in the sunlight within a year of use.

"It's an unknown, unproven technology, but if we could make it work it could transform everything," Alam says. "Roughly one-fourth to one-third of U.S. solar-energy research funding is going into these organic solar cells. They represent a potential game changer."

The polymer mixture must be annealed for just the proper time and precise temperature for the cells to be as efficient as possible.

"We mix two polymers and heat it, but we don't know how long we should heat it, or at what temperature to get the best efficiency," says Ray, who, working with Alam, has developed the first model that determines the proper annealing time and temperature depending on the polymers used.

Ray also has shown how the cells degrade when operated in sunlight. That model interprets experimental results, describing how the two polymer components "phase segregate," or come apart over time.

"If you understand how it phase segregates, then you should also be able to understand how to design these polymers differently so that they remain functional over many years," Ray says.

Findings were detailed in research papers appearing earlier this year in the journal *Applied Physics Letters and Solar Energy Materials and Solar Cells*.

"This kind of modeling allows you to think creatively and systematically," Alam says. "Otherwise, you cannot perfect this technology just by trial-and-error experimentation because solar cells are very complex."

Models may enable engineers to perfect solar cells, just as they did for the computer chips.

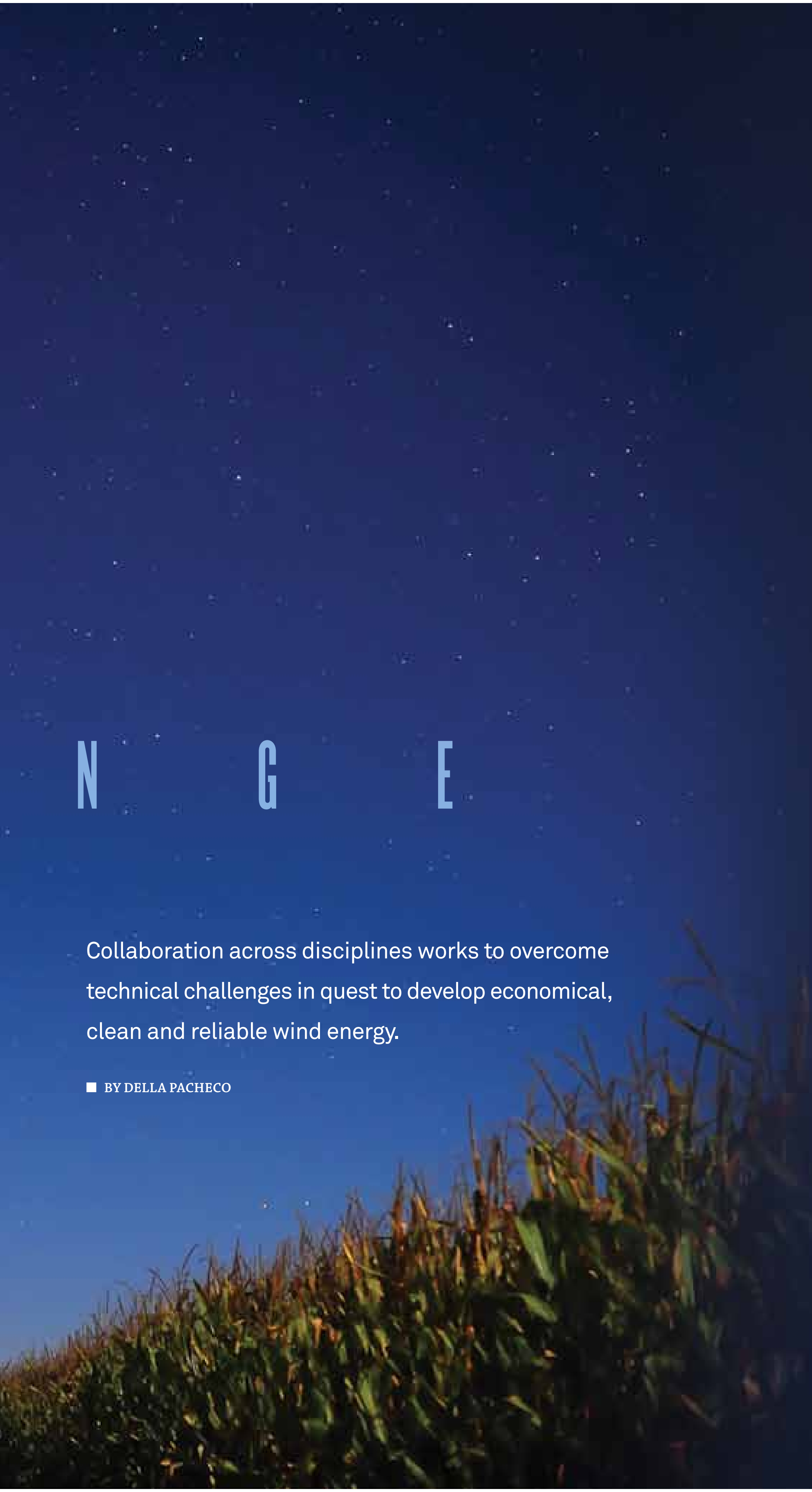
"Modeling and simulation transformed the silicon semiconductor industry during the 1980s," Alam says. "That's when the industry was really able to design integrated circuits and microprocessors and test them ahead of time using models to predict their performance."

For the plastic solar cells to effectively compete with other energy technologies, new materials that don't degrade quickly will be needed, Alam says.

"You need 15 percent efficiency and 15-year lifetime for polymer solar cells to be economically competitive with oil and natural gas. We have framed the problem very cleanly, but the solutions are still not there."

The work is associated with the Energy Frontier Research Center at Columbia University. The Columbia EFRC is a collaboration between the University of Texas, Purdue and the Brookhaven National Laboratory.


WINDS OF C H A



N G E

Collaboration across disciplines works to overcome technical challenges in quest to develop economical, clean and reliable wind energy.

■ BY DELLA PACHECO

The answer to energy independence may be, as Bob Dylan penned, blowing in the wind. If the United States is to reach the U.S. Department of Energy's goal of 20 percent wind power by 2030, it will take innovative technology to improve the performance of new and existing wind power plants. And that's just what Purdue researchers from multiple disciplines are developing.

Doug Adams, the Kenninger Professor of Renewable Energy and Power Systems, and computer science professors Jan Vitek, Ananth Grama and Suresh Jagannathan received a $1.6 million three-year grant from the National Science Foundation's Division of Computer and Network Systems to advance sensor technology and computer simulation tools for tracking and improving the performance and reliability of "smart" wind turbines and wind farms.

The project builds on years of research by Adams, who is developing "smart" turbine blades that use sensors and computational software to improve energy capture by adjusting for changing wind conditions. Adams developed these sensing techniques working with Sandia National Laboratories.

One year into the project, a specialized facility has been built in Lafayette that allows researchers to study and manipulate the interaction of multiple turbines in a controlled environment — a nearly impossible task in the field.

Scott Dana (MSME '11) designed and built the Wind Energy Dynamics and Control Facility in Lafayette, where the testing is being conducted. He constructed an earlier test cell as his master's thesis. He is currently working as a researcher at the DOE's National Renewable Energy Laboratory just outside Denver.

Adams explains that wind turbines are self-contained units that pay no attention to what another turbine is doing. "As long as the turbines don't interact, there are no issues," he says. But the fact is in large wind farms with turbines 240 feet off the ground, the wind enters one rotor of one turbine extracting energy. What's left travels downstream creating a "wake" that reduces wind speed. Variables such as wind direction and blade pitch can compound the effects of this wake effect.

What is ideal, Adams says, is to optimize the system so the turbines are immune to the effects of wake. "There is existing research that shows the drop in productivity as a result of interaction can be as high as 25 percent in offshore wind farms," he says.

ATTACKING MULTIPLE CHALLENGES

Adams' co-principal investigators on the NSF project are writing computer code and interpreting the mathematical output for the code to make control decisions in real time.

"The wake moves downstream quickly so you don't have much time to react," Adams says. "They are developing computer code and validating that it will work properly all of the time. It's like the adage: 'If you measure it, then you can control it.'"

One of the important parts of the project is exploring the long-term implications of turbines as a system. Ignoring this can result in the economically devastating loss of turbine longevity.

For example, most often the turbines that experience wakes — the dirty air —experience failures more frequently.

"By measuring the interaction better, and making the right control decisions, we can extend the life of the wind turbine," Adams explains — something that is critical to meeting the Department of Energy's 2030 goal.

From a turbine-life aspect, in 2030 the turbines are going to be at the end of their life, Adams says. "Turbines typically are designed to operate about 25 years. We have to look at what we're doing now to improve their life down the road."

The NSF project is just one part of a large, multidisciplinary approach to studying wind energy. Karen Marais, assistant professor of aeronautics and astronautics, is studying reliability of wind turbines. What kinds of measurements and preventive maintenance are needed to reduce the cost of wind energy?

Adams and Marais are co-principal investigators on a project at Sandia Laboratories studying how to anticipate repairs to avoid failure.

FINDING SOLUTIONS

To advance the use of wind energy, it's important to assess the environmental impact on people, flora and fauna.

Bryan Pijanowski, professor of forestry and natural resources, is researching frequency ranges of noise created by the turbines. Are the frequencies affecting the migration pattern of birds? Do bats communicate in a particular frequency range that overlaps with the blades? These are just a few of the questions being explored.

Adams says that with wind energy and other emerging technologies, people tend to focus on the good aspects, like renewability, but don't pay as much attention to the challenges associated with it.

One major misconception, he says, relates to a perceived negative impact on agriculture since many of the turbines are placed on agricultural farms. "People believe that wind turbines could have a negative impact but in the College of Agriculture, faculty researchers have instrumented a wind farm measuring the air coming into the farm and the temperature coming out," Adams says. "They found that the air warms up coming out, which could potentially extend the growing season in the Midwest."

Noise is another concern for nearby residents. Some landowners say the wind turbines are quiet and others complain, Adams says. "Who is right? Maybe both are because of the conditions in which the wind farm operates — the wind speed and topography of the land – these factors affect how sound is generated and propagated."

IMPROVING POWER TRANSMISSION

For a long time, wind turbines were placed in the center of the U.S. — a wind corridor that anyone driving through the area can attest to. The problem, Adams says, is there are few places to hook up the turbines to the power grid.

"You're transmitting power over long distances," he says, "and the longer the distance, the more power you lose." According to the Department of Energy, approximately 6 percent of electricity generated is lost in the transmission and distribution system, costing consumers roughly $25 billion annually.

The U.S. electric grid is a complex network of independently owned and operated power plants and transmission lines that powers our factories, homes and schools. Often taken for granted, the electrical power we depend on is most likely produced by a coal

or gas-fired plant that can be ramped up or down to meet demand. The United States' current electric grid was designed more than a century ago, and its inefficiencies are expensive. Rising energy prices and increased power demands weigh heavily on the aging infrastructure, forcing experts to critically examine the status and health of the nation's electrical systems.

To answer these challenges, utilities will be turning to more efficient transmission and digital infrastructure and communication processes called the smart grid. Purdue, in partnership with Ivy Tech Community College, is training the workforce of tomorrow that can design, develop, install and maintain the electrical grid through the Crossroads Smart Grid Training program.

Maryam Saeedifard, assistant professor of electrical and computer engineering, is researching transmission issues related to offshore wind farms. Her focus is High Voltage Direct Current (HVDC) transmission technology as more wind parks are being planned farther offshore.

"When the undersea cables using three-phase AC current exceed a specific length, power is lost along the way and practically no energy can be effectively transferred from the wind parks," she says. The solution is HVDC transmission in which the three-phase AC current produced by the wind turbines is collected and transformed to higher voltage levels at offshore substation platforms.

"The HVDC substation platforms are based on Voltage Sourced Converters (VSCs)," Saeedifard says. "The main technical challenges in the design of VSCs for HVDC transmission are to improve the efficiency of those VSCs and subsequently the HVDC transmission, and to increase the scalability and modularity of the system to meet any voltage or power level and to improve fault tolerance."

UNDERSTANDING FATIGUE FAILURE

Adams' colleague Sanford Fleeter, the McAllister Distinguished Professor of Mechanical Engineering, is an expert in gas turbine engines who became interested in wind power not just because he thought he could make a contribution to the rapidly advancing science, but also because he recognized its commercial potential.

"When I looked at wind power, I saw a growing business," Fleeter says. "With energy costs going up, wind power is a green alternative."

It also makes sense economically, since wind power is not subject to supply-and-demand fluctuations in the marketplace.

Fleeter constructed a model wind turbine facility at Purdue to study fatigue failure and other issues that arise from the dynamics of the turbine. He quantifies the interactions between the tower and the rotor in a wind tunnel. Because the rotors have three blades that are revolving past a columnar tower, they create a three-beat impulse that affects operational reliability. These vibrations, plus phenomena like acoustic noise from the blade tips, are factors that need to be accounted for. "We're trying to understand and monitor these vibrations, and hopefully be able to control them," he says.

Natalie Barrett, a doctoral mechanical engineering research assistant, is doing computational analysis of the costs associated with offshore wind farms. She is a former project engineer at Pratt & Whitney, a global company specializing in the design, manufacture and service of aircraft engines, industrial gas turbines and space propulsion systems.

"I am evaluating the cost benefit of a wind turbine blade condition monitoring system that detects damage early to prevent failure," she says — something that will contribute to reduced cost for both consumers and the wind industry. "Cost and reliability are critical elements. Consumers want a good price for their energy and wind power owners want to make a good profit."

Adams agrees. "Environmental impacts are here to stay so you have to make sure you design systems in such a way to give maximum benefit with minimum cost. You have to have credible analysis. No developer is going to make money if there are negative environmental consequences."

WHY WIND?

The benefits of tapping the power of the wind are numerous. Approximately 40 percent of total U.S. CO^2 emissions come from power generation facilities. Since substantial amounts of coal and natural gas fuels would be displaced by a 20 percent wind power scenario, CO^2 emissions in 2030 could be reduced by 825 million metric tons. Wind power saves water, too, by not using any of it in the generation of power. Unlike the water-thirsty processes of fossil fuel and nuclear energy generation, generating 20 percent of U.S. electricity from wind would reduce water consumption in the electric sector in 2030 by 17 percent.

And then there is the economic impact. The U.S. Department of Energy report "20% Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply" finds that during the decade preceding 2030 the U.S. wind industry could:

- Support roughly 500,000 jobs in the U.S., with an annual average of more than 150,000 workers directly employed by the wind industry.
- Support more than 100,000 jobs in associated industries (accounting, law, steel work, and electrical manufacturing).
- Support more than 200,000 jobs through economic expansion based on local spending.
- Increase annual property tax revenues to more than $1.5 billion by 2030.
- Increase annual payments to rural landowners to more than $600 million in 2030.

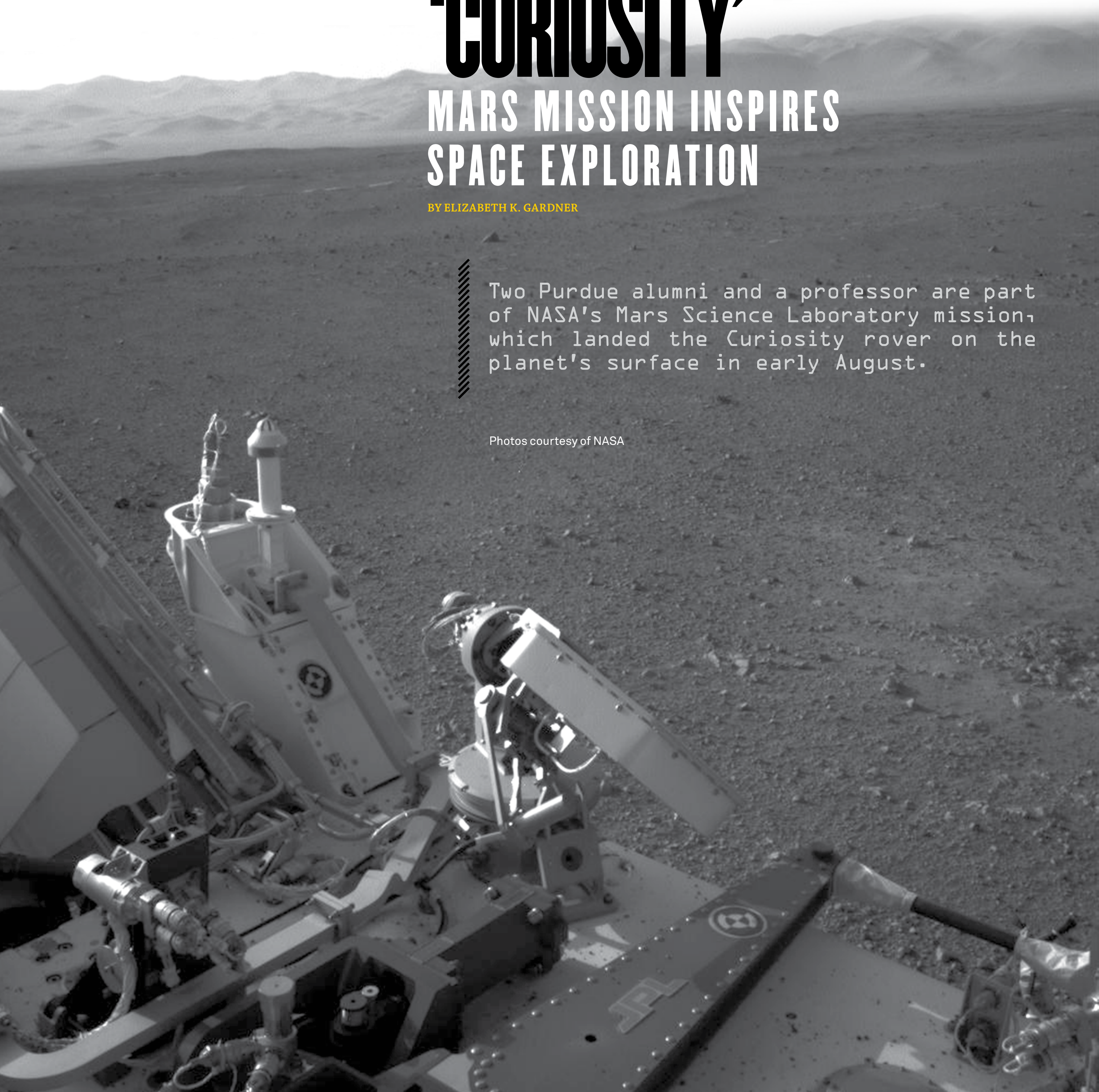
Pictured at left: The Wind and Energy Dynamics and Control Facility allows researchers to test interaction between wind turbines. Purdue University photo/Mark Simons.

'CURIOSITY'

MARS MISSION INSPIRES SPACE EXPLORATION

BY ELIZABETH K. GARDNER

Two Purdue alumni and a professor are part of NASA's Mars Science Laboratory mission, which landed the Curiosity rover on the planet's surface in early August.



Photos courtesy of NASA

NASA Curiosity Mars mission
nasa.gov/mission_pages/msl

> "When ... we got the 'Tango Delta Nominal' call... the atmosphere changed to a chaos of jubilation. It was incredible. A once-in-a-lifetime experience."
>
> - Douglas Adams

Purdue alum Douglas Adams, NASA's Mars Science Laboratory parachute cognizant engineer, helped design, build, test and deliver the parachute decelerator system on the Mars Science Laboratory, or MSL, spacecraft.

Testing of the parachute, which at 130 pounds is the largest ever used outside Earth's atmosphere, took place in the world's largest wind tunnel. The tunnel could hold a 737 jet, but couldn't quite contain the parachute, which peeked out one end of the tunnel, Adams says.

"Being next to something so massive that is moving so quickly gave me an understanding of how an ant must feel when a foot comes to step on it," he says. "The parachute had to be robust because it faced grueling conditions. Here on Earth, a parachute begins to slow an object as it is being deployed, but on Mars the entry vehicle hardly slowed at all until the parachute fully opened. It had to hold up to a very sudden onset of tremendous force."

The parachute was designed to generate up to 65,000 pounds of drag force, according to NASA's Jet Propulsion Laboratory.

Adams also helped develop the mortar deployment system, which he describes as basically an enormous cannon that shot out the parachute.

"The mortar had to fire very precisely as the spacecraft traveled at 900 mph, and any delay of even a half a second would have had a significant effect on targeting," he says. "As with many of the various teams' hardware and systems for MSL, if it had failed, it could have ended the mission. We only had one chance."

Adams said he nervously watched the data with other scientists at the Jet Propulsion Laboratory during the landing event.

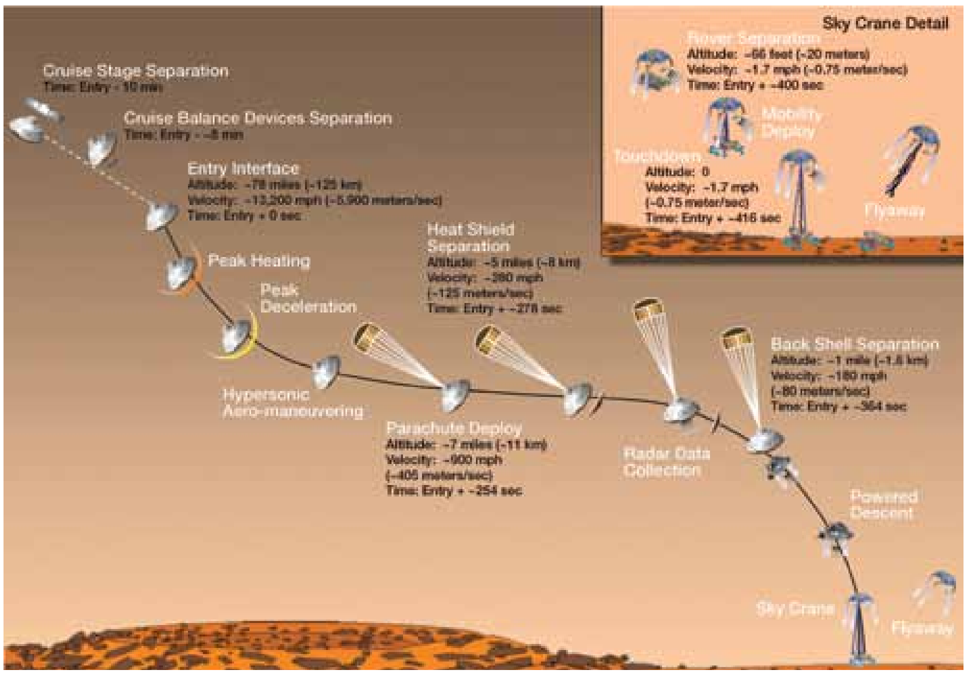
"The tension in the room was palpable as every person there had invested a significant portion of their life in getting Curiosity to Mars," he says. "When the sky crane maneuver was completed and we got the 'Tango Delta Nominal' call, for touchdown nominal, the atmosphere changed to a chaos of jubilation. It was incredible. A once-in-a-lifetime experience."

Adams is a low-density supersonic decelerator parachute systems engineer and soil moisture active passive dynamics and systems engineer at the Jet Propulsion Laboratory in Pasadena, Calif. He earned his bachelor's, master's and doctoral degrees at Purdue in 1994, 1996 and 2001, respectively.

Purdue alum Eugene Bonfiglio, a NASA mission design engineer in the entry, descent and landing guidance and control system group, helped test and prepare the on-orbit contingency plan for the MSL that would have been enacted if a launch failure left the spacecraft orbiting Earth. Bonfiglio helped determine ways to control the spacecraft's fall back to Earth so that it would have landed safely in the Pacific Ocean. He also was involved in performing system tests that helped fine-tune the software used to control the spacecraft during its entry, descent and landing.

Before this mission, most of Bonfiglio's work was related to trajectory and navigation and involved computer simulations. He said he is most looking forward to the measurements from MSL's actual entry, descent and landing.

"As hard as we try, any testing that we do here on Earth to understand aerodynamic interactions that occur during entry and landing will never perfectly simulate the conditions that are actually experienced when flying through the Martian atmosphere," Bonfiglio says. "Not only is this data priceless, but we will get more of it than ever before and it will go a long way in helping us better understand what is actually happening to the vehicle."



Artist's concept of Mars Science Laboratory entry, descent and landing. (NASA/JPL-Caltech)

> "Not only is this data priceless, but we will get more of it than ever before ... ."
> – Eugene Bonfiglio

Bonfiglio earned his bachelor's and master's degrees from Purdue in 1997 and 1999, respectively.

Both Adams and Bonfiglio earned their degrees from the School of Aeronautics and Astronautics.

Steve Schneider, professor of aeronautics and astronautics, evaluated the heat shield that protected the MSL spacecraft when it entered the Martian atmosphere. The heat shield is the largest ever built for a Mars mission. Schneider was on a review board for the thermal protection system. Input from the review led to a change in the heat shield material, he says.

"The heat generated on entry depends on the weight of an object relative to its size and this was the largest, heaviest probe ever landed on Mars," Schneider says. "This heat shield faced a very different scenario from past missions, and its engineering was quite complicated. This was the first Mars mission to use a heat shield made from Phenolic Impregnated Carbon Ablator (PICA), which can handle a much higher temperature than previously used materials."

As the MSL plowed through the atmosphere of Mars, which is 100 times thinner than that of Earth, the heat shield was estimated to reach 2,900 degrees Fahrenheit, according to the Jet Propulsion Laboratory.

The Curiosity Mars rover will function as a mobile laboratory to investigate the current and past environment of Mars' Gale Crater to determine if it is or ever was capable of supporting life. The rover is equipped with 10 science instruments and a robotic arm that can drill into rocks, scoop up soil and deliver samples to internal analytical instruments.

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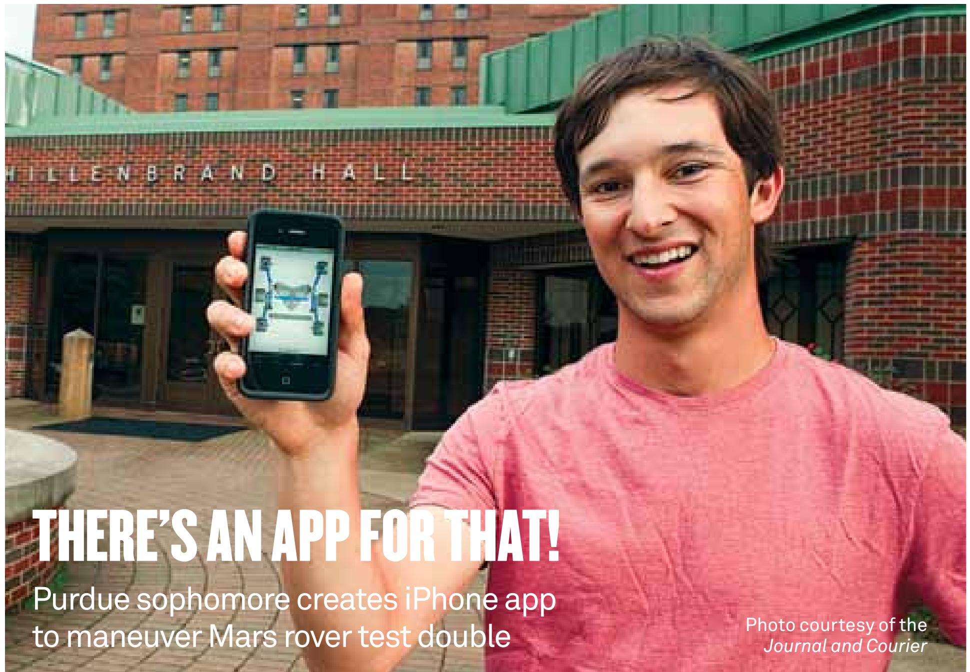


THERE'S AN APP FOR THAT!

Purdue sophomore creates iPhone app to maneuver Mars rover test double

Photo courtesy of the *Journal and Courier*

When engineers at the Jet Propulsion Laboratory (JPL) in California sought an answer to the problem of maneuvering one of the Mars rover test doubles — dubbed Scarecrow — across the Mars Yard at the agency's headquarters, they turned to one of their 450 interns: Riley Avron.

A sophomore in electrical engineering at Purdue, Avron coded nearly 8,000 lines in 10 weeks to develop an iPhone app to accomplish the goal. Previously the test rover was controlled using a low-level but rather obtuse command-line interface.

"The app wraps this interface in a user-friendly graphical manner," he explains. "I wasn't clear on what exactly the interface should look like, so before coding a single line, I drew out a number of possible interface designs and solicited feedback from various employees."

It allows rover drivers to focus more on the behavior of Scarecrow — a full-scale engineering model of the Mars Science Laboratory mobility system — instead of on the mostly irrelevant methods of commanding it, Avron says.

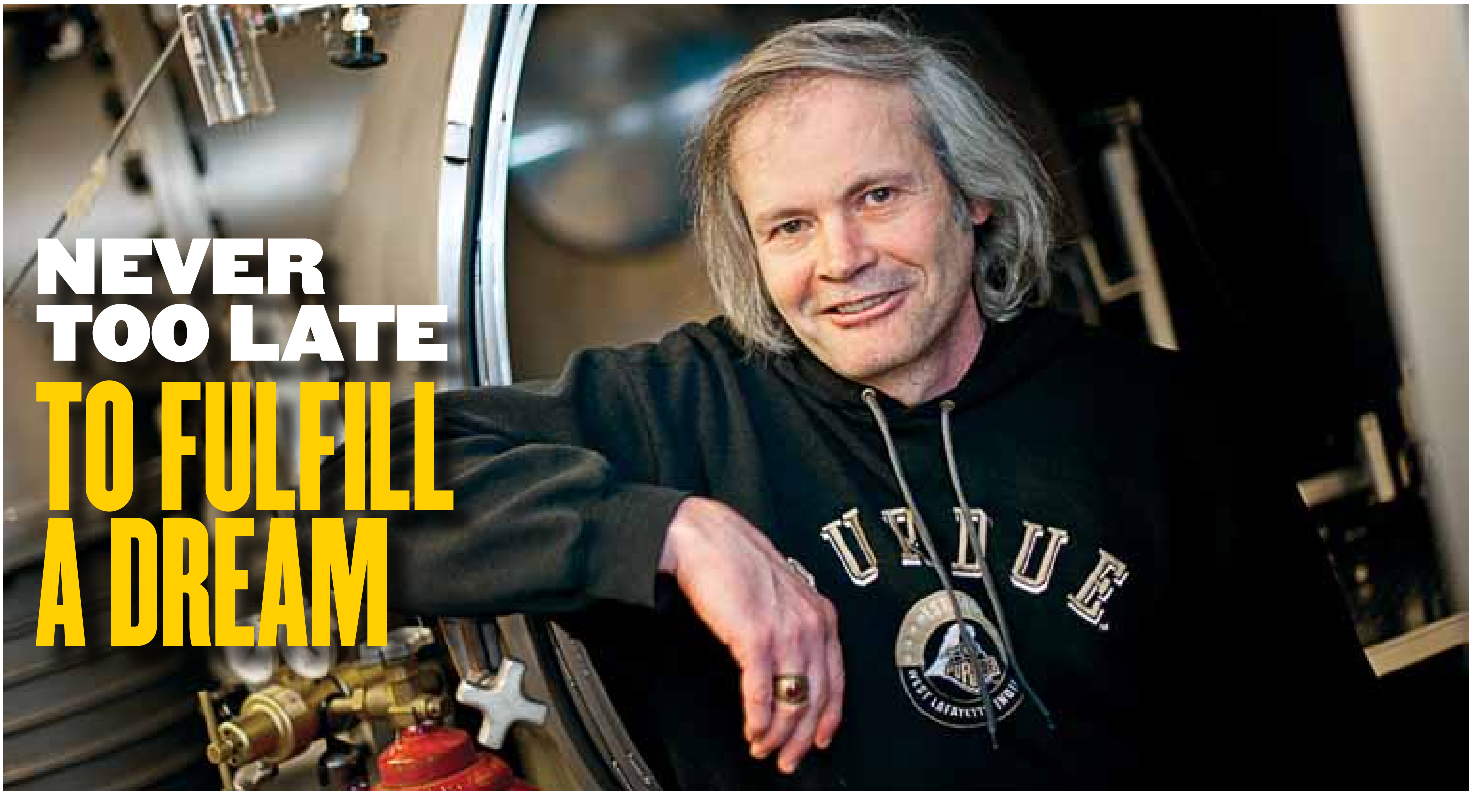
Scarecrow includes duplicates or near-duplicates of all relevant parts from the flight version of MSL. It was tested in the Mars Yard, a Martian terrain simulation area on JPL's campus, to predict drive system response on various terrains on Mars.

JPL staff, including the team tasked with driving Curiosity on Mars, is using the app. Scarecrow's mobility system performance continues to be verified and validated.

This wasn't Avron's first internship at JPL. He started interning there after his junior year at North Hollywood (Calif.) High School. Because of his interest in the Mars project, JPL staff will keep him up-to-date on the latest news about the rover and the mission.

This project has served as an incredible learning tool, Avron says. "I did have some experience with iPhone and iPad platforms prior to the internship, but each new challenge has forced me to research and learn new ways to code on these devices."

What's in his future? Avron says he doesn't have solid plans. "I'm only entering my sophomore year so I have some time to decide. I expect to work on startup ideas, both in software and hardware fields. I figure there's no better time than in college to gamble on a crazy idea."



NEVER TOO LATE TO FULFILL A DREAM

As a young boy growing up 60 miles from Kennedy Space Center in Florida, Tony Cofer could see the big rockets go up into space, fueling his dream of becoming a rocket scientist. The dream, however, was interrupted by reality — 20 years as a laborer in a furniture factory. Now, at the age of 49, his dream is about to come true. He is a year away from receiving a doctorate in aeronautical and astronautical engineering.

Cofer, the first in his family to go beyond a high school education, planned to pursue aerospace engineering when he enrolled in college in 1980. He wasn't ready to apply himself, though, and dropped out to take a job in a furniture factory in southern Indiana. He lived in a mobile home in the woods near the small town of Paoli and liked the quiet life. But in 2006, as the company began outsourcing jobs and reducing worker hours, he decided to jump ship and take a risk. Rather than hitting the unemployment line, he applied to Purdue and hit the books.

"I had to make a change," he says. "It was a choice to start over again in another factory or go back to school and start something else. I knew what I had to do, so I did it. Anybody can do anything if they try hard enough."

Cofer arrived at Purdue in 2007 and blazed into classes, taking 24 credits one semester (the average full-time student takes 15 credits). He wrapped up his undergraduate degree and continued for a master's degree with a focus on propulsion. He anticipates receiving his doctorate in 2013.

Cofer has come a long way from the home-made experiments of childhood, which took place in the basement and involved using mason jars as beakers and light bulb pieces as flasks. Today, his workplace is Purdue's Aerospace Sciences Laboratory, where he works with Professor Alina Alexeenko on microthruster technology.

Microthrusters control the position and orientation of satellites. Cofer hopes to develop microthrusters that are cheaper and lighter and can be used with the nanosatellites and picosatellites of the future.

As for his journey from laborer in a furniture factory to rocket scientist, he takes it humbly in stride.

"When you're a common laborer you aren't given a lot of self-worth. They tell you they can pull anyone off the street to do your work for you," he says. "Hopefully, now, that won't be the case."

■ LINDA THOMAS TERHUNE

Q&A

David Loffing, third from left, leads a team of engineers at Boeing.

DESIGNING FOR EFFICIENCY

Reduce operating costs while helping the environment — that is the goal of Boeing engineer David Loffing, who earned undergraduate and graduate degrees in aeronautical and astronautical engineering at Purdue. He completed two summer internships at Boeing as an undergraduate and was hired full time after earning his master's degree.

Loffing explains his role in the wing development on the new Boeing 747-8, which has resulted in the best fuel efficiency for any large jetliner.

How have you used your Purdue degrees in the development of this new wing?

My engineering degrees established a foundation in science and engineering that taught me what it takes to design an aerospace vehicle or product. I learned how to dissect complex problems into simpler pieces to find solutions. Within the school we had great facilities, like the wind tunnel, that offered hands-on opportunities to design, build and test. You could put a design through its paces to discover any mistakes.

In lay terms how does this new wing design differ from conventional wings?

Most people wouldn't be able to tell a difference just looking at them. The wing for the 747-8 is built off the technology foundation that former chief engineer for development Joe Sutter and his group used to develop the first 747 back in 1960s.

When we looked to bring this airplane to the 21st century, we utilized new tools and technologies that Boeing applied to the 787 and lessons learned from the 777.

If you look at the wing, you might just see changes to the wing tip but the differences go much deeper than that. Everything from the side body all of the way up to the wing tip has changed utilizing the latest in aerodynamic design and new airfoil technology.

Probably the biggest change to the wing design is integrating the engines and the wing together aerodynamically to optimize the shape and loft of the wing for reduced drag and improved fuel burn performance.

We used computational photodynamics. Back in the day we would have to do all of this design iteration in the wind tunnel. With new tools and processes we can now do this on computers and come out with an even more optimal design.

How will this new design help with better fuel efficiency?

Our world is dependent on commercial airfreight and cargo and not just commercial airliners in the traditional sense. A lot of what we use on a daily basis — from electronics to food — is flown on planes.

Bringing in the new, more efficient 747-8 vehicle to the airlines will improve the lives of those around the world and help our industry become a better global neighbor by reducing fuel burn and carbon emissions in a more environmentally efficient fleet of airplanes.

How long was the process for developing the new wing?

I started on the project when I joined Boeing in 2004. After doing a lot of studies it became apparent that we needed a new wing to go along with this new engine.

Airplanes are highly integrated and we couldn't achieve the efficiencies needed just by swapping the engines. I followed the wing through the product development "paper" idea onto the detailed design phase with first flight in 2010 and delivery in 2011. It took about six years from beginning to end.

As a student, did you see yourself following this career path?

I am now a manager in aerodynamic stability control, managing about 20 engineers. The group is responsible for our aerodynamic simulation modeling for all of our commercial airplanes.

If you had told me in 2004 that I would be a manager in the aero industry, I would probably have laughed. When I left Purdue, I considered furthering my education to take more of a technical path at Boeing, not necessarily a managerial path. Life has a funny way of changing.

ON COURSE FOR DISCOVERY

A discovery by any other name might just be as unpronounceable. Yet for Emilia Czyszczon, a newfound passion for research led to a previously unidentified virus that will forever share her name — Czyszczon1.

Czyszczon, a senior in agricultural and biological engineering, dove into research the summer after her freshman year and enrolled in a class where every student had the chance to discover a virus. Jenna Rickus, associate professor of agricultural and biological engineering, inspired Czyszczon to think beyond the normal festering grounds for bacteria and viruses.

After some initial investigation, Czyszczon took her search underground — to Bluesprings Caverns in Bedford, Ind. It was there she collected soil samples from an underground river where cave walls contained mud and dirt with remnants from the Ice Age. "I went to a cave that had glacial mud, so my virus had a lot of evolutionary significance," she says.

Her discovery could be medically significant, too, as the bacteriophage, a virus that infects bacteria, could prove useful in treating diseases like tuberculosis.

All of these possibilities have changed the course of Czyszczon's life. Where she once thought on attending medical school, she now plans to follow a researcher's path in the life sciences. "Most students aren't exposed to research before college," she says. "After gaining more exposure to the process, I realized I wanted to continue research with the goal of helping people in an indirect way."

And she could be well on her way. The National Cave Association has already offered her a fellowship to pay for graduate school. In the best-case scenario, Czyszczon says she would go off to another university for her graduate and PhD work (Purdue typically does not hire their own) and then end up teaching and doing research back at Purdue.

The daughter of Polish immigrants and a Purdue civil engineer (Andrew Czyszczon, CE '69), Czyszczon was signed up to go to the University of Wisconsin when her father suggested that she at least visit his alma mater. "I stepped outside of the car near the Armory and said, 'This is it. This is where I'm going to school,'" she says. "I just had a feeling that I belonged here."

Now the second-generation Boilermaker who bleeds the same old gold and black as her father will continue on her own journey. "I've always been fascinated by places that most people won't go to, like caves or the deep oceans," she says. And who knows the discoveries that await her?

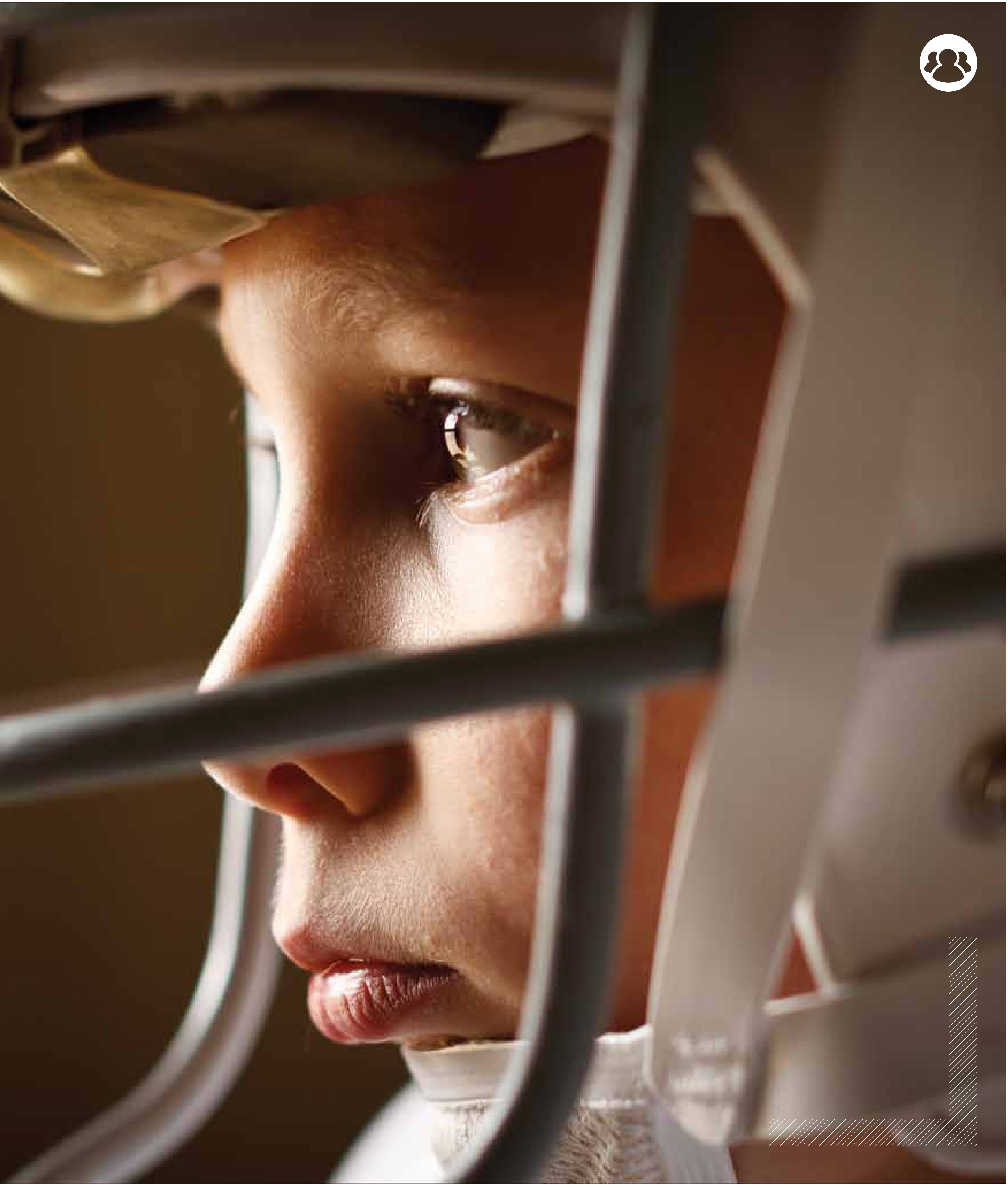
■ WILLIAM MEINERS

WHEN IS ONE HIT TOO MANY?

Purdue researchers are examining subconcussive injury in football players

BY JIM SCHENKE AND EMIL VENERE

The suicide of former NFL middle linebacker Junior Seau focused renewed attention on the problem of brain injuries in football. On June 7, a “master complaint” was filed by more than 2,000 former NFL players and their families alleging that the NFL has ignored scientific research showing a direct correlation between football and brain injury.



Ongoing Purdue research into football players' brains bolsters one element of the lawsuit against the league: Repetitive blows to the head produce subconcussive injury and increase the risk of long-term brain damage and cognitive decline.

The Purdue Neurotrauma Group (PNG) gained national attention in 2010 for its work in studying the brains of high school players. But the research, which first focused on the effects of concussions, now shows something even more disturbing: More than half the players who never suffered concussions experienced neurophysiological changes to their brain that often affects cognitive abilities. This was determined using functional magnetic resonance imaging (fMRI).

"I don't know what the NFL said or didn't say to its players, but fMRI exams repeatedly tell the truth: Repeated blows to players' heads change the way the brains function for the worse," says Tom Talavage, professor of biomedical engineering and a principal investigator. "We may be putting too much focus on concussions. That is only the final straw after thousands of hits over several years."

> "JUST TRYING TO GET RID OF THE **BIG HITS** ISN'T GOING TO SOLVE THE PROBLEM."
> - ED BREEDLOVE

Early research was featured in *Sports Illustrated*, "NBC Nightly News," CNN and PBS' "Frontline." Over three seasons the researchers have used sensors in helmets to document blows to the head. Players take cognitive exams and fMRIs before, during and after the season.

A high school football player may take anywhere from 200 to 1,800 hits to the head during the course of a single season. The researchers have uncovered data contradicting the classic idea that the concussion a player receives in November is completely unrelated to anything that may have happened in August or September.

"What we're finding is that you can get a concussion from a single blow, but if you take a whole bunch of blows before that, the concussion will probably be a lot worse," says Eric Nauman, professor of biomedical engineering and a PNG co-investigator.

Findings could aid efforts to develop safety guidelines that stipulate the number of hits a high school player should receive and may help determine techniques that coaches and players might use to reduce the severity of blows to the head. The work has also led to the development of new shock-absorbing materials for football and the military.

Purdue will also be collaborating with the Big Ten Conference and the Ivy League on a major, co-sponsored research partnership to examine and address concussions and other head injuries among athletes. Combined the Big Ten and Ivy League have more than 17,500 athletes. The initiative, announced June 19, is part of the Committee on Institutional Cooperation, the Big Ten's internal academic association.

NEW HELMET TECHNOLOGIES TO REDUCE G-FORCE TRANSFER TO THE BRAIN

The researchers have been consulting with high school and college athletic associations to improve safety through better coaching and officiating. They have also developed new helmet technologies that dramatically reduce the G-force transferred to the brain.

"Football helmets are designed to protect the skull and the face, not the brain," says Nauman. "We can build a better helmet, but we are probably going to have to find ways to reduce the number of times boys and young men subject their brains to massive G-forces."

New football helmet interior padding has been developed using silicone-based material. Talavage says that when you push it in, it continues to give more than the rigid pads current used.

In an interview with Indianapolis NBC affiliate WTHR-13, Talavage said that the padding "acts as a crumple zone of a car. Your car collapses and in generally your passenger compartment remains relatively intact."

Nauman says that improvements could also come to the helmet's outside material too, adding, "Anytime you can get it to flex or deform without doing damage to the helmet, it will absorb energy and transfer less energy to the skull or brain."

> "WE MAY BE PUTTING **TOO MUCH FOCUS** ON CONCUSSIONS."
> - TOM TALAVAGE

USING BRAIN-IMAGING TECHNOLOGY TO REVEAL CHANGES

Researchers at PNG are using a type of brain imaging technology called functional magnetic resonance imaging, or fMRI, along with a computer-based neurocognitive screening test. The fMRI scans reveal which parts of the brain are most active during specific tasks.

Talavage says the scans have indicated that players are adapting their mental processes to deal with brain changes.

"The changes in brain activity that we are observing suggest that a player is having to use a different strategy to perform a task, and that is likely because functional capacity is reduced," Talavage says. "The level of change in the fMRI signal is significantly correlated to the number and distribution of hits that a player takes."

Though performance doesn't change, Talavage says, brain activity does "showing that certain areas are no longer being recruited to perform a task."

The team wants to increase the number of football players in the study and include soccer athletes, who don't wear head protection, Nauman says. "We also want to include girls to see whether they are affected differently from boys."

Evan Breedlove, a graduate fellow in mechanical engineering, is part of the PNG research team. He says that findings have shown that it's the whole set of hits a player takes that lead up to the final one that "breaks the camel's back."

"Just trying to get rid of the big hits isn't going to solve the problem."

STUDENT ENTREPRENEUR AIMS TO HEAD OFF CONCUSSIONS

Anne Zakrajsek didn't come to Purdue with becoming a serial entrepreneur foremost in her mind. But she knew she wanted to be more than successful. She also wanted to do things that are "significant," work that somehow makes a difference.

One of the first projects that Zakrajsek, a first-year doctoral student in mechanical engineering, will help to commercialize will likely benefit people in helmets who are in danger of concussive brain injuries, including football players and, eventually, soldiers.

Her project to redesign padding for football and other helmets takes a systematic approach to the problem by protecting wearers from concussive forces with multiple energy absorption mechanisms. The system is being tested using standard protocols in order to make improvements on the next design iteration, Zakrajsek says.

The helmet system stems from the work done for her master's thesis and as a graduate research assistant in the Purdue Neurotrauma Group (PNG) and for biomedical and mechanical engineering professor Eric Nauman, a mentor who is himself an entrepreneur.

It was during the data collection time that the team saw the magnitude and frequency of the impacts.

"It was apparent that the current helmets available were not fulfilling their purpose of mitigating impacts," Zakrajsek says. "The obvious next step was to work on designing our own helmet system to better protect against the hits we were seeing."

Zakrajsek told the Purdue Exponent in March that the helmet material was a novel idea designed in parallel with their concussion research.

"We looked at multiple mechanisms for deformation absorption, whereas some of the padding you see in existing helmets only have one mode of energy absorption," she says. "We designed this from the ground up and that's something that hasn't necessarily been done before."

Zakrajsek is pleased to be part of the development of materials and their potential use in safety equipment for military personnel. Blast testing has been conducted on the material in the Zucrow laboratory of Steven Son, professor of mechanical engineering.

"It's exciting to think that what you're doing in the lab could eventually help soldiers who are fighting for our country," she says.

So what's her future goal after earning her PhD? "Ultimately, I would like to start a program at Purdue in which design students develop custom assistive technology solutions for disabled persons," Zakrajsek says. "I believe that engineers need to play a more direct role in the care of disabled persons, especially when it comes to assistive technology and rehabilitation. As engineers, we are problem solvers. Instead of seeing a finite solution to a disability, we can think outside the box and design custom devices that ultimately increase functionality in our patients."

ENGINEERING ACE

Former Boilermaker tennis star helps bring lifesaving products to market.

Brooke Beier came to Purdue for the chance to play Big Ten tennis and earn a first-rate engineering degree. She has stayed through three degrees and now a position at the Life Sciences Institute for Biomedical Development at Purdue to satisfy her passion for discovery and to help see products through to the marketplace.

The daughter of an audiologist (mother) and civil engineer (father), Beier (BS BME '08, MS BME '10, PhD '11) grew up in Michigan all too familiar with the need to treat nagging sports injuries. She first thought of a career in sport medicine, but after entering into a burgeoning biomedical engineering undergraduate program, she quickly found herself heading down a researcher's path.

The success of an NCAA athlete is often contingent upon her ability to balance her time on the court and in the classroom. Beier was dialed in on both fronts. She lettered in tennis in 2005-08 and was named All-Big Ten in 2008 to go along with three Academic All-Big Ten accolades in 2006-08. A team captain her senior season, Beier won 73 singles matches in her career, tied for fifth most in school history; her 79 doubles wins are tied for the Purdue best. She also won the Big Ten Sportsmanship Award for Purdue in her senior year, which goes to just one female and one male athlete from all sports.

Her best efforts in the biomedical engineering labs helped lead to two patents. "My master's focused on the development of a continuous intravascular glucose monitoring system, a closed loop system for diabetics," Beier says. Instead of pricking fingers to get blood, diabetics could use an implanted device to monitor glucose levels directly from the bloodstream.

For her PhD work, also under the supervision of Pedro Irazoqui, associate professor of biomedical engineering and director of the Center for Implantable Devices, Beier used the same technological platform to create a device to wirelessly monitor pulmonary artery pressure in congestive heart failure patients.

That research and patent background makes Beier a good fit for the Life Sciences Institute, where she helps bridge the gap between research and development. "My passion is to see a product through from start to finish," she says.

From better designed football helmets that could soften the blows brought on by repeated potentially concussive hits to a device that will help people living with Parkinson's disease speak louder, Beier not only speaks the same language as fellow researchers but has learned to help them navigate the regulatory lanes of the Food and Drug Administration. A unique entity within a university, Beier and her colleagues enable the researchers to invest their energy in the discovery process.

Experience is often a great teacher and practitioners can make for great leaders. And Beier still keeps it going through tennis and engineering. As a volunteer assistant coach, she was a hitting partner and encouraging voice that helped lead the Purdue women to their first Big Ten tennis championship in 2012.

■ WILLIAM MEINERS

HERITAGE, ENGINEERING COMBINE TO BREW A UNIQUE CAREER

Perhaps it was the German genes. Maybe, fatherly advice. Perchance, a desire to go off the beaten track. Whatever the cause, something led chemical engineer Otto Kuhn to a career that, 35 years into it, he still adores — brewmaster.

Kuhn (BSChE '76) grew up in Managua, Nicaragua; his father of German descent, his mother of Spanish heritage. While beer and beermaking may be distinctly tied to German culture, that is not entirely what led Kuhn to the brewery. His father was a mechanical engineer. A high school teacher instilled in young Otto a love of chemistry. The two came together when he enrolled at Purdue to study chemical engineering. The road from Managua to West Lafayette, seemingly a long one, had been made short by a line of cousins and brothers who had studied pharmacy and engineering in West Lafayette.

In 1976, with a freshly minted diploma, Kuhn returned to Nicaragua and faced the decision of either working for a pharmaceutical laboratory owned by his uncle or making beer. "My father advised me, as a good German would, to make beer," he says. He went to work for Industrial Cervecera S.A., managed, coincidentally, by a graduate of Purdue's Krannert School of Management.

Kuhn supplemented his on-the-job learning with a certificate in brewing from Siebel's Institute of Technology in Chicago. It was there, in 1977, that he encountered his first taste of Budweiser, a meeting now permanently etched in his sensory memory. It is a taste he strives over and over again to create in his current job as an Anheuser Busch brewmaster.

In 1981, after the Sandanistas took control of the Nicaraguan government, Kuhn left his homeland. He signed on with the Lion Brewery in Wilkes-Barre, Pennsylvania, brewing a wide variety of beverages from lagers to natural soft drinks. In 1989, he joined Anheuser Busch and began traveling the world in the name of beer as the company expanded its global reach. He worked with Labatts in Canada; collaborated with a start-up in Spain; spent time in England, Italy and the Philippines; and has been onsite in Argentina. For the last 11 years, he has been based at the company's brewery in Merrimack, New Hampshire.

His job, he says, is not so different from that of other chemical engineers. His chemical is beer; others may work with petroleum. His job, like that of other chemical engineers, is to make sure processes run smoothly. At Anheuser Busch he is responsible for ensuring a consistent "flavor profile" for the 3 million barrels of Budweiser produced by the New Hampshire plant annually.

"Chemical engineering is married into brewing," he says. "Brewing used to be more of an art, an obscure art. I have seen the business grow to computer-controlled systems with 100 heat exchangers. We heat and cool and boil and sterilize and ferment with living organisms. These are all things I learned in chemical engineering. Our job is to maintain consistency with the materials that we have."

One of the biggest differences between Kuhn and his peers may be that other chemical engineers don't taste their products. For Kuhn, it's a required part of the job. He does a lot of beer tasting – ever-seeking to match the first savory gulp he had years ago. If it meets his approval, the beer then travels from New Hampshire to tasters at headquarters in St. Louis, where a corporate panel gives it the official sign-off to be released for sale.

"I have dedicated my whole career to the pursuit of quality and excellence in making one thing — beer. I love what I do. I have never felt like I worked a day in my life. There are so many things you can do with your life," Kuhn says. "Mine? I was lucky enough to start with a brewery."

■ LINDA THOMAS TERHUNE

BODY OF WORK

Alum achieves unprecedented accolades for her breakthrough work in biomaterials and tissue engineering.

A lifelong athlete, Kristi Anseth (BSChE '92) likens her early career success in engineering and medicine to sinking a buzzer beater to win a basketball game. Elected to the National Academy of Engineering in 2009 and the Institute of Medicine of the National Academies in 2010 when she was only 40, Anseth is surely in the midst of a "hall of fame" career for an engineering scientist.

Anseth says she never met an engineer growing up in rural North Dakota, but the possibilities of math and science, with a particular focus on chemistry, put her on an engineering path. Purdue provided the open door to explore those possibilities as she learned more of its reputation.

"Purdue offered a world-class program in chemical engineering and I had a chance to meet and learn from numerous faculty and graduate students as an undergrad," says Anseth, who did her primary work with Nicholas Peppas. "I was surrounded by people who were exceptional examples of the best teachers and researchers."

Anseth would quickly join them as one of the best of the best in her chosen field. After Purdue, it took her just two years to earn her PhD at the University of Colorado, where she stayed and began rising in the faculty ranks and earning awards.

Her research specialty focuses on biomaterials and tissue engineering. "We are interested in using engineering principles to design biomaterials that can help the body heal itself when natural processes go awry from disease or injury," says Anseth, now the Tisone Distinguished Professor of Chemical and Biological Engineering. "This often involves designing materials that present the right chemical and physical signals to cells at the right time and the right place."

Anseth points to initial applications in humans as a promising breakthrough. "We're trying to develop hydrogel materials to help promote tissue regeneration, such as cartilage," she says.

She must be onto something. In 2008, she was named a university professor, the youngest in Colorado history. *Popular Science* named her one of the "Brilliant Ten," and the American Institute of Chemical Engineers named her among the "One Hundred Chemical Engineers of the Modern Era."

The accolades, however, are the byproduct of the excitement Anseth feels every day as she goes to work. "The best part of my day is when I wander through the lab and talk with the members of my research group," she says. "It's inspiring to see their enthusiasm, perseverance in overcoming challenges and passion for discussing ideas. I really learn something new every day."

In February, Anseth received two awards from Purdue — named both an Outstanding Chemical Engineer and a Distinguished Engineering Alumna. In April, the Materials Research Society (MRS) selected her to receive the inaugural MRS Mid-Career Researcher Award "for exceptional achievement at the interface of materials and biology enabling new, functional biomaterials that answer fundamental questions in biology and yield advances in regenerative medicine, stem-cell differentiation and cancer treatment."

The consummate team player, Anseth takes the awards in stride, giving due credit to colleagues. "Professionally, I feel so fortunate to be surrounded by a wonderful team of past mentors, current colleagues, students and my research group," she says. "It's definitely a group effort."

On the personal front, she must occasionally recall those schooldays in North Dakota, when math equations and science projects seemed to offer something greater than solutions and confirmed hypotheses. "I have a 5-year-old daughter and I hope she grows up knowing that there are no boundaries to her dreams," Anseth says. "And that maybe I have been a good example for her."

■ WILLIAM MEINERS

125 YEARS OF EXCELLENCE

Civil Engineering embarked on its road to greatness in September 1887 with 39 students registered. By 1906, the discipline had its own ruddy brick building. Today more than 550 undergraduate students and 420 graduate students specialize in architecture, environment, construction, geotech, geomatics, hydraulics and hydrology, materials, structures and transportation. State-of-the-art facilities include more than 20 research and undergraduate teaching laboratories, two large computer laboratories and classrooms.

In 1887, Civil Engineering's road was paved with lofty intentions that shine as reality in 2012. The school ranks among the nation's top programs, with an undergraduate ranking of 7th and a graduate ranking of 6th as reported by U.S. News & World Report in 2013.

As we celebrate this important anniversary, take a look back at significant events that have shaped the school as compiled by writer Angie Klink and Cindy Lawley, director of external relations.

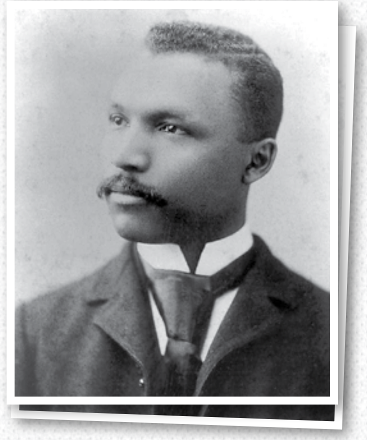
THE BEGINNINGS

President James H. Smart appointed a committee early in 1887 to “have jurisdiction over” the establishment of a course in civil engineering.

In 1896 Professor William Kendrick Hatt was named director of the Materials Testing Laboratory. Hatt was director for 31 years and served as head of the school for 30 years. He began his research on concrete in the spring of 1899, and because of his work, Purdue became widely known for its contribution to the art and science of construction in concrete.

David Robert Lewis was the first African-American to graduate with an engineering degree at Purdue. He received his B.S. in civil engineering in 1894. Lewis became an educator and businessman.

Martha Dicks Stevens graduated in 1897 with a bachelor’s degree in civil engineering, securing her place in history as Purdue’s first woman engineering graduate and pioneering the way for females to enter the engineering field.



William Kendrick Hatt, far left, was said to be a complex person—subtle, brilliant, shrewd, mischievous—and a puzzle to his contemporaries. Robert Lewis, left, wrote a thesis titled Highway Road Construction that included a review of European road building practices.

For mere days in 1894, the majestic tower of the original Heavilon Hall decorated the campus and symbolized the attainment of unequalled engineering facilities before a gas explosion brought the building down.

HEAVILON HALL

A gift of $35,000 from Amos Heavilon with an appropriation of $50,000 from the state made it possible to erect the long-desired mechanical building where students would attend classes along with other engineering students.

On Jan. 19, 1894, the governor dedicated Heavilon Hall as the pride of Indiana. Four days later, there was an explosion in the boiler room, and within two hours most of the new, long anticipated Heavilon Hall burned to the ground.

President Smart watched with tears in his eyes. He was nearly ill from exhaustion after spearheading the construction and had planned to take a year off once it opened. The next day, before the ruins had cooled, as smoke wafted from the rubble and the stench of smoldering wood filled the campus air, Smart spoke words that would become Purdue legend:

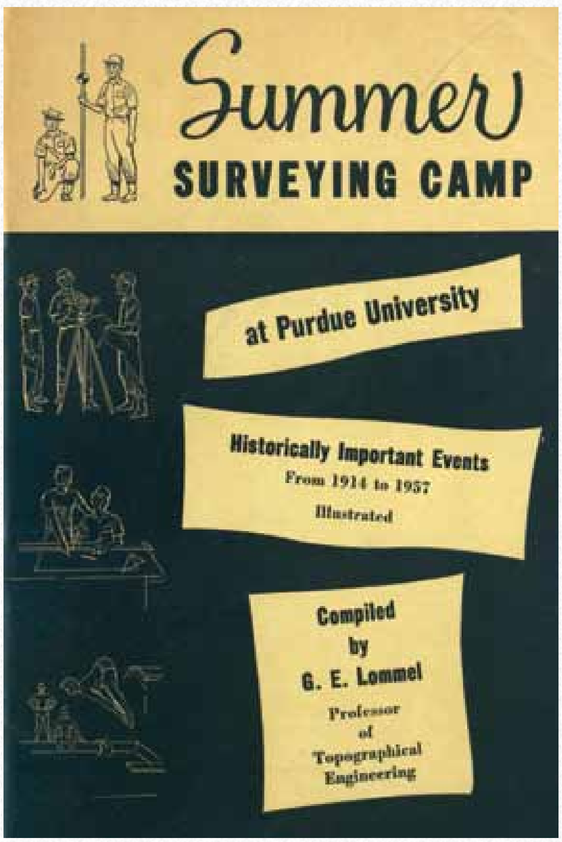
I have shed all my tears for our loss last night. We are looking to the future, not to the past. I am thankful no one was injured. But, I tell you, young men, that tower shall go up one brick higher.

Heavilon Hall was rebuilt taller than the original, but rather than one brick higher, the building with its iconic tower was nine bricks taller than its short-lived predecessor when it opened in the fall of 1894.

CIVIL ENGINEERING BUILDINGS

Enrollment in the school grew from its initial 29 students to more than 400 by 1907. Heavilon Hall was bursting at the seams with both mechanical and civil engineering students. Civil Engineering moved into its own, newly constructed three-story building in 1906. A second and larger addition to the building, facing Grant Street, was completed in 1927.

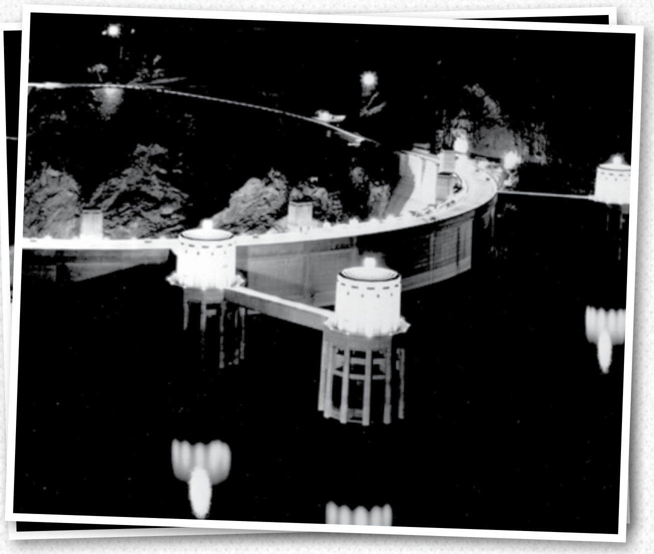
A new building was constructed in 1962, and all but two areas of specialization moved into the modern red brick quarters north of the Engineering Mall. Materials and geotechnical engineering remained in the Grant Street structure, which later was named Grissom Hall, after astronaut alumnus Virgil I. "Gus" Grissom.



SUMMER SURVEYING CAMP

George E. Lommel spent a large part of his life at Purdue, receiving his B.S.C.E. degree in 1910. After graduation he worked as a landscape engineer and laid out a good part of East Hollywood — "when the land was cheap and I could have been independently wealthy if I had had any foresight."

Lommel returned to Purdue in 1912 as professor in topographical engineering. He designed Ross Summer Surveying Camp and was director from 1929 until his retirement in 1958.



ENGINEERING MARVELS: HOOVER DAM AND GOLDEN GATE BRIDGE

Elwood Mead engineered the Hoover Dam, which spans the Colorado River between Arizona and Nevada. Constructed in the 1930s, the concrete arch-gravity structure prevents flooding and provides much-needed irrigation and hydro-electric power to arid regions.

Charles Ellis designed the Golden Gate Bridge — deemed as one of the "Seven Wonders of the Modern World" by the American Society of Civil Engineers. Yet Ellis was only credited in recent history despite designing, in his words, "every nut and bolt on the darn thing." Ellis was a professor of structural engineering at Purdue from 1934 to 1946.

SANITARY ENGINEERING EVOLVES INTO ENVIRONMENTAL ENGINEERING

In 1896, President Smart initiated sanitary engineering at Purdue, which dealt primarily with water supply and waste removal. Typhoid fever was prevalent, and students were ordered not to throw themselves or their fellow classmates into the nearby Wabash River for fear of contamination from the sewage-filled water.

Sanitary engineering may be defined as the art and science of applying the forces of nature in the planning and construction of work pertaining to public or individual health. It is the branch of civil engineering concerned with the health of a community and it's water supply and sewage.

ENVIRONMENTAL ENGINEERING

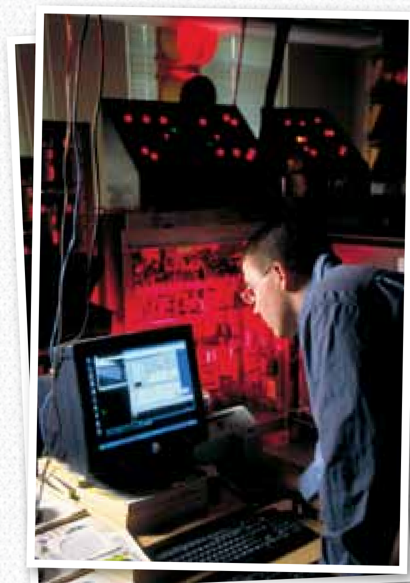
With only one world to live in, environmental engineers help to ensure we handle it with care. The skills of environmental engineers are becoming increasingly important as we attempt to protect the fragile resources of our planet. Purdue's top environmental facilities and faculty place the university at the forefront of research and education.

TRANSPORTATION

When automobiles were first around in the 1920s, Civil Engineering began attracting a large number of students in the academic specialty of transportation. Today, a vital amount of research is done in transportation through various programs indispensable to Indiana's people: the Joint Transportation Research Program (JTRP), the Center for Road Safety (CRS), the Nextrans University Transporation Center, and the Local Technical Assistance Program (LTAP).

Kumares C. Sinha, the Edgar B. and Hedwig M. Olson Distinguished Professor of Civil Engineering, is an internationally recognized expert on various transportation and public works issues, including traffic congestion, road maintenance and traffic planning.

The Harold L. Michael Traffic Operations Laboratory serves as a teaching and research lab for technology related to Intelligent Transportation Systems. The application of information technology more efficiently manages transportation infrastructure.



PANKOW LABORATORY

Charles Pankow earned a bachelor's degree in civil engineering in 1947 and an honorary doctorate in 1983. In 2009, the family gave funds to create and equip a world-class laboratory in his name. The lab was designed to look at materials at the nano, micro, and macro scales, with special emphasis on chemistry and durability of construction materials.

ARCHITECTURAL ENGINEERING

Architectural engineering deals with integrated design, construction and operation of buildings. U.S. buildings account for more than one third of the total energy use and associated greenhouse emissions. In the program, students study the integration of different building systems and learn how to design for sustainability and energy efficiency.

NEESCOMM CENTER

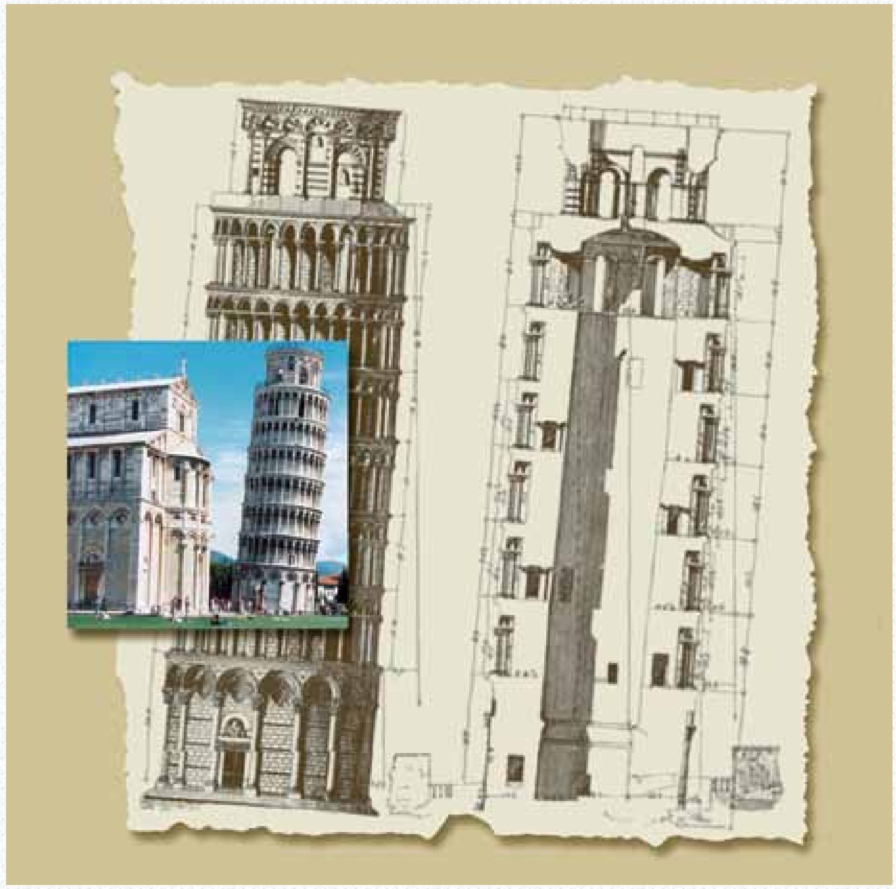
In 2009, the National Science Foundation awarded $105 million to a Purdue-led team to spearhead a center that serves as headquarters for the operations of the George E. Brown, Jr. Network for Earthquake Engineering Simulation, or NEES. Earthquake engineers use information to develop better and more cost-effective ways of reducing earthquake damage through improved materials, construction techniques and monitoring tools.

THE ROBERT L. AND TERRY L. BOWEN LABORATORY FOR LARGE-SCALE CIVIL ENGINEERING

This premiere facility opened in 2002 after the Bowens provided a gift toward a new civil engineering laboratory for the study of large structures. The facility also simulates earthquakes and the effects of high winds on structures and tests beams, structural members, and subassemblies of bridges and buildings that weight thousands of pounds.

CONSTRUCTION ENGINEERING:

Construction has been an important Civil Engineering option from the earliest days. Stephen D. Bechtel, Jr. earned a bachelor's degree in civil engineering in 1946 and serves as chairman emeritus of Bechtel Group in San Francisco, one of the nation's premier engineering and construction firms. Bechtel has led a number of technically complex, one-of-a-kind projects, including the James Bay Project and the England-France Channel.



MATERIALS ENGINEERING

Materials engineers improve the roads we travel on, the coal used to fuel a factory and the sidewalks in our neighborhoods. The research facilities offer hands-on experiences to undergraduate and graduate students in two broad areas: Asphalt and Bituminous Materials, and Portland Cement and Concrete.

GEOTECHNICAL ENGINEERING: KEEPING PEOPLE SAFE

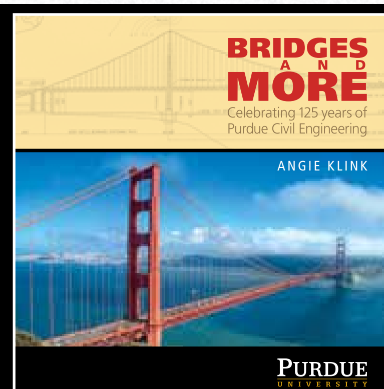
Geotechnical engineers examine the behavior of the earth's soil and rock layers in order to determine their physical and chemical properties.

Gerald Leonards and Fritz Leonhardt, two civil engineering graduates, worked on stabilizing Italy's iconic Tower of Pisa in 1990. A massive restoration and stabilization project was initialized to straighten the tower by removing 38 cubic meters of soil from underneath the raised end. Leonards consulted on the stabilization until his death in 1997. In 2001 the project was completed — straightened by 45 centimeters, returning it to the exact 1838 position.

MOVING FORWARD

Civil Engineering has a long history of educating outstanding engineers, researchers and educators. Graduates have had a hand in shaping the skylines of many great cities, developing the infrastructure that is the underpinning of the world's economic engine and working on a wide variety of environmental issues to improve quality of life.

Bridges and More, Celebrating 125 Years of Purdue Civil Engineering by Angie Klink. Designed by Natalie Powell. Available through Purdue University Press.



NEWS SPOTLIGHTS

01

Purdue engineering professor receives presidential research award

Alice Pawley, assistant professor of engineering education, was among 96 recipients of a Presidential Early Career awards for Scientists and Engineers conferred July 31 by President Barack Obama at a Washington, D.C., ceremony.

The award — also known as PECASE — is the highest honor bestowed by the U.S. government on science and engineering professionals in the early stages of their independent research careers. Awardees are selected for their pursuit of innovative research at the frontiers of science and technology and their commitment to community service as demonstrated through scientific leadership, public education or community outreach.

Pawley, who is studying why some groups, including white women and people of color, have remained chronically underrepresented in engineering degree programs, was excited when she was informed of her selection.

"It's a huge honor to be recognized by the White House," says Pawley, who also is an affiliate faculty member in the Women's Studies program and the Division of Environmental and Ecological Engineering. "Such recognition encourages the American public and funding agencies to support studies aimed ultimately at improving diversity in engineering. I am thrilled that feminist research methods hailing from women's studies, blended with engineering education research questions, have been recognized in this way."

Pawley was among six Purdue faculty members to receive a Faculty Early Career Development award in 2010, the National Science Foundation's most prestigious honor for outstanding young researchers. Women represent about 18 percent of undergraduate engineering students — a proportion that hasn't changed much in two decades. To address issues of underrepresentation, Pawley uses information from the personal experiences of underrepresented undergraduate students to better understand how different institutional structures affect their persistence and success.

Alice Pawley, center, received a Presidential Early Career Award at a White House ceremony in July. John Holdren, science advisor to President Barack Obama, and Cora Marrett, deputy director of the National Science Foundation, are also pictured.

The research may help policymakers learn how to better structure institutions to better meet the needs of underrepresented students. She is developing tools, including systematically collected and analyzed stories from students, to teach policymakers to "learn from small numbers" of underrepresented engineering students, rather than through statistics alone.

"Dr. Pawley's pioneering research represents an important component in efforts to increase diversity in engineering," says Leah H. Jamieson, the John A. Edwardson Dean of Engineering. "She is working to learn some of the root causes underlying why women and people of color continue to be underrepresented in engineering fields."

02

Civil Engineering Building named for alumnus

The Purdue Civil Engineering Building has been named for alumnus and donor Delon Hampton and his mother, Elizabeth Hampton.

Delon Hampton, who has made a $7.5 million gift to the School of Civil Engineering, earned a master's degree in civil engineering from Purdue in 1958 and a doctorate, also in civil engineering, in 1961. He received an honorary degree from Purdue in 1994.

Hampton, of Potomac, Maryland, is the founder of Delon Hampton & Associates (DHA), a top design firm specializing in civil, structural and environmental engineering, and construction and program management and planning services.

He has received the Edmund Friedman Professional Recognition Award and James Laurie Prize from the American Society of Civil Engineers (ASCE) and the Distinguished Engineer Award from the National Society of Black Engineers. He is a fellow of the American Academy of Arts and Sciences and a member of the National Academy of Engineering. He is a past president of ASCE.

"Dr. Hampton is among the school's extraordinarily successful graduates, and it's fitting that the Hampton name will be an integral part of Purdue civil engineering," says Leah Jamieson, the John A. Edwardson Dean of Engineering.

"It also shines a light on Purdue's longstanding commitment to diversity," she says, noting that the School of Civil Engineering had the first Purdue engineering African-American graduate in 1894.

Purdue graduate student Samantha Alberts and professor Steven Collicott discuss details of a zero-gravity flight experiment that flew this June on NASA's "vomit comet," an airplane that induces short periods of weightlessness by flying in steep parabolic maneuvers. (Purdue University photo/Andrew Hancock)

03

Students to design, build experiment to fly on space station

NASA has selected a team of students from Purdue and North Carolina Agricultural and Technical State universities to design and build an experiment to be operated on the International Space Station.

"This project will give students unique and in-depth, real-world, team-based, original, design-build-test educational experiences that will accelerate their learning and their careers," says Steven Collicott, professor of aeronautics and astronautics, whose students will complete the project while taking his course on zero-gravity flight experiments. He is leading the project with John Kizito, a professor of mechanical engineering at N.C. A&T.

The experiment is part of overall work to provide data that could help in the design of systems that require the precise control of fluids and gases, such as life-support equipment and fuel tanks for spacecraft. Students will study the physics of how fluids change shape inside tubes in weightlessness. Findings also could apply to technologies for use on Earth such as fuel cells, medical instruments and miniature diagnostic devices.

Primarily undergraduate engineering students at both universities will design and build the shoebox-size experiment, develop the procedures for operation in space, train the astronauts, process the data, and write research papers describing the results.

"We anticipate the experiment becoming operational in orbit in 2014 or 2015," says Collicott, who has designed previous experiments operated on the space station and also using suborbital rockets and drop towers.

The project includes efforts to inspire middle school students to pursue and enjoy topics in science, technology, engineering and math, or STEM, fields. "We envision curriculum development that teaches basic STEM concepts based on the topic of the experiment," Collicott says. "A great thing about the experiment topic is that we can design desktop demonstrations that middle school teachers and students everywhere can replicate and learn from in a hands-on manner."

04

Hassanein elected ANS fellow

Ahmed Hassanein, the Paul L. Wattelet Professor and Head of Nuclear Engineering, has been elected an American Nuclear Society fellow.

Hassanein earned the highest grade of ANS membership for "his significant development of comprehensive models and computer simulation packages for plasma material interactions for fusion energy applications in both magnetic and inertial confinement, as well as other plasma science applications."

His research interests include plasma material interactions, magnetic and inertial fusion research, radiation damage in materials, computational physics and hydrodynamics, materials under extreme conditions, advanced numerical methods, extreme ultraviolet lithography, laser and discharge-produced plasma, nuclear radiation detection, and high power targets for accelerators. He is also the director of the Center for Materials Under Extreme Environment (CMUXE), which combines state-of-the-art computational tools and experimental devices for beam/target interactions for various applications.

The ANS fellowship is Hassanein's fourth fellowship in less than two years. Hassanein also is a fellow of SPIE, International Society for Optics and Photonics, a fellow of AAAS, the American Association for the Advancement of Science, and a fellow of IEEE, the Institute of Electrical and Electronics Engineers.

Ahmed Hassanein and ANS President Eric Loewen.

05

Energy-dense biofuel from cellulose close to being economical

A new Purdue-developed process for creating biofuels has shown potential to be cost-effective for production scale, opening the door for moving beyond the laboratory setting.

A Purdue economic analysis shows that the cost of the thermo-chemical H2Bioil method is competitive when crude oil is about $100 per barrel when using certain energy methods to create hydrogen needed for the process. If a federal carbon tax were implemented, the biofuel would become even more economical.

H2Bioil is created when biomass, such as switchgrass or corn stover, is heated rapidly to about 500 degrees Celsius in the presence of pressurized hydrogen. Resulting gases are passed over catalysts, causing reactions that separate oxygen from carbon molecules, making the carbon molecules high in energy content, similar to gasoline molecules.

The conversion process was created in the lab of Rakesh Agrawal, the Winthrop E. Stone Distinguished Professor of Chemical Engineering. He said H2Bioil has significant advantages over traditional standalone methods used to create fuels from biomass.

"The process is quite fast and converts entire biomass to liquid fuel," Agrawal says. "As a result, the yields are substantially higher. Once the process is fully developed, due to the use of external hydrogen, the yield is expected to be two to three times that of the current competing technologies."

The economic analysis, published in the June issue of *Biomass Conversion and Biorefinery*, shows that the energy source used to create hydrogen for the process makes all the difference when determining whether the biofuel is cost-effective. Hydrogen processed using natural gas or coal makes the H2Bioil cost-effective when crude oil is just over $100 per barrel. But hydrogen derived from other, more expensive, energy sources — nuclear, wind or solar — drive up the break-even point.

"This economic analysis shows us that the process is viable on a commercial scale," Agrawal says. "We can now go back to the lab and focus on refining and improving the process with confidence."

The U.S. Department of Energy and the Air Force Office of Scientific Research funded the research. Agrawal and his collaborators received a U.S. patent for the conversion process.

06

Ultrasensitive biosensor promising for medical diagnostics

Researchers have created an ultrasensitive biosensor that could open up new opportunities for early detection of cancer and "personalized medicine" tailored to the specific biochemistry of individual patients.

The device, which could be several hundred times more sensitive than other biosensors, combines the attributes of two distinctly different types of sensors, says Muhammad A. Alam, professor of electrical and computer engineering.

"Individually, both of these types of biosensors have limited sensitivity, but when you combine the two you get something that is better than either," he says.

Findings are detailed in a paper published in the May 14 *Proceedings of the National Academy of Sciences*. The paper was written by Purdue graduate student Ankit Jain, Alam and Pradeep R. Nair, a former Purdue doctoral student who is now a faculty member at the Indian Institute of Technology, Bombay.

The device, called a Flexure-FET biosensor, combines a mechanical sensor, which identifies a biomolecule based on its mass or size, with an electrical sensor that identifies molecules based on their electrical charge. The new sensor detects both charged and uncharged biomolecules, allowing a broader range of applications than either type of sensor alone.

The sensor has two potential applications: personalized medicine, in which an inventory of proteins and DNA is recorded for individual patients to make more precise diagnostics and treatment decisions; and the early detection of cancer and other diseases.

In early cancer diagnostics, the sensor makes possible the detection of small quantities of DNA fragments and proteins deformed by cancer long before the disease is visible through imaging or other methods, Alam says.

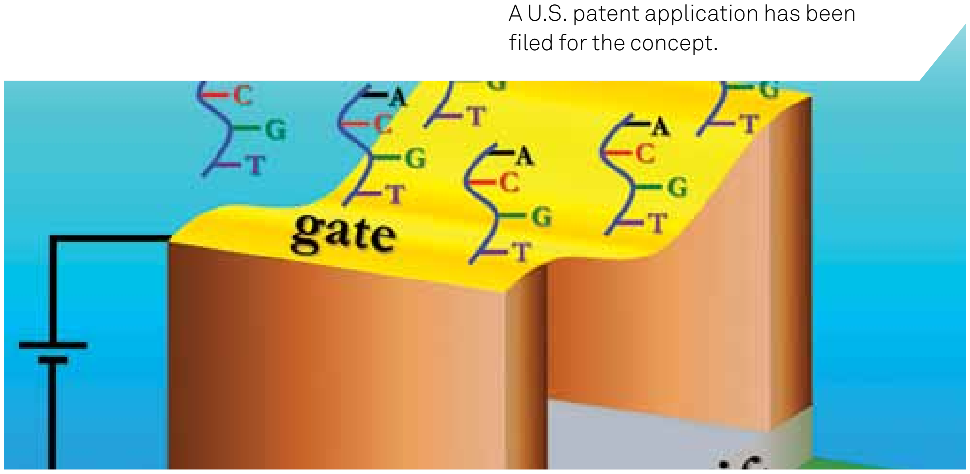
The sensor's mechanical part is a vibrating cantilever, a sliver of silicon that resembles a tiny diving board. Located under the cantilever is a transistor, which is the sensor's electrical part.

In other mechanical biosensors, a laser measures the vibrating frequency or deflection of the cantilever, which changes depending on what type of biomolecule lands on the cantilever. Instead of using a laser, the new sensor uses the transistor to measure the vibration or deflection.

A key innovation is the elimination of a component called a "reference electrode," which is required for conventional electrical biosensors but cannot be miniaturized, limiting practical applications.

"Eliminating the need for a reference electrode enables miniaturization and makes it feasible for low-cost, point-of-care applications in doctors' offices," Alam says.

A U.S. patent application has been filed for the concept.



07

New design tool nixes mouse

Researchers have developed a design tool that enables people to create three-dimensional objects with their bare hands by using a depth-sensing camera and advanced software algorithms to interpret hand movements and gestures.

"It allows people to express their ideas rapidly and quickly using hand motions alone," says Karthik Ramani, the Donald W. Feddersen Professor of Mechanical Engineering. "We're democratizing the design process. You don't have to be an engineer or an accomplished potter to use this. You can be a kid."

The tool, called Handy-Potter, represents a potentially significant advance in how people interact with computers, he says.

"In our lab we have a saying, 'The mouse is dead,'" Ramani says. "With Handy-Potter, we are trying to make the computer interface natural to the user."

The research, funded by the National Science Foundation, addresses the limitations of conventional computer-aided design tools that are needed to create geometric shapes.

Users interact with a computer using natural user interfaces like hand gestures to create and modify shapes.

The tool could have applications in areas including games, architecture, art and engineering design. It uses the Microsoft Kinect camera, which senses three-dimensional space. The camera is found in consumer electronics games that can track a person's body without using handheld electronics.

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