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College of Engineering

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SHERMAN AND JOYCE BOWIE SCOTT HALL fits like a jigsaw piece into Carnegie Mellon University's campus, and was designed with the university's culture of collaboration and sustainability in mind. The building officially opened April 30, 2016.

The building spans multiple disciplines, housing the Wilton E. Scott Institute for Energy Innovation, the Department of Biomedical Engineering, the Engineering Research Accelerator, the Disruptive Health Technologies Institute, and a nanotechnology research facility.

CARNEGIE MELLON UNIVERSITY ENGINEERING

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CARNEGIE INSTITUTE OF TECHNOLOGY
ALUMNI MAGAZINE
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FALL
2016
ISSUE

FROM THE DEAN

DEAR FRIENDS,

Research is at the heart of the College of Engineering. Our capacity for transformative research has made us a top-ten engineering school. The College's research funding accounts for over 40% of the College's overall budget. From a practical perspective, research funding is our lifeblood, but winning grants is not easy. We vie with other leading universities for shrinking research money in a highly competitive landscape. To win robust awards, we have to broaden our reach and demonstrate why the Federal government and others should support us instead of our competitors. To help our researchers find, apply for, and win grants, I have created the Engineering Research Accelerator.

The Accelerator was formed by combining the office of the Associate Dean for Research and the former Institute for Complex Engineered Systems (ICES). By uniting these groups, the Accelerator has in place an experienced team that can identify larger, multidisciplinary research opportunities and provide necessary services to grow our research enterprise.

I think of the Accelerator as a one-stop-shop for providing research assistance to our faculty. It provides an integrated, coordinated, and college-wide set of services for research pursuit, incubation, and support.

The Accelerator targets research opportunities with Federal and State groups and industry partners. Incubation activities entail awarding seed grants, founding new centers and boldly pursuing moonshot initiatives that few institutions other than Carnegie Mellon can deliver on. Already, the Accelerator has incubated the NextManufacturing Center. Yet, none of these important things will happen without steadfast attention to required administrative tasks, and the Accelerator offers pre- and post-award administrative support, contract streamlining, equipment management, and other services.

We will demonstrate through internal reforms that boost efficiency, accountability, and impact, that when people invest in us they can expect a return on their investment. Further, by increasing the quantity and quality of grant applications, we raise the odds that our professors will receive the money they need to do their important work.

I want to sincerely thank Burcu Akinci, director of the Engineering Research Accelerator, and Matt Sanfilippo, chief partnership officer for the college, for helping to make this dream a reality. They, along with the faculty, staff, and students who work within the Accelerator, are ensuring that the College maintains its competitive research advantage.

SINCERELY,

JAMES H. GARRETT JR.
DEAN, COLLEGE OF ENGINEERING

ADVANCED COLLABORATION

@CMUengineering

This icon was recently adopted to represent the collaborative state of our College.

We WANT TO HEAR FROM YOU!

SEND EMAIL TO STOKES@CMU.EDU
Please include your name and, if applicable, major and date of graduation. Letters will be edited for clarity and space.

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FORALLSECURE, A CARNEGIE MELLON UNIVERSITY SPINOFF STARTUP, TOOK HOME $2 MILLION IN PRIZE MONEY AS THE WINNERS OF THE DEFENSE ADVANCED RESEARCH PROJECTS AGENCY (DARPA) CYBER GRAND CHALLENGE (CGC), A FIRST-OF-ITS-KIND HACKING CONTEST IN WHICH ALL PARTICIPANTS ARE AUTONOMOUS COMPUTER SYSTEMS.

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SPRING 2016

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01

FEATURE

FLYING BRIDGE INSPECTORS

Imagine strapping on a harness and dangling yourself over the side of a bridge, 100 feet in the air—the wind whipping past you, the earth far below. It might sound like a scene from a spy movie or a fun idea for a vacation activity. For a bridge inspector, however, it's just another day on the job.

BY **ADAM DOVE**

BUT JUST BECAUSE IT'S ROUTINE doesn't mean it's safe. When hanging by a tether from a bridge, accidents are possible. Service cranes can tip over, workers can be crushed. The job of inspecting our bridges for potential dangers is essential to the safety of the thousands of people who cross them every day—but where there are humans, there's always the potential for error.

That's why Burcu Akinci, professor of Civil and Environmental Engineering at Carnegie Mellon University, wants to leave the dangerous work to the drones.

"Using drones to scan bridges for structural problems could provide data on the conditions of the bridge without putting people in high-risk situations," says Akinci. "We could then analyze this data using algorithms, to gain an objective assessment of bridge conditions."

Akinci, along with a team from the Robotics Institute led by Sanjiv Singh and a team at the Department of Civil and Environmental Engineering at Northeastern University led by Jerome Hajjar, have joined forces to develop the Aerial Robotic Infrastructure Analyst (ARIA). This tabletop-sized drone uses photo and video capture techniques, as well as state-of-the-art laser scanners, to create a high-resolution 3-D model of the bridge which can then be safely analyzed by an inspector on the ground. The project is made possible by a grant through the National Science Foundation National Robotics Initiative.

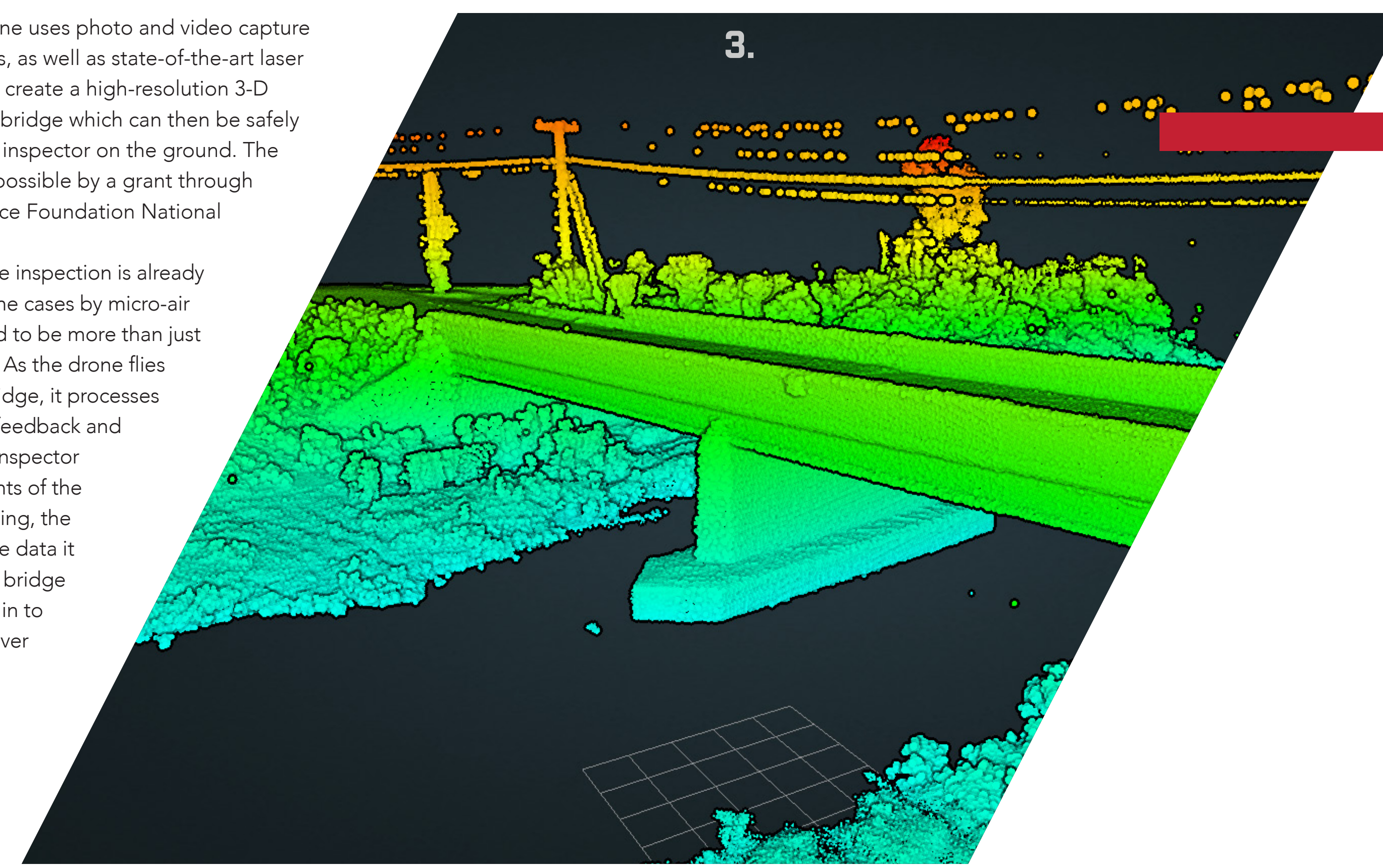
While infrastructure inspection is already being conducted in some cases by micro-air vehicles, ARIA is designed to be more than just a means of data gathering. As the drone flies autonomously around the bridge, it processes the data it gathers, providing feedback and suggestions while allowing the inspector on the ground to make assessments of the bridge in real-time. Then, after landing, the drone's onboard software can take the data it gathered and build a 3-D model of the bridge that inspectors can immerse themselves in to accurately visualize the structure without ever having to leave the ground.

Carnegie Mellon and Northeastern are pioneering this technology, and they predict that ARIA will be one of the first ones in a long line of robotic infrastructure inspection technologies. Already, the researchers are working on applying ARIA's capabilities to other infrastructure problems, such as the inspection and assessment of power transmission lines.

"The unique aspect of this team is that it combines the robotics perspective, the vision-based data processing perspective, and the civil engineering condition assessment and structural analysis perspectives," Akinci says. "This allows us to approach the complicated problem of infrastructure inspection from multiple perspectives and create a system that works for everyone involved in the process."

Thanks to this unique combination of perspectives, our bridges' near future will be safer for civilians above and below.

1. BRIDGE INSPECTING DRONE
2. INSPECTOR USING A DRONE TO EVALUATE BRIDGE
3. 3-D MODEL OF BRIDGE DYNAMICALLY CREATED BY DRONE



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USING DRONES TO SCAN BRIDGES FOR STRUCTURAL PROBLEMS COULD PROVIDE DATA ON THE CONDITIONS OF THE BRIDGE WITHOUT PUTTING PEOPLE IN HIGH-RISK SITUATIONS. WE COULD THEN ANALYZE THIS DATA USING ALGORITHMS, TO GAIN AN OBJECTIVE ASSESSMENT OF BRIDGE CONDITIONS."

BURCU AKINCI

ADVANCING ADDITIVE MANUFACTURING IN THE AEROSPACE INDUSTRY

BY LISA KULICK

Carnegie Mellon engineers are leading a collaborative initiative to develop computational technologies for optimal design and fabrication of complex core structures for the aerospace industry.

Funded by a $970K award from America Makes, the project's research partners include: Automated Dynamics Corporation; Aurora Flight Sciences; Lockheed Martin Aeronautics; Siemens Corporate Technology; Stratasys; and United Technologies Research Center (part of United Technologies Corporation).

Professors of mechanical engineering Levent Burak Kara, Kenji Shimada, and Burak Ozdoganlar are leading the project, which aims to provide engineers with a software tool that optimizes the design and manufacturing process by taking advantage of 3-D printing technology, also known as additive manufacturing.

Cores are internal scaffolds or skeletons that are wrapped in high-performance outer skin materials to form aerodynamic structures, like airplane wings. These cores must be strong enough to withstand the traveling forces of being wrapped in material, yet simple enough in shape to be removed after they have served their purpose, leaving the skin as intact as possible. The last thing an airplane wing needs is excess, unnecessary weight.

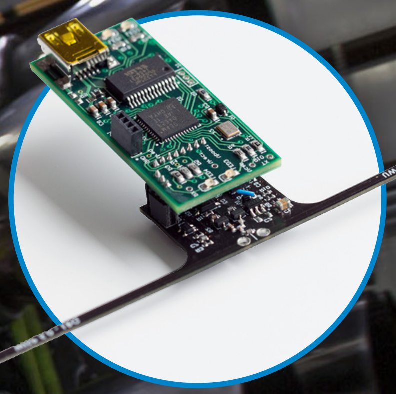
"Because the current process uses traditional fabrication methods, it is labor intensive and expensive," said Kara. "We want to take advantage of the design space enabled by additive manufacturing with a computational design tool that will identify solutions that humans have not yet conceived. This will take topology optimization to a whole new level."

How would the design software optimize the traditional process? In addition to reducing design time, it would allow for cores to have more intricate, geometric shapes to increase aerodynamics and functionality. Because these new cores would be 3-D printed from a lightweight polymer material, they could easily be broken into smaller pieces, dissolved, or not need to be removed at all.

"Optimizing this process will greatly decrease life-cycle energy costs in the aerospace industry, resulting in thousands to millions of dollars in savings," said Kara. A feature of the software is that it will integrate with existing computer-aided design (CAD) platforms.

Another component of the project will focus on workforce education. The project team will develop learning materials such as digitally disseminated lectures, software, and tutorials. A large-scale grand challenge will provide an active, hands-on competition to engage students as well as those in industry.

The project is titled "Optimal design and AM of complex internal core structures for high performance aerial vehicle production."



STAMP SIZED SATELLITE

BY KRISTA BURNS

ECE Assistant Professor Brandon Lucia and Ph.D. student Alexei Colin developed the first programming language for intermittently-powered computing devices, called Chain. Chain enables intermittently-powered systems to operate reliably, even when they are running on scarce energy harvested from their sources in their environment, like radio waves or solar energy. Chain makes possible a new wave of highly reliable IoT applications, implantable and ingestible medical devices, and other emerging applications. As a first deployment, Lucia's team is working together with nano-satellite company KickSat, as well as collaborators at Disney Research to send two tiny, postage-stamp-sized satellites into low-earth orbit. The satellites will operate using minuscule energy from tiny solar panels to collect and process sensor data and send information back to earth. While satellites are typically powered by solar energy, these satellites will be the first with strong software correctness guarantees furnished by Chain, ensuring continuous, reliable operation.

02

RESEARCH

UBIQUITOUS LIQUIDS OF THE COMPLEX KIND

Sunscreen, laundry detergent, the can of paint you just picked up from the hardware store. What if we told you that your everyday liquid consumer products aren't just liquids—they're a complex blend of liquid and solid particles?

BY **EMILY DURHAM**

IF YOU WERE TO LOOK VERY CLOSELY—say, with a high-powered microscope—you'd see tiny solid particles suspended in these liquids that are not actually dissolved, but floating in place. The forces of physics keep these particles in place to make your products work. These forces may be microscopic, but they're no small challenge to engineer.

Bob Tilton, professor of chemical and biomedical engineering and director of the Center for Complex Fluids Engineering, has received a three-year, $365,000 NSF grant for a project titled "Synergistic or antagonistic effects of polymer/surfactant supramolecular assembly on the colloidal depletion force," which will explore the forces that cause particles to suspend or aggregate in complex fluids.

BUT WHAT MAKES CERTAIN FLUIDS "COMPLEX"?

"Lots of liquids are what we would call simple liquids—everything in the liquid is dissolved," explains Tilton. "We also have liquids that we refer to as complex fluids. There are many different kinds of complex fluids, one of which would be where some of the components of the liquid are not actually dissolved, but are suspended as very small, sub-micron particles."

Take your paint can, for example: the pigment particles used to tint the paint are not actually dissolved. They're solids suspended in a liquid base, whereas dishwashing detergent molecules are truly dissolved, surfactants, that spontaneously self-assemble into bigger swarms of molecules called micelles.

The applications of complex fluids engineering are ubiquitous and significant—the same principles that allow engineers to suspend particles in sunscreen and lotion can be manipulated to planarize, or polish, microchips. Chips wouldn't work if they couldn't be planarized, which is done with suspensions of solid particles in metal polishing liquids. The grit and debris that come off of planarized circuits have to be suspended in the liquid and not redeposited on the surface; the same physical chemistry used to create sunscreen helps in the fabrication of functioning microcircuitry.

Forces between suspended particles are either repulsive or attractive—particles either avoid each other or pull toward each other—and in order to get a stable suspension of particles, engineers need to strike the right balance between those forces. Tilton's project examines how to gain control over "depletion force," a force determined by how many dissolved polymers are able to fit between suspended particles. The smaller the gap between suspended particles, the fewer dissolved polymers can fit between them, and the greater the pressure around the suspended particles, pushing them together. In other words, a higher depletion force means greater attraction.

For a product like paint, a higher depletion force would mean a more watery liquid, as the attracted and clustered pigment particles would sink to the bottom of the can. But if removing particles from a liquid were your goal—like in water treatment processing, for example—then a higher depletion force causing unwanted particles to attract and aggregate out of the solution would be very desirable.

"

THE THING ABOUT THE FIELD OF COMPLEX FLUIDS THAT I THINK APPEALS TO SO MANY OF US IS THAT THE SAME PHYSICAL AND CHEMICAL IDEAS WORK IN MANY, MANY DIFFERENT SETTINGS. IT'S AN ENABLING DISCIPLINE FOR A HUGE VARIETY OF INDUSTRIAL AND CONSUMER PRODUCTS, PHARMACEUTICALS, NATURAL ENVIRONMENTAL PROCESSES, AND TECHNOLOGICAL APPLICATIONS.

BOB TILTON

THE VENTS IN YOUR OFFICE AREN'T JUST PUMPING OUT AIR

BY **ADAM DOVE**

WE RELY ON OUR HVAC SYSTEMS to keep us cool when it's hot and warm when it's cold—but that's not all they're doing. Current systems waste huge amounts of energy and hemorrhage money as a result. It's estimated that buildings consume more than 40% of our country's energy, and of that energy, nearly one third is wasted due to outdated, inefficient systems like heating and cooling. Not only is this hard on the environment, significantly contributing to greenhouse gas emissions, it's also hard on our wallets. Even cutting out half of these inefficiencies could lower the nation's annual energy bill by nearly $80 billion.

Professors Mario Berges of the Department of Civil and Environmental Engineering and Anthony Rowe of the Department of Electrical and Computer Engineering have come up with a way to combat these inefficiencies. Where current HVAC systems assume maximum occupancy in each room, Berges and Rowe aim to develop a system that can be installed into HVAC units, which will use depth sensors to accurately estimate how many people are in a particular room. That way, the system can stop heating or cooling empty rooms, and instead focus the energy on occupied ones.

The project is funded by the Department of Energy (DOE), as part of their $19 million dollar investment into 18 different projects designed to reduce building inefficiencies. The DOE's aim is to reduce energy use in the U.S. buildings sector by 30 percent by the year 2030.

"If this project is successful, consumers will have indoor environments that are able to adjust their own temperature, to maximize comfort for their inhabitants, while minimizing energy consumption," Berges explains. "We expect to be able to significantly reduce the energy consumption of heating, ventilation, air conditioning, and lighting for spaces installed with this solution, simply through gathering more accurate information about occupants."

The project will develop a depth-sensor-based occupancy estimation and HVAC control solution that can be easily installed into existing buildings. The system will be able to sense and take into account much more than just the number of occupants in a space—using even the specific clothing worn by occupants to determine the space's ideal temperature.

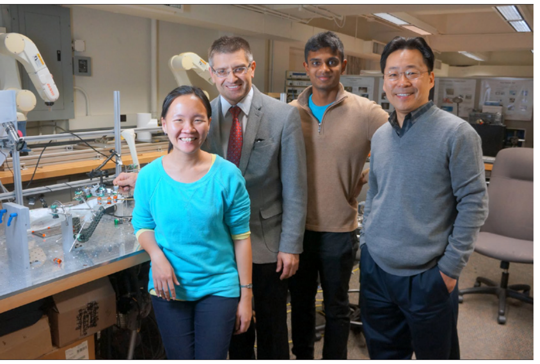
Berges, Rowe, and the rest of their team will begin work on the three-year project in the fall of 2016, in partnership with Bosch Research and Stony Brook University.

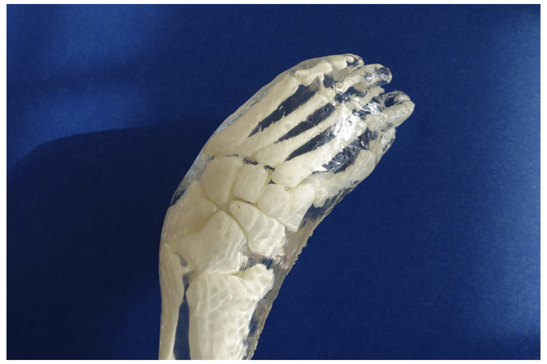
40 PERCENT of our country's energy consumed by buildings

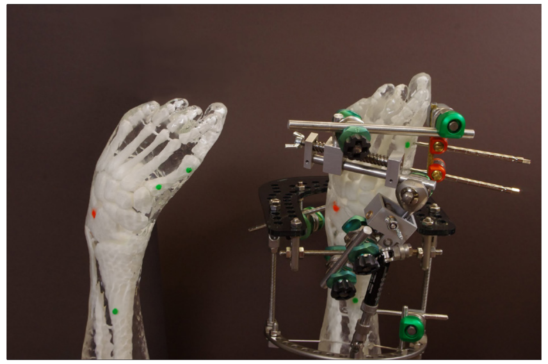
DOE target date for reducing U.S. building energy use by 30% **2030**

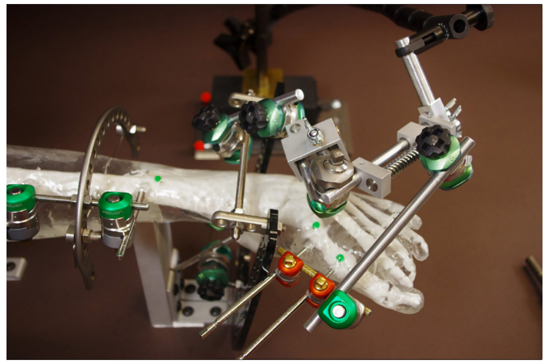
80,000,000,000 DOLLARS projected yearly national energy savings achieved from eliminating half of building heating and cooling system inefficiencies

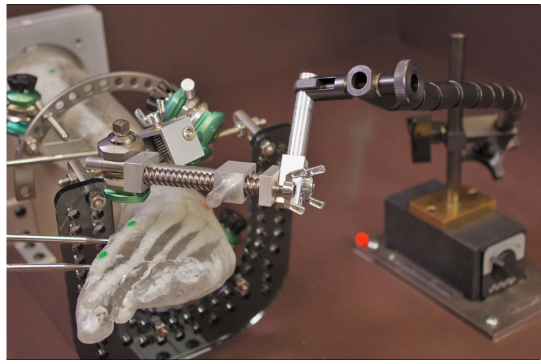
19 MILLION DOLLARS DOE investment in 18 different projects to reduce building inefficiencies











3-D PRINTING BETTER MEDICAL TRAINING

If we are learning how to drive a car or speak a foreign language, the notion "practice makes perfect" applies. But how do you learn something where the stakes are higher? How do you train a surgeon?

BY **HANNAH DIORIO-TOTH**

"**THERE'S AN ANALOGY** we tell surgical residents. When you are using an ultrasonic cutter on the skull, we say you should treat it like you were trying to carve an eggshell," explains Boyle Cheng, director of research for the Allegheny Health Network Neuroscience Institute and adjunct professor in the Department of Biomedical Engineering. The thought of carving an eggshell, without puncturing the thin membrane below, magnifies the learned precision of the field. "If your loved one was getting brain surgery, wouldn't you want their surgeon to be able to carve an eggshell?"

One of the most important ways to train young surgeons is, yes, practice. Hands-on training usually means operating on cadavers, which can be scarce, expensive, and difficult to store. Or, students can sacrifice some of the realistic feeling of human tissue and practice on foam models.

"It's important that a student does as many simulations as they can. And the closer that simulation is to reality, the closer it is to actually feeling what it's like to operate on a patient," Cheng says.

For a new type of hands-on surgery training tool, Cheng is looking to Mechanical Engineering Professor Kenji Shimada. Shimada's team, which includes BME Ph.D. alumna Ying Ying Wu, and MechE graduate student Mabaran Rajaraman, has combined their expertise in mechanical design, medical devices, and biomedical applications to create the *medical phantom model* for training surgeons. Currently designed for training orthopedic surgeons, the model combines hard, bone-like material with a soft gel that mimics human tissue.

"The human body is incredibly complex: bones have coral-like, three-dimensional internal structures, and they are surrounded by layers of membranes, ligaments, tendons, and muscles. When training orthopedic surgeons, what we have found to be critical are the bone with the internal structure and the soft material around it," says Shimada. "Intellectual curiosity asks us to make this model as accurate and close to the real thing as possible. But as engineers, we are really trying to identify and include the minimum set of anatomical components that will work as a training tool."

The team uses 3-D printing to create the bones, giving them the ability to build specific models directly from patients' CT scans. Using this technique, they have honed in on one specific training area: clubfoot correction surgery. This research, titled "A Patient-Specific Flexible 3D Printed Orthopedic Model for Training and Teaching of Clubfoot Correction Surgery," was recently published as a featured article in *3D Printing and Additive Manufacturing.*

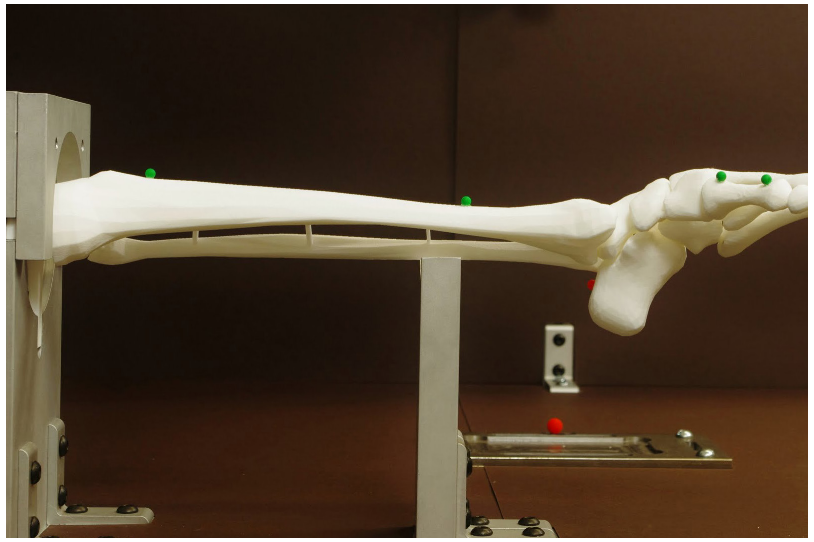
About 1 in 1,000 babies are born each year with clubfoot in the United States, and in developing countries, such as the Polynesian Islands, about 75 babies in 1,000 are born annually with the birth defect. Caused by short tendons in the foot, clubfoot rotates an infant's foot or feet inwards. It is often so severe that the bottom of the foot is turned entirely upwards to expose the soles of the feet. Left untreated, children afflicted with the condition are unable to walk normally.

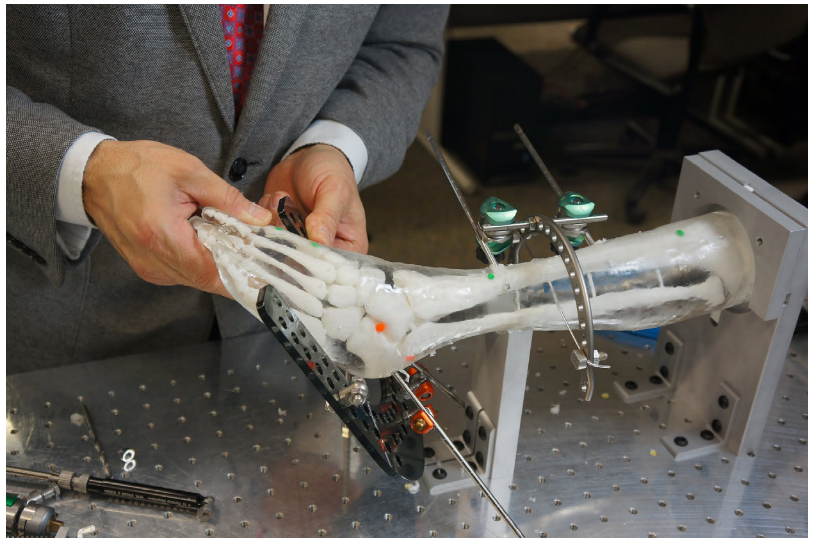
Shimada's group is developing other applications of the 3-D printed medical phantom model and hope to partner with a local surgical residency program soon. The researchers are optimizing the training tool by varying the internal structure of the bone-like material to better mimic the tactile sensation of drilling through a bone during surgery.

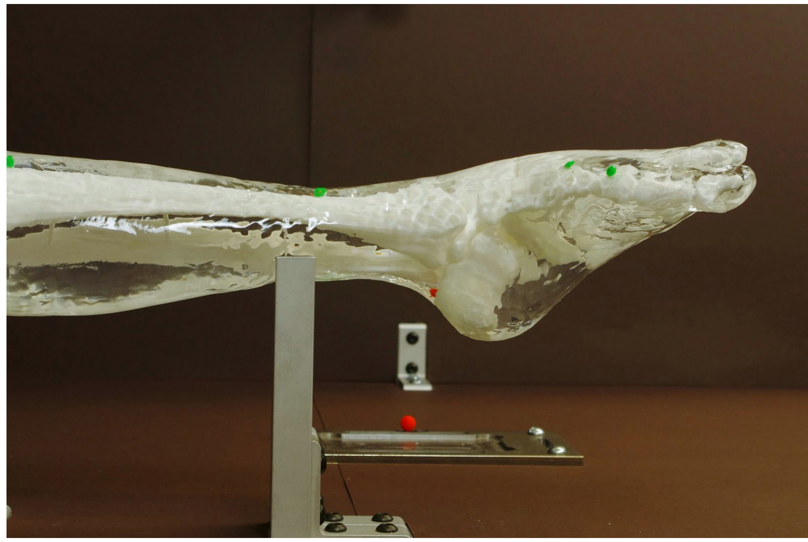
"This is a nice example of how technology from CMU can be transferred to medical education. We often think of treatment as direct-to-patient care. But this technology is about making better surgical residents, which makes for better patient care," says Cheng. "Innovation can infiltrate the healthcare system in many different ways as long as we keep an open mind about it."

"THIS IS A NICE EXAMPLE OF HOW TECHNOLOGY FROM CMU CAN BE TRANSFERRED TO MEDICAL EDUCATION. WE OFTEN THINK OF TREATMENT AS DIRECT-TO-PATIENT CARE. BUT THIS TECHNOLOGY IS ABOUT MAKING BETTER SURGICAL RESIDENTS, WHICH MAKES FOR BETTER PATIENT CARE. INNOVATION CAN INFILTRATE THE HEALTHCARE SYSTEM IN MANY DIFFERENT WAYS AS LONG AS WE KEEP AN OPEN MIND ABOUT IT."

BOYLE CHENG







Air Quality

CARNEGIE MELLON AWARDED $10M FOR CENTER FOR AIR, CLIMATE AND ENERGY SOLUTIONS TO IMPROVE HEALTH OUTCOMES

Carnegie Mellon launched a multidisciplinary, multi-institutional research center, funded by a $10 million grant from the Environmental Protection Agency (EPA). This Center for Air, Climate and Energy Solutions represents an unprecedented approach to the integrated management of air quality, climate and energy.

BY **LISA KULICK**

THE CENTER, which was announced in May, is measuring and mapping air pollutant concentrations across the country to improve the health of vulnerable populations like children, the elderly and those suffering from cardiac, respiratory and other medical conditions. It will develop air quality assessment tools to help average citizens and policymakers alike understand which regions and neighborhoods hold the most health risk.

"Issues like shale gas development, electric car subsidies and power plants of the future are interconnected issues that require integrated thinking," said Allen Robinson, the new center's director and head of the Department of Mechanical Engineering. "When you consider that air pollution is the 4th leading cause of death globally, an innovative approach to addressing pollution and climate change challenges is critical."

One goal of the center is to develop an app that will recommend the route to take for a bike ride or morning jog based on real-time air quality measurements that compare one route to another.

Another goal will address the urban development of future cities as their electricity and transportation needs evolve. According to Robinson, public policy will need to evolve, also. "Policymakers need to understand how future changes in cities, transportation and industry impact air quality and public health. Ideally, this knowledge will lead to the creation of smarter cities," he said.

"This grant from the EPA recognizes the College of Engineering for its leadership in multidisciplinary and adaptive problem solving," said James Garrett, dean of the College of Engineering. "The new center is excellent progress toward our strategic goal to bring more research centers into the university and it leverages our strengths in engineering to improve the quality of life for people and ensure the well-being of our planet."

Carnegie Mellon's College of Engineering has 10 faculty members who will collaborate with experts from seven other participating institutions across North America. In addition to Robinson, other project leaders include: Peter Adams, professor of civil and environmental engineering and engineering and public policy; Spyros Pandis, research professor of chemical engineering; and Albert Presto, assistant research professor of mechanical engineering.

$750K EPA GRANT FOR MONITORING AIR POLLUTION IN PITTSBURGH

BY **ALEXANDRA GEORGE**

AS A RESULT OF THE LAUNCH of the Center for Air, Climate and Energy Solutions, the university received this grant in August 2016.

While Pittsburgh no longer turns on its lights at noon to see through the smog, the famous Steel City is still infamous for its air pollution. Many communities suffer from high levels of pollutants detrimental to residents' health.

Motivated by the need to improve air quality and human health, Carnegie Mellon researchers were awarded a $750K NCER STAR grant by the EPA for monitoring air pollution in Pittsburgh communities. The project seeks to reduce exposure to pollution by placing low-cost sensors around neighborhoods that deliver readings to residents in terms they can understand.

"The idea is for scientists to reach out towards the community and give them the information that they need in context," said R. Subramanian, principal investigator and research scientist in the Department of Mechanical Engineering.

Multiple, low-cost RAMP sensors will provide localized information. The sensors will identify the gradient of air pollution in the city, instead of generalizing pollutant levels for all of Pittsburgh. For example, on the same day the air is clean in Shadyside, pollutant levels could be dangerous in Braddock.

"People who have asthma or want to minimize their exposure to air pollution will know the air quality specific to their area," said Subramanian. "If levels are high, perhaps they will not send their child to the playground that day."

The project focuses on environmental justice communities, or communities that unfairly bear the cost of pollution exposure. These are often economically depressed areas located near coking plants or other high-emission facilities where housing prices are inexpensive. In Pittsburgh, these areas include Mon Valley, Braddock, Clairton, and other neighborhoods.

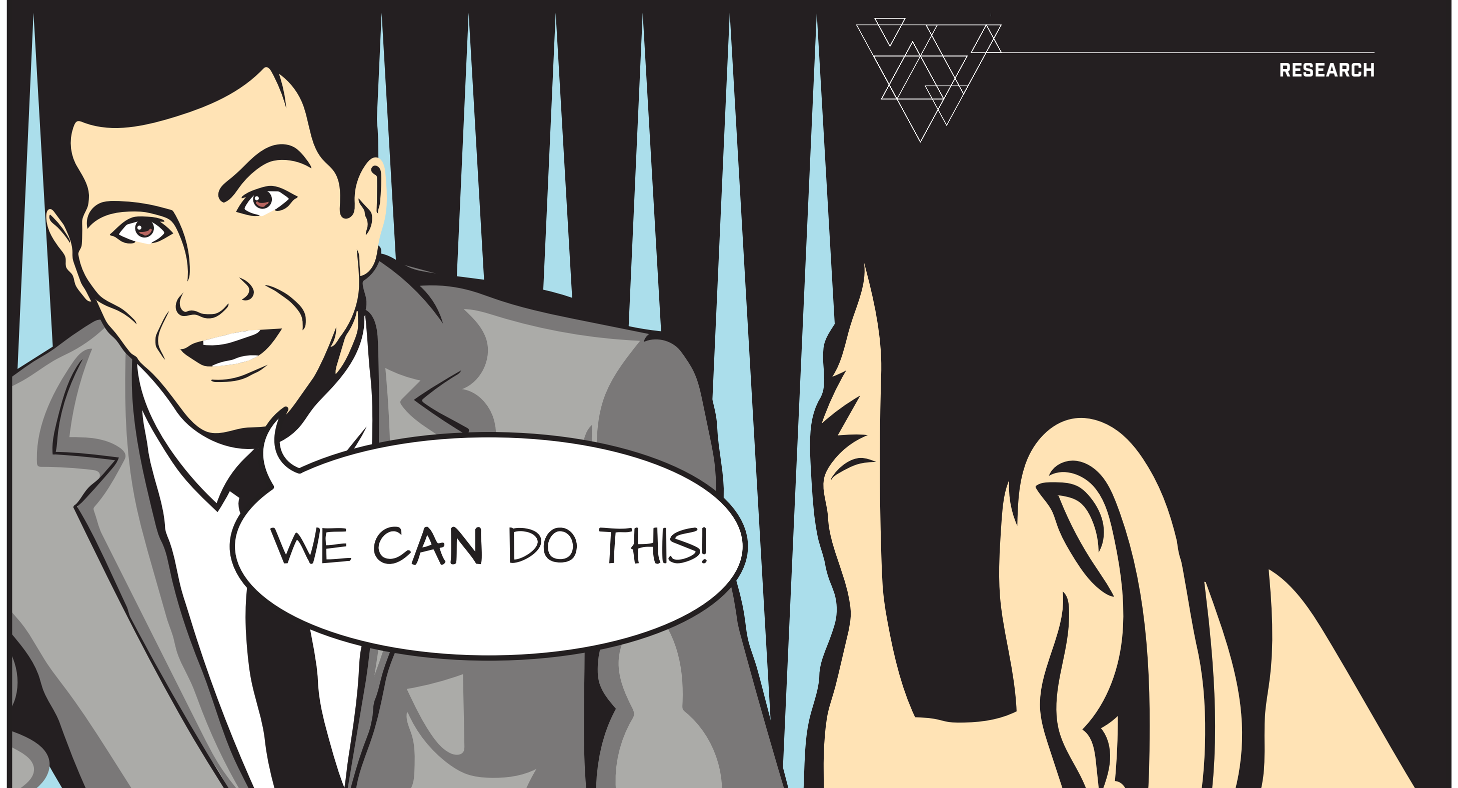
Pittsburgh community groups Clean Water Action, Group Against Smog and Pollution (GASP), and Clean Air Council will partner with CMU's Center for Atmospheric Particle Studies, CREATE Lab, and Social and Decision Sciences for community involvement and outreach.

The project will create a publicly available Pittsburgh Air Quality Map designed with community input. The map will disseminate local air pollutant concentrations and risks. Subramanian, with co-PIs Albert Presto (Mechanical Engineering), Spyros Pandis (Chemical Engineering), and Julie Downs (Social and Decision Sciences), will look at how people interact with air quality data and pollution maps and what actions they take after knowing their pollution risk.

"At the end of the day, you study air quality because of its effects on people," said Subramanian. "You can study atmospheric chemistry reactions, you can go to a field and make some measurements, and it is very useful. But I also feel the need to actually communicate with people."

NOW YOU SEE IT, SOON YOU WON'T

RESEARCH



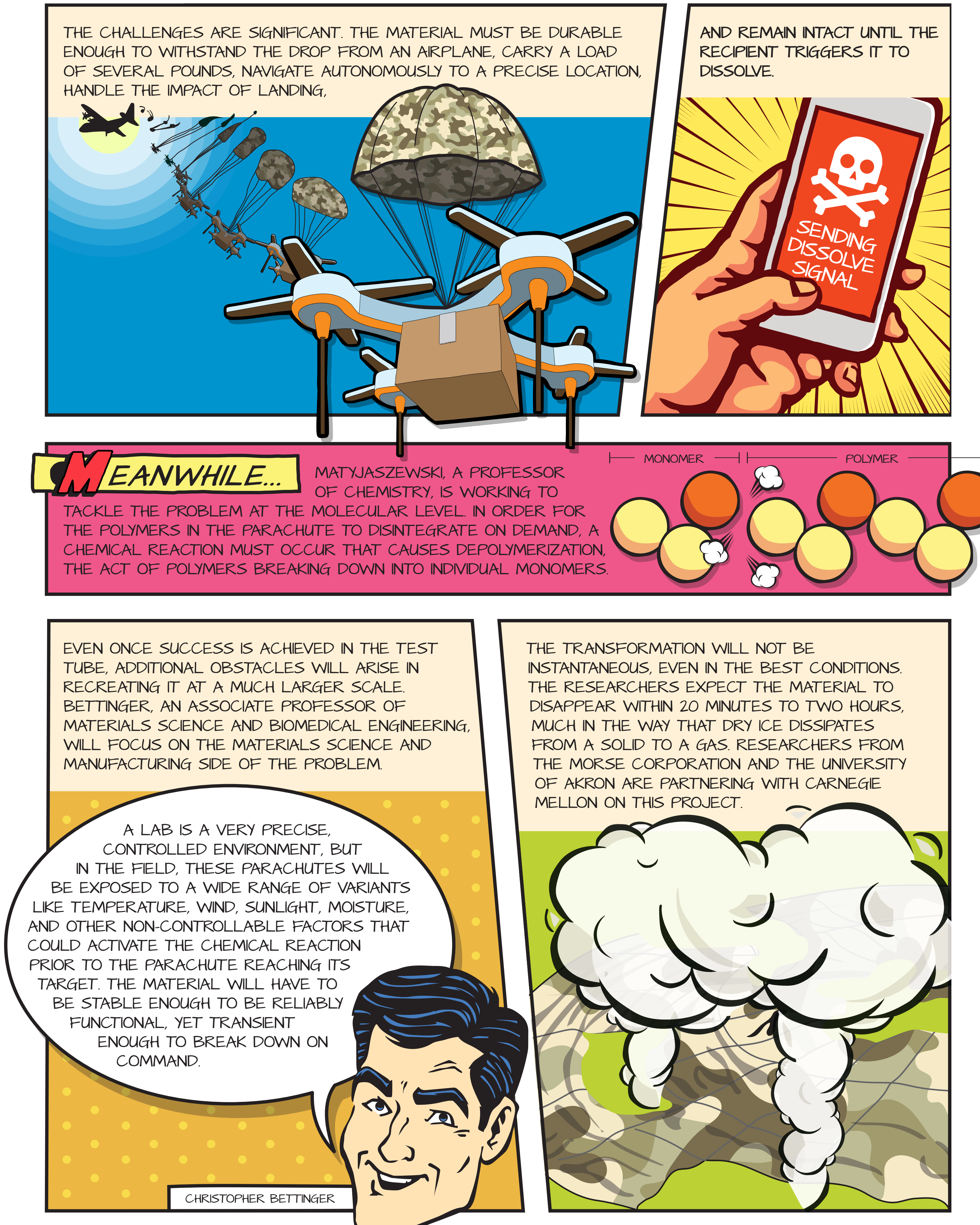
A DEVICE THAT DISAPPEARS ON COMMAND AFTER MAKING A CLANDESTINE DELIVERY MIGHT SOUND LIKE SOMETHING FROM A SPY NOVEL, BUT CARNEGIE MELLON RESEARCHERS ARE WORKING TO MAKE SUCH SPY TECH A REALITY.

RESEARCHERS CHRISTOPHER BETTINGER AND KRZYSZTOF MATYJASZEWSKI ARE PART OF A TEAM RECEIVING A $3 MILLION GRANT FROM DARPA'S ICARUS PROGRAM, WHICH SEEKS TO DEVELOP VANISHING DRONES AND DEVICES FOR THE MILITARY AND INTELLIGENCE COMMUNITIES.

SUCH DEVICES COULD KEEP DEPLOYED PERSONNEL SAFE BY DELIVERING NEEDED ITEMS (LIKE SMALL COMPUTERS OR MEDICAL SUPPLIES) WITHOUT ALERTING OTHERS OR ALLOWING TECHNOLOGY AND MATERIALS TO FALL INTO HOSTILE HANDS. ULTIMATELY, THESE DEVICES WOULD INCREASE THE CHANCES OF AGENTS AND SOLDIERS COMPLETING THEIR MISSIONS SUCCESSFULLY.

THE CARNEGIE MELLON RESEARCHERS ARE DESIGNING SPECIAL POLYMERS FOR SINGLE-USE PARACHUTES THAT WILL DISINTEGRATE ON DEMAND IN RESPONSE TO AN ELECTRICAL TRIGGER.

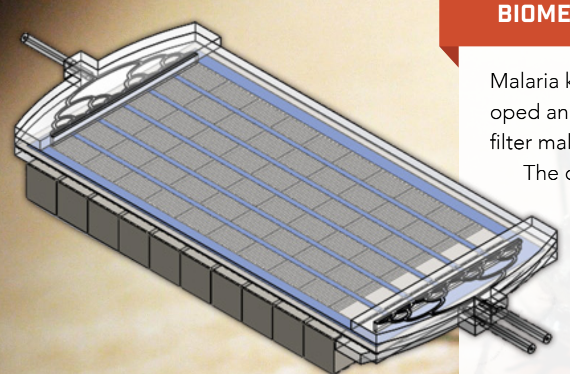
LISA KULICK	SHERRY STOKES	EMILY DURHAM	TIM KELLY
SCRIPT	EDITOR #1	EDITOR #2	ART



03

DEPARTMENT NEWS

THE INITIATIVES UNDERWAY IN THE COLLEGE'S DEPARTMENTS EMBODY THE VALUE WE PLACE ON PROGRESS. HERE ARE SOME OF OUR CURRENT PROJECTS AND PRIDES.



BIOMEDICAL ENGINEERING

Malaria kills over half a million people per year—but BME Ph.D. candidate Blue Martin has developed an electricity-free, cellphone-sized magnetophoretic separation device that uses magnets to filter malaria-infected red blood cells out of a patient's system.

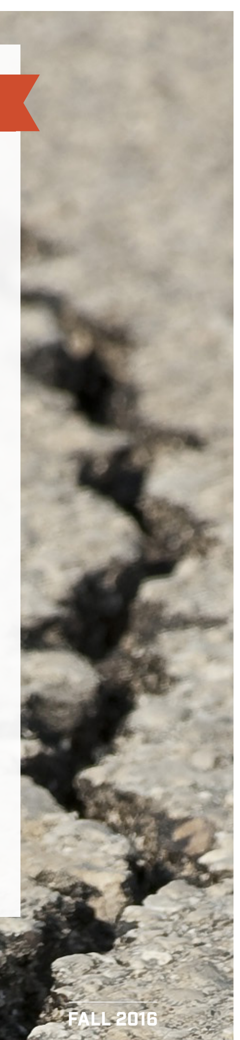
The device is about the size of a smartphone. It works by passing malaria-infected blood in a very thin layer, as thin as a piece of human hair, over a very carefully designed array of magnets and ferromagnetic wires, which separates the malaria-infected cells from the healthy cells, thanks to the fact that malaria makes red blood cells magnetic. Once the blood is separated, the infected blood can be filtered out while the clean blood is cycled back into the body.

CHEMICAL ENGINEERING

Carbon nanotubes, or tiny hollow cylinders of one-atom-thick carbon sheets, are strong, flexible, and hugely promising for many fields, such as nanotechnology and electronics. But Associate Professor of ChemE/BME Kris Dahl and Associate Research Professor of MSE Mohammad Islam are collaborating to aim these carbon nanotubes towards medicine.

Dahl and Islam engineer proteins which wrap around specific types of drugs so they can be delivered to the body more effectively. The drugs, when being delivered to the body's cells, sit on the surface of the carbon nanotubes, then are covered by proteins.

When feeding a dog a pill, you might wrap it in cheese to mask the medicine. To enhance drug delivery, Dahl and Islam have engineered proteins that wrap around the drug-coated nanotubes. The cells, which love these proteins, more readily take up the drug—much as a dog would more happily eat the cheese-coated pill. So when cells take in more of the drugs, the efficacy of the medicine increases dramatically.

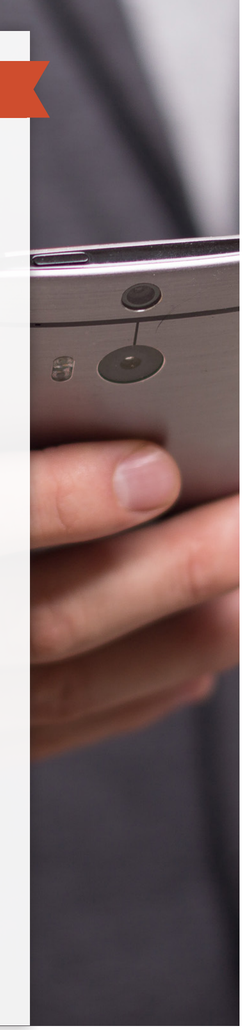


CIVIL & ENVIRONMENTAL ENGINEERING

In 2011, a 5.6-magnitude earthquake struck Oklahoma, damaging 14 homes and injuring two people. The cause of the earthquake has been linked to activities related to oil and gas production, specifically wastewater disposal. The occurrence of such manmade quakes is called "induced seismicity."

Among other efforts to reduce the risk associated with induced seismicity, CEE Ph.D. student Pengyun Wang, along with Professors Mitchell Small and Matteo Pozzi, have been working to develop approaches for detecting and quantifying increases in the frequency of manmade earthquakes, using data such as magnitudes and epicenters from Oklahoma quakes.

Through all of their work, the researchers are making it easier to determine when and where seismic activity presents danger—and if they can detect increases in activity early, they can implement strategies in time to mitigate the effects of earthquakes.



ELECTRICAL & COMPUTER ENGINEERING

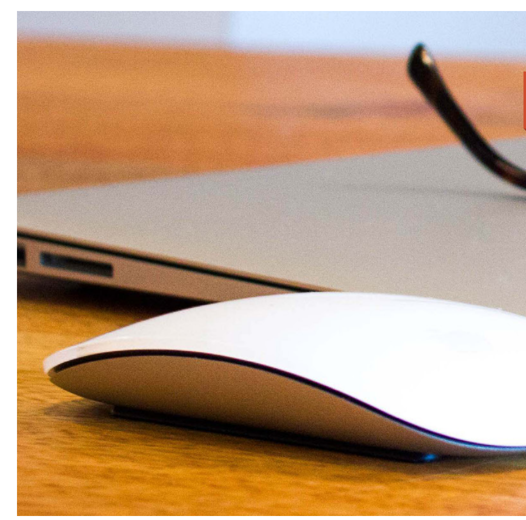
In November of 2015, the Federal Communications Commission (FCC) proposed an overhaul of the Wireless Emergency Alert (WEA) system, which sends out alerts via phone to warn citizens of natural disasters. The revisions to WEA regulations—which include improving the clarity of WEA messages through increased message length and embedded URLs, improved geo-targeting, and periodic testing—will ensure that WEA messages only reach the subset of the population that's in danger. On September 29, 2016, the FCC voted to instate the proposal updates.

The FCC's proposed updates to the WEA regulations are supported by extensive research—including research performed by CMU-SV ECE faculty Martin Griss, Hakan Erdogmus, and Bob Iannucci through the Department of Homeland Security Science and Technology Directorate First Responders Group's WEA Program. This research was the basis for the proposed rule changes, which will empower state and local alert originators to participate more fully in WEA and ensure that relevant emergency information reaches the public in a timely and effective manner.

ENGINEERING & PUBLIC POLICY

When patients participate in a clinical trial, they are required—for legal and ethical reasons—to complete consent forms that are typically long, complicated, and filled with technical language. Some experts fear these forms can lead some patients to enroll in studies without fully understanding them and others to miss valuable opportunities.

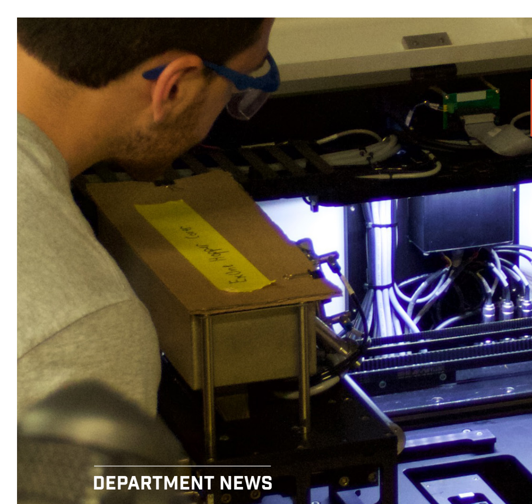
To improve patient comprehension, Assistant Research Professor Tamar Krishnamurti and Research Scientist Nichole Argo have developed approaches to simplify the process by focusing on the information that patients need most when deciding whether to enroll in a trial. They let potential trial participants determine what information is most relevant, then created written and video versions of a shortened consent form focused on that information. Krishnamurti and Argo found that despite being 86% shorter, the new consent forms were equally effective at securing patient understanding and keeping patients engaged.



MATERIALS SCIENCE & ENGINEERING

When it comes to computers, people never look for "bigger and better"—they want "smaller and faster." How do we continue to keep up with that demand? According to Assistant Research Professor Vincent Sokalski, the answer may be in the fundamental origins of magnets—the spin of electrons.

Sokalski and his group study the interaction of electron spins in magnetic materials poised for use in next-generation cellphones and computers, discovering how to better measure and predict the changing magnetic state of those materials. This new understanding is exciting for the future of computing technology, because it will allow scientists to explore and develop materials that are more energy-efficient and faster than traditional semiconductor-based materials. To come to this new understanding, Sokalski and his group leveraged the power of a 19th century mathematical technique called the "Wulff Construction," traditionally used by mineralogists and crystallographers to study the formation of gemstone facets.



MECHANICAL ENGINEERING

The Department of Mechanical Engineering has recently acquired an ExOne Innovent Research & Education 3-D Printer, an additive manufacturing machine designed for education and laboratory environments, in order to train the next generation of scientists and engineers. Jointly funded by a Dean's Equipment Grant and a Pennsylvania Infrastructure Technology Alliance (PITA) Grant, the Innovent uses binder jetting technology to 3-D print complex parts in industry-grade materials.

Carnegie Mellon University is the only U.S. university to currently offer metals additive manufacturing to all of its mechanical engineering undergraduate students, and the acquisition of the Innovent will allow the hundreds of students who take additive manufacturing courses to create metal parts they design. Only mechanical engineering undergraduates currently have access to the Innovent, but the College of Engineering envisions being able to introduce metals additive manufacturing to all engineering undergraduate students within the next few years.

04

INSIDE THE COLLEGE

CARNEGIE MELLON IN EAST AFRICA GETS BOOST FROM MASTERCARD FOUNDATION

Carnegie Mellon University's commitment to educating Africa's next generation of technology leaders and entrepreneurs received a boost on June 20, with a $10.8 million commitment from The MasterCard Foundation.

THIS NEW PARTNERSHIP that's been established at the College of Engineering program in Kigali, Rwanda, will benefit 125 academically talented but economically disadvantaged students from Sub-Saharan Africa as part of The MasterCard Foundation Scholars Program.

The university joined a global network of 23 Scholars Program partners, comprising educational institutions that are committed to developing Africa's young leaders. These Scholars will use their knowledge to lead change in their communities and contribute to meaningful transformation across the continent.

"We are excited to partner with Carnegie Mellon University in Rwanda, an exceptional institution committed to training the next generation of African engineers, innovators and entrepreneurs to meet pressing global challenges," said Reeta Roy, President and CEO of The MasterCard Foundation.

By offering degree programs in ICT to 125 students from lower-income families in Africa, Carnegie Mellon will have impact in three ways: first, this Program will expand career options for the Scholars; second, it will be an educational and research resource underpinning the growth and development of the technology sector in Africa; and third, alumni and faculty will benefit from Carnegie Mellon's resources that support entrepreneurship and innovation.

The MasterCard Foundation Scholars Program at Carnegie Mellon University in Rwanda will attract a diverse mix of Scholars from Rwanda and the rest of Sub-Saharan Africa, with a priority on increasing the enrollment of women. It will provide holistic student support, including scholarships, leadership development, volunteerism and industry-driven career services.

The Program started this fall and will conclude in 2023, underscoring the importance of long-term education programs in Africa. Research underway at Carnegie Mellon in Rwanda also takes a long-term approach. The faculty understand that to address Africa's technology needs, students require time to analyze and solve problems in the context in which they occur. Research at Carnegie Mellon explores topics relevant to Africa: wireless networking, mobile applications, energy systems, cyber security, agriculture, financial services and telecommunications.

The partnership announcement was made during the Rwandan program's third graduation ceremony, when 24 students received master's degrees in Information Technology and Electrical and Computer Engineering. To date, the program has graduated 70 students from Rwanda, Kenya, Uganda and the United States. Most of these graduates are working in their home countries, making an impact in the private sector, government and academia, and the rest are pursuing doctoral programs or creating startup companies.

CYLAB WINS BIG AT DEFCON

COMPUTERS VS. COMPUTERS: CYBER GRAND CHALLENGE

ForAllSecure, a Carnegie Mellon University spinoff startup, took home $2 million in prize money as the winners of the Defense Advanced Research Projects Agency (DARPA) Cyber Grand Challenge (CGC), a first-of-its-kind hacking contest in which all participants are autonomous computer systems.

BY **DANIEL TKACIK**

FORALLSECURE WAS ONE OF SEVEN FINALIST TEAMS in the contest, which took place on Thursday, August 4, in Las Vegas, Nevada.

"Our vision is to check the world's software for exploitable bugs so they can be fixed before attackers use them to hack computers," says David Brumley, who wears several hats as CEO of ForAllSecure, director of Carnegie Mellon's CyLab Security and Privacy Institute, and professor of Electrical and Computer Engineering. "We believe our technology can make the world's computers safe and secure."

ForAllSecure's system, dubbed "MAYHEM" by the team, scans software for bugs, generates exploits, and fixes vulnerabilities. The system performs every task completely autonomously.

"This is a shining moment for a startup born at Carnegie Mellon," says Jim Garrett, Dean of the College of Engineering. "We couldn't be more proud of ForAllSecure for applying its vision to the development of cutting-edge technology that addresses the global issue of security."

DARPA launched the CGC in response to the recent increase in software bugs, due in large part to the explosion of the Internet of Things—billions of connected devices like smart thermostats or fitness trackers that are built with little regard to cybersecurity. The challenge aimed to identify state-of-the-art technology to find these bugs quickly, and at scale.

ForAllSecure was co-founded in 2012 by Brumley and two Carnegie Mellon graduate students, Thanassis Avgerinos and Alex Rebert. The startup currently has nine employees and is based in Pittsburgh, Pennsylvania.

> **"OUR VISION IS TO CHECK THE WORLD'S SOFTWARE FOR EXPLOITABLE BUGS SO THEY CAN BE FIXED BEFORE ATTACKERS USE THEM TO HACK COMPUTERS. WE BELIEVE OUR TECHNOLOGY CAN MAKE THE WORLD'S COMPUTERS SAFE AND SECURE.**
>
> **– DAVID BRUMLEY**

TIMES SQUARE
NEW YORK CITY

CARNEGIE MELLON SWEEPS DEFCON AS TEAM WINS THIRD "WORLD SERIES OF HACKING" TITLE IN FOUR YEARS

BY **DANIEL TKACIK**

CARNEGIE MELLON'S COMPETITIVE COMPUTER SECURITY TEAM, The Plaid Parliament of Pwning, won its third title in four years at the DefCon Capture the Flag competition. The win came on the heels of CMU-spinoff ForAllSecure's win at the DARPA Cyber Grand Challenge just days earlier.

The DefCon Capture the Flag competition, widely considered the "World Series of Hacking," was held August 7 – 9 at the Paris and Bally's Hotels in Las Vegas.

"Our team has put in thousands of hours of practice and it is rewarding to see them win amongst the best hackers in the world," says David Brumley, faculty advisor to the CMU team. "Every year this competition becomes harder and harder to win."

Capture the Flag (CTF) is one of the most popular competitive hacking games in the world, with hundreds of smaller CTFs being held annually. During these competitions, teams try to break into competitors' servers while protecting their own. After achieving a successful breach, teams catch virtual "flags" and earn points.

While thousands of CTF teams exist worldwide, only 15 teams representing at least 10 countries qualified for this year's DefCon CTF.

"The consistency of our team's performance over the last four years demonstrates CMU's strength in cybersecurity education and research," says Jim Garrett, dean of the College of Engineering. "These students will clearly help drive the next level of cybersecurity."

Carnegie Mellon's win comes at a time that the computer security field is struggling to find suitable hires to join the workforce. These contests give people a place to practice and hone their computer security skills.

"These contests are critically important to developing a skilled cybersecurity workforce," says Brumley.

The Carnegie Mellon hacking team formed in 2009 and began competing in DefCon's Capture the Flag competition in 2010. Prior to this year, the team held two DefCon Capture the Flag titles from 2013 and 2014.

STEINBRENNER INSTITUTE'S FIRST ENVIRONMENTAL COLLOQUIUM

BY ADAM DOVE

THE HEALTH OF OUR ENVIRONMENT has always been a focus of research and education at Carnegie Mellon. But researchers know that to create real-world change, the environment must become a lens through which we view everything, from mechanical engineering, to chemical engineering, to business, design, and everywhere in between.

With this in mind, the Steinbrenner Institute for Environmental Education and Research (SEER) hosted its first annual Earth Day Environmental Colloquium on April 22, 2016.

"The Steinbrenner Institute promotes the breadth of environmental research across all colleges and seeks to find additional areas for potential collaboration and impact," says Deborah Lange, executive director of SEER since its inception.

Neil Donahue, Steinbrenner Faculty Director adds that, "The primary purpose of the annual colloquium is to assess our components across campus and brainstorm about how we can continue to be greater and more impactful than the sum of our parts."

The event began with presentations from eight environmentally focused research centers housed within the university, including the Climate and Energy Decision Making Center, the Center for Atmospheric Particle Studies, the CREATE Lab, and others.

From there, the Colloquium broke for a strolling lunch, and the student competition began. Participants were invited to walk through over 30 research posters designed by undergraduate and graduate students. The Steinbrenner Institute fellows also presented their research to the gathered crowd.

Lowell Steinbrenner, Bargara Granito (National Academy of Sciences and National Academy of Engineering – Science Ambassador Program), Burcu Akinci (CMU Engineering Research Accelerator), and Karl Thomas (CMU University Advancement and EPP alum) served as judges.

Civil and Environmental Engineering's Kelly Good and Mechanical Engineering's Deepak Ravi and team won $1,500 travel grants for their posters, while Engineering and Public Policy student and Steinbrenner Institute fellow Brian Sergi won a travel award for his presentation.

"These awards are a big part of why we're here; supporting students in their environmental research," says Lange. The Steinbrenner Institute grants $120,000 to 160,000 a year in doctoral fellowships.

After the competition, faculty and stakeholders remained for an informal discussion on strategic planning for the institute. Next year's Colloquium is scheduled for April 7, 2017.

ONE OF PROFESSOR CARTWRIGHT'S DESIGN AND CONSTRUCTION COURSE'S MANY CONTRIBUTIONS TO CARNEGIE MELLON'S CAMPUS

IN MEMORIAM

LARRY CARTWRIGHT

LARRY CARTWRIGHT, a mentor, professor and friend passed away on Sunday, August 28, 2016.

Cartwright was born October 8, 1945, in New Brighton, Pennsylvania. After serving in the U.S. Air Force in the Vietnam War, he enrolled in the Civil Engineering program at Carnegie Mellon, earning his BSCE in 1976. He joined the Department in 1977 as the manager of the Civil and Environmental Engineering Laboratories. Within five years, he became an instructor and his penchant for teaching quickly became clear.

Cartwright earned a master's degree in Civil Engineering in 1987. After promotions to Senior Lecturer and Principal Lecturer, Cartwright was designated a Teaching Professor in 2004, the highest rank for teaching faculty at CMU.

During his 38-year career, Cartwright was recognized many times for his teaching excellence and contributions to the university.

Cartwright's heart was always in mentoring. Among his students' favorite courses was Design and Construction, a junior-senior course Cartwright helped to develop and then led for over 25 years. This course brought students together from civil, mechanical, and electrical engineering and fine arts, to design and construct projects on campus from start to finish. Producing study spaces, pavilions and even an amphitheater, Cartwright and his students left a lasting, visible legacy on the CMU campus.

Cartwright retired from Carnegie Mellon in June 2013, but continued teaching part-time. In 2013, CEE alumni established the Lawrence Cartwright Support Fund for Teaching Professors, (http://www.cmu.edu/cee/giving/index.html), ensuring that Cartwright's name will remain forever tied to Civil and Environmental Engineering.

CHRISTODOULOS FLOUDAS

The chemical engineering community mourns the loss **CHRISTODOULOS "CHRIS" FLOUDAS**, who passed away on August 14, 2016. Floudas earned his Ph.D. in Chemical Engineering from Carnegie Mellon in 1986. Afterwards, he pursued an exceptional career, first at Princeton University and then at Texas A&M, where he became the director of the Energy Institute. He made significant contributions to the field of process systems engineering, and he received many awards, including membership to the National Academy of Engineering and the U.S. National Academy of Inventors.

FLETCHER OSTERLE

J. FLETCHER OSTERLE, who devoted his entire career to Carnegie Mellon, passed away peacefully on July 22, 2016 at the age of 90.

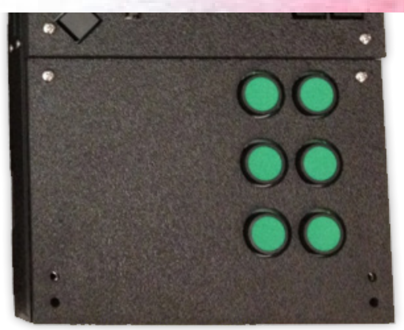
In 1946, Osterle graduated from the Carnegie Institute of Technology (CIT) with a bachelor of science, but that milestone did not mark the end of his time at Carnegie Mellon.

Six years later, he earned both his master's and doctorate in mechanical engineering from CIT (now Carnegie Mellon College of Engineering). He remained at Carnegie Mellon, becoming an instructor, assistant professor, and later the Theodore Ahrens Professor of Mechanical Engineering.

In the 1950s, Osterle's research centered on lubrication, and in the 1960s it shifted to direct energy conservation. From 1975-1983, he served as the department head of nuclear science and engineering, and from 1985-1986, he served as acting head of the mechanical engineering department.

Osterle's service earned him the prestigious Carnegie Mellon Alumni Merit Award in 1989. He remained a faculty member until 1995, when he retired and continued to be an actively involved alumnus.

We remember and celebrate Osterle's commitment to Carnegie Mellon and the field of engineering.



IMPROVING GLOBAL LITERACY WITH A BRAILLE TUTORING DEVICE

BY EMILY DURHAM

Literacy is key to social and human development—which is supported by UNESCO's declaration of its status as a fundamental human right. Being able to write and read one's own language is crucial for participation in the ever-evolving world of communication—which makes global literacy, particularly in developing countries, a target of many humanitarian efforts.

But what about unspoken languages? Susan Zuo, an undergraduate senior in electrical and computer engineering, has spent the last two years helping to develop a braille tutoring device to improve literacy in visually impaired communities around the world. In May, Zuo traveled to Stockholm, Sweden, to present her research on the Stand-Alone Braille Writing Tutor at the Institute of Electrical and Electronics Engineers (IEEE) International Conference on Robotics and Automation 2016.

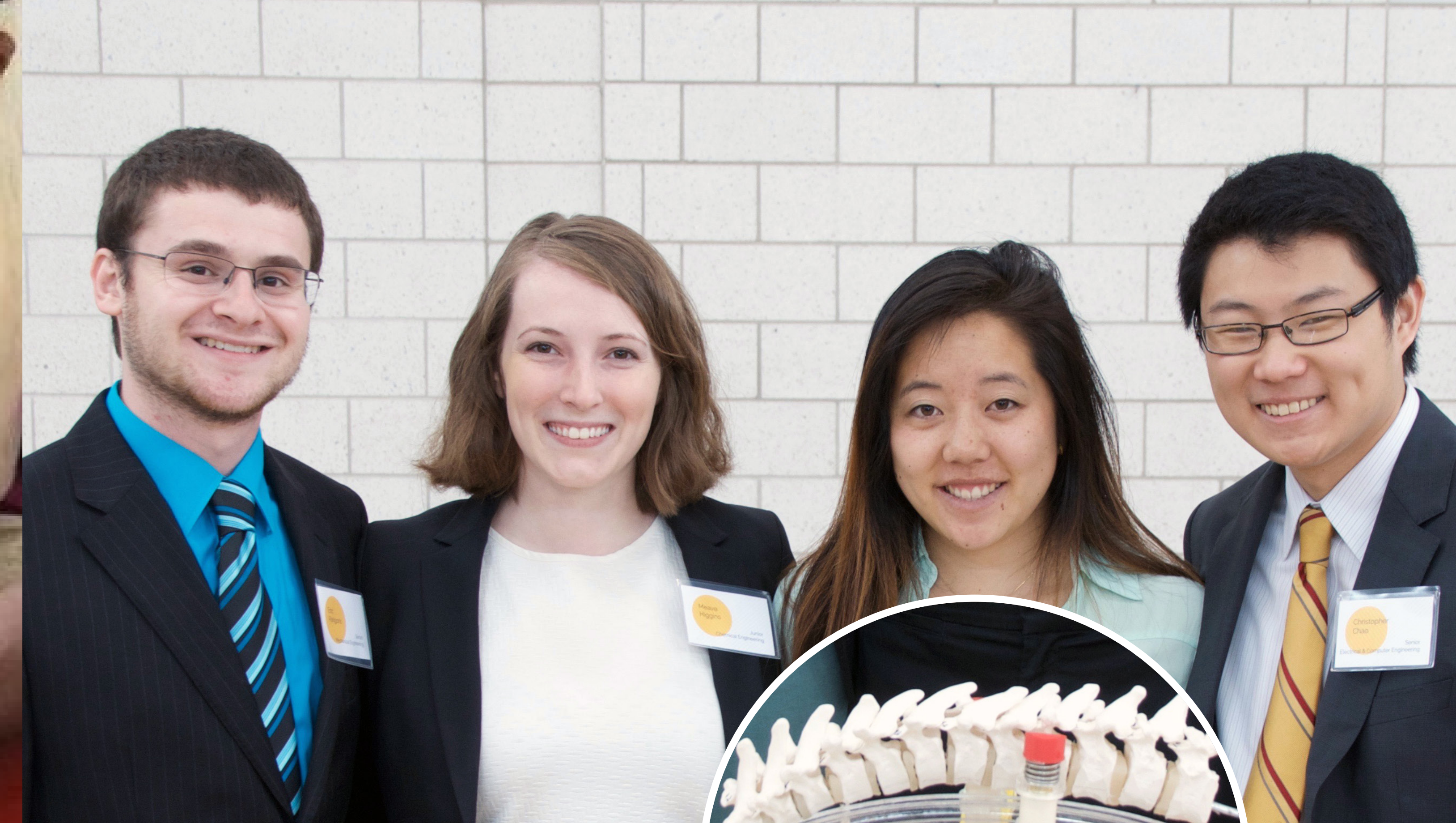
"Before this project I had no prior experience working with blind populations, but the humanitarian side of this project really drew me in," says Zuo, who has been involved with the braille tutor project since the end of her freshman year. Zuo works on the back end of the device, doing internal processing, optimization, and development of the primary user interface for beginner braille learners.

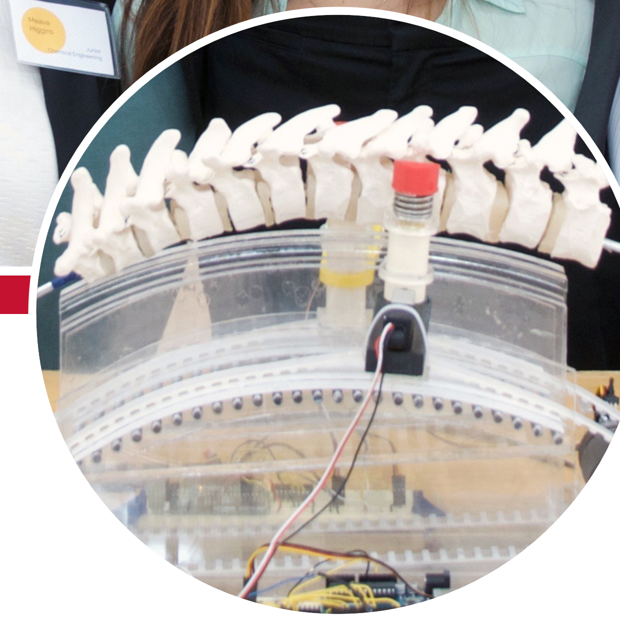
In braille, each letter and number is represented through a unique six-dot pattern. The same six-dot system is used across all languages—English and Hindi alike. The battery-powered braille tutor, a black box with six buttons that represent braille dots, offers three different automated, audio-based user interfaces: primary, intermediate, and advanced.

"What's interesting is that when a blind person writes braille, they have to write the mirror image of each letter with a stylus, and when they push on the paper, they have to flip the paper over to read it so they feel the bump of the dot," explains Zuo. "In order to read it, it has to be written as a mirror image, so it's a lot of mental work. So the concept behind the braille tutor is that we have enlarged six physical push buttons that represent the braille dot, and we're teaching people how to write braille, rather than read it."

The device, which is open-sourced, teaches how to write braille through games—for example, one of the games includes a two-player version of Hangman, in which one student writes a word in braille into the device, and the other student has to guess the word by writing individual braille letters. The device has two modes—learning and testing—which teaches the user to practice different braille patterns. In addition to English, the tutor also includes a setting for Hindi braille.

This winter, Zuo will travel to Bangalore, India, to complete her project with the Mathru Educational Trust for the Blind. The IEEE Robotics and Automation Society Special Interest Group on Humanitarian Technology (RAS-SIGHT), will provide funding for Zuo's travel. In Bangalore, she will collect user feedback, compile errors, and upgrade the current test device, which has been deployed in a classroom in the Mathru School for several years, with their most up-to-date software.





CHIROPROKTOR: THE CPR DUMMY OF SPINAL MANIPULATION

BY EMILY DURHAM

Think back to your first bike. You learned to ride by practicing—feeling out your balance, tipping over a few times, but ultimately getting up and trying again. The best way to learn is by doing, and doing often. But learning how to adjust the bones in a spine is a bit more complicated than riding a bike.

Chiropractors don't typically have the luxury of such a "hands-on" approach to training, but an interdisciplinary team of undergraduates in the College of Engineering is developing an educational tool to change that.

ChiroProktor—an instructional medical device being developed by Carnegie Mellon University undergraduates Christopher Chao (ECE/BME), Eric Parigoris (MechE/BME), Nicole Kawakami (MSE/BME), Meave Higgins (ChemE/BME), Lauren Zemering (Industrial Design), and Tepper School of Business master's student Torrell Jackson—is a model spine capable of recreating spinal misalignments on command.

"You learn to ride a bike by practicing on the bike—not by reading a textbook. Unfortunately, that's how a lot of chiropractors today learn their trade," says Chao. "For many students, their first practical experience comes when faced with their first human patient. Before then, all of their experience is theoretical, which makes these first patients their test dummies."

The device, nicknamed the "CPR Dummy of Spinal Manipulation," will allow chiropractors-in-training to practice on a mechanical body, giving them the practical experience they need before going into the industry.

ChiroProktor uses an input system that allows the user to request specific spinal misalignments, so students in chiropractor school can practice fixing both common and rare misalignments. Once the user has input their desired settings, a motorized track mechanism pushes spring-loaded vertebrae out of alignment along the true curvature of the spine, so that the user can feel the same angles of motion and amounts of resistance as those encountered in a real spine.

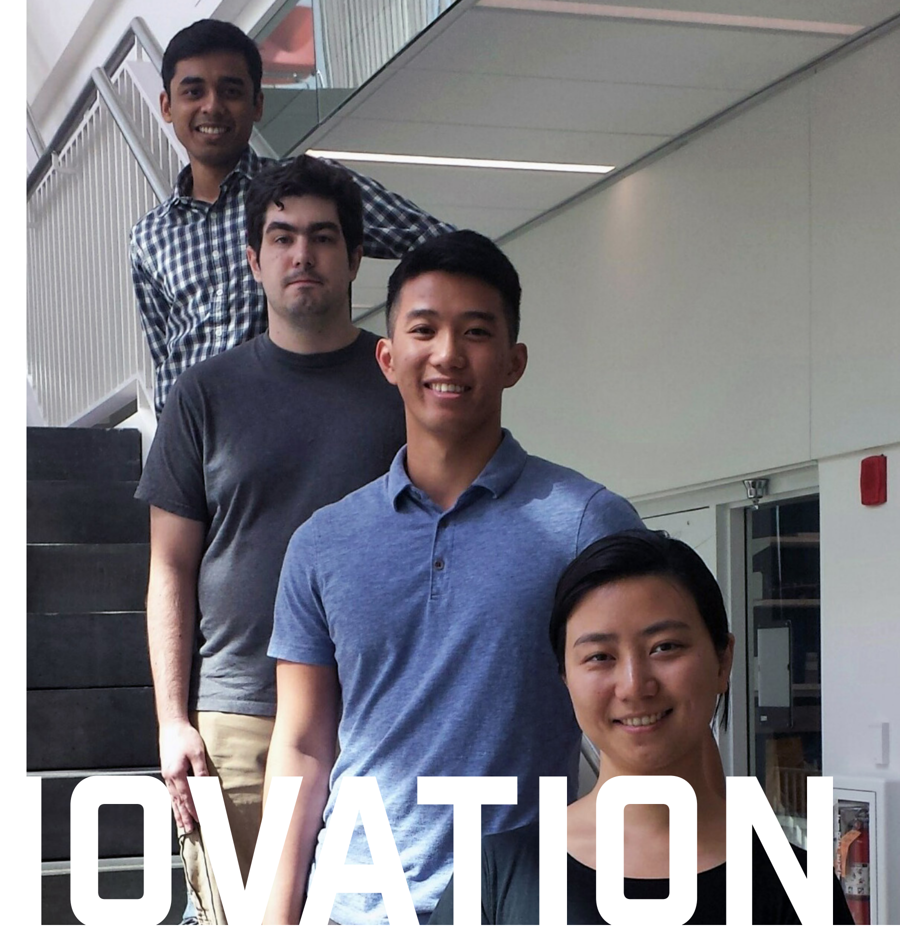
"The nice thing about this solution," explains Parigoris, "is that initially we were talking about having a motor on every single vertebra, which would be quite a lot of motors, but our solution just has two motors, one on either side. The device can just move along the track, which is a benefit in terms of weight and cost."

While most of the team is comprised of graduating seniors, they plan to continue developing a marketable ChiroProktor product together. They presented the ChiroProktor prototype at the 2016 Meeting of the Minds, held in May. The prototype allowed visitors to press a button to create misalignments, while members of the team moved the motorized track mechanism to individual vertebrae.

Future improvements to the device will include pressure sensors and accelerometers, so that students will know exactly how much force they are applying and in what direction, and the team is working with another university on a soft tissue solution to simulate muscles and epidermis, so that training chiropractors can practice on a device with a tissue layer of similar compliance and elasticity to human skin.

06

ALUMNI



INCUBATING INNOVATION

THE PHILIP AND MARSHA DOWD ENGINEERING SEED FUND FOR GRADUATE STUDENT FELLOWSHIPS

Some of the greatest innovations of our time started out with the riskiest ideas. But risky ideas often go unfunded—until someone is brave enough to trust in the researcher's dreams.

BY **EMILY DURHAM**

ALUMNUS PHILIP DOWD (B.S. MSE '63) AND HIS WIFE MARSHA have given generously to Carnegie Mellon University throughout the years, encouraging an enormous number of Carnegie Mellon affiliates in the pursuit of their visions. The Dowds' generous gifts have funded several Carnegie Mellon endeavors, including the establishment of a teaching fellowship, a professorship, and a new conference room on campus.

Just one of the many meaningful contributions the Dowds have made to the university is the Dowd Engineering Seed Fund for Graduate Student Fellowships: an endowment created in 2001 to fund cutting-edge doctoral research in engineering at Carnegie Mellon.

Each year, the Dowd Fellowship supports multiple Ph.D. students through a year of doctoral expenses. Research projects supported are so new that insufficient intellectual property exists for them to be funded by government agencies and foundations, and thus must garner funding from elsewhere. Targeted in particular at doctoral candidates working with young faculty, Philip and Marsha Dowd established this fellowship to incubate "high-risk, high-reward" projects: the seeds sown for an orchard of cutting-edge research careers.

> **"WE'RE TRYING TO INSPIRE INNOVATION, INCUBATE NEW IDEAS."**
> PHILIP AND MARSHA DOWD

HERE ARE FOUR OF THE PH.D. STUDENTS WHOSE RESEARCH PROJECTS WERE FUNDED BY THE DOWD FELLOWSHIP IN 2015 AND 2016.

LILI EHRLICH (MechE) – 2015
PREDICTING COOLING AND REWARMING RATES FOR THE SUCCESSFUL CRYOPRESERVATION OF A HUMAN KIDNEY

18,000 kidneys are transplanted each year in the United States alone. The time window between kidney donation and recipient transplantation is just 24 to 48 hours, using traditional hypothermic storage methods. Cryopreservation, or the preservation of organs at extremely low temperatures for later use, has been explored as a promising approach to extend this time window, but many hurdles still stand in the way of reducing cryopreservation technology to practice. For example, the recovery of an organ from cryogenic storage is contingent upon the ability to control ice formation during cooling and subsequent rewarming, where crystallization is known to be the cornerstone of cell injury in cryogenic temperatures.

2015 Dowd Fellow Lili Ehrlich, a Ph.D. student in MechE, is working with Professors Jonathan Malen and Yoed Rabin to identify the ideal cooling and warming rates to maximize human kidneys recovery from cryogenic storage. By developing a thermal model of the human kidney and measuring its key thermal properties, Ehrlich aims to create thermal engineering tools to facilitate the development of robust cryopreservation technologies.

CARL MALINGS (CEE) – 2016
SURFACE HEAT ASSESSMENT FOR DEVELOPED ENVIRONMENTS (SHADE)

Cities, in general, tend to have hotter temperatures than rural areas. This is due to the abundance of urban infrastructures made of materials that absorb heat (for example, concrete, steel, and asphalt) and the lack of gardens, parks, and green space. This phenomenon, known as the urban heat island (UHI) effect, when combined with the high population densities in cities means that during heat waves, temperatures can spike to incredibly high heats and can cause major health crises such as heat stroke and death.

2016 Dowd Fellow Carl Malings, a Ph.D. student in CEE advised by Assistant Professor Matteo Pozzi, is collaborating with researchers at Carnegie Mellon and Princeton University to develop probabilistic models for urban temperatures, with the aim of being able to predict heat spikes before they occur. These models, if successful, will provide enough warning to city residents to prepare for disaster and prevent future injury.

DIANE NELSON (BME) – 2015
PULMONARY DRUG DELIVERY VIA PERFLUOROCARBON EMULSION

When treating respiratory diseases, such as asthma, chronic obstructive pulmonary disease (COPD), and cystic fibrosis (CF), doctors often prescribe treatments that require patients to inhale a drug deeply for even distribution throughout the lungs. However, for patients with chronic lung disease, lung functionality lessens over time, and eventually, aerosol drug delivery can be hindered by poor ventilation and buildup of mucus. In emergency situations where patients with COPD or CF have sudden and temporary worsening of their disease states, the normal means of treatment—intubation and mechanical ventilation—can make treatment of infections nearly impossible, making chance of survival extremely low.

2015 Dowd Fellow Diane Nelson and her advisor, Associate Professor Keith Cook, are developing a different approach to treating lung disease: delivering drugs by filling the lungs with high-oxygen liquids, known as liquid perfluorocarbons (PFCs). Perfluorocarbons (PFCs) are chemically and biologically non-toxic liquids that are capable of dissolving high amounts of oxygen and carbon dioxide. Though intuitively one might think flooding the lungs with any liquid would result in drowning, the high amounts of oxygen in PFCs enhance gas exchange—and drugs delivered via PFCs can reach target areas without relying on airflow for distribution. Nelson and Cook hope to increase patient survival during these emergency scenarios by using this method to bypass the difficulties in inhalation.

PRAVEEN VENKATESH (ECE) – 2016
FUNDAMENTAL LIMITS, ALGORITHMS, AND EXPERIMENTS TO VALIDATE THE UTILITY OF HIGH-DENSITY EEG IN CLINICAL AND NEUROSCIENTIFIC SETTINGS

In order to diagnose brain disorders, doctors will often place electrodes on the patient's scalp to record abnormal brain signals. Though this electrode placement technique, known as electroencephalography (EEG), is commonly used for rudimentary diagnostics, it is widely believed to be incapable of obtaining the high resolution needed for more specialized brain imaging.

2016 Dowd Fellow Praveen Venkatesh, however, is challenging the limits of EEG technology. With the advising of Assistant Professor Pulkit Grover, Venkatesh's Ph.D. work will be to further EEG's capabilities and reestablish EEG's potential for specialized brain diagnostics. If successful, Venkatesh's research will have a significant impact on how brain injuries are diagnosed in the future—invasive brain imaging could become non-invasive, for the good of all.

ALL OF THESE DOCTORAL CANDIDATES are pursuing rigorous study of ideas that, at a different institution, might be considered too new or too risky to fund. But Philip and Marsha Dowd see the issue at hand: that young researchers must have the opportunity to pursue the ideas that could change the world.

And they have every faith that the graduate students they fund can accomplish their world-changing ambitions.

"When we mingle with the fellows, we stop worrying about the future of our country, of our culture, of our planet," say the Dowds. "These kids are going to solve all our problems, and that's all there is to it."

07

ANNOUNCEMENTS

A New Partnership Breaks Ground

ANSYS AND CARNEGIE MELLON CELEBRATE COLLABORATION

BY LISA KULICK

A GROUNDBREAKING CELEBRATION FOR A NEW BUILDING honoring and supporting the Carnegie Mellon University–ANSYS partnership took place on Tuesday, October 4, 2016, on Carnegie Mellon's campus.

The building, thanks to a generous gift from ANSYS, will become the hub of the College of Engineering's undergraduate program. Here, faculty and students—experts and experts-to-be—will use cutting-edge computational and prototyping tools that inspire innovation and creative problem solving.

The resources in this 30,000 square foot facility will firmly connect computation with making. This will expand the hands-on, learning-by-doing culture—the maker ecosystem—of the College.

By partnering, ANSYS and Carnegie Mellon will leverage greater use of simulation to empower future engineers, thus setting a new standard for engineering education and industry.

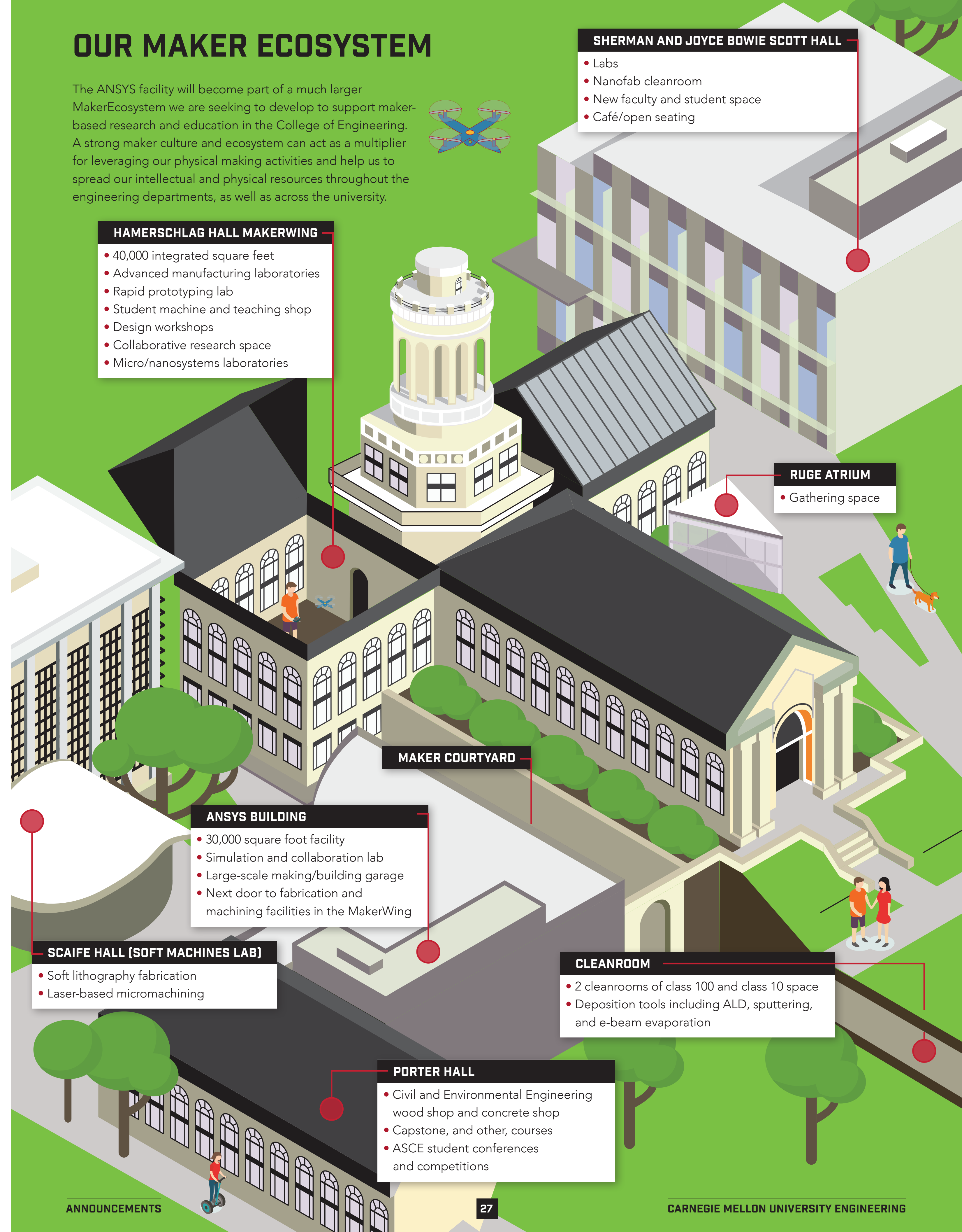
The focus of the making activity in the new building will be a large, high bay space where students will assemble full-scale projects and prototypes. Other features include collaboration areas, conference rooms, training and lecture space, and office space.

President Subra Suresh and College of Engineering Dean James Garrett invited guests to attend the groundbreaking event. It took place under a tent between Scaife and Hamerschlag Halls at the new building site. A reception featuring student project demonstrations followed in Rothberg's Roasters II in Scott Hall.

LEFT TO RIGHT: COLLEGE OF ENGINEERING DEAN JAMES GARRETT, CARNEGIE MELLON UNIVERSITY PRESIDENT SUBRA SURESH, CHAIRMAN-ELECT OF ANSYS BOARD OF DIRECTORS JIM CASHMAN

OUR MAKER ECOSYSTEM

The ANSYS facility will become part of a much larger MakerEcosystem we are seeking to develop to support maker-based research and education in the College of Engineering. A strong maker culture and ecosystem can act as a multiplier for leveraging our physical making activities and help us to spread our intellectual and physical resources throughout the engineering departments, as well as across the university.



HERZOG VISITS US TO LEARN ABOUT SELF-DRIVING CARS

Oscar®-nominated documentarian Werner Herzog traveled to Carnegie Mellon to interview Electrical and Computer Engineering Professor Raj Rajkumar for his film *Lo and Behold: Reveries Of The Connected World.* Herzog interviewed Rajkumar to reveal how self-driving cars will profoundly change travel in the not-too-distant future.

1. JACK BEUTH
2. GARY FEDDER
3. ADAM FEINBERG

RESEARCHERS PARTICIPATE IN CONGRESSIONAL BRIEFING ABOUT THE ECONOMIC IMPACT OF 3-D PRINTING

3-D printing, also known as additive manufacturing, is a rapidly expanding technology. Every industry from aerospace to dentistry is exploring how these methods can be used to transform their businesses. As industry shifts its focus to additive, policymakers are also moving their attention to its potential economic impact.

On March 16, College of Engineering faculty Jack Beuth and Adam Feinberg, along with Vice Provost for Research Gary Fedder participated in a congressional briefing to the House Manufacturing Caucus and the Maker Caucus titled "Additive Manufacturing/3-D Printing: Transforming Industry, Creating New Economic Opportunity." Hosted by Carnegie Mellon University and America Makes in Washington, D.C., the briefing examined how additive manufacturing is transforming U.S. industry and creating new economic opportunity.

Beuth, professor of mechanical engineering and director of the NextManufacturing Center, discussed the future of metals additive manufacturing and how industry and academia can take advantage of the technology. Feinberg, associate professor of materials science and engineering and biomedical engineering, covered 3-D bioprinting for medical applications and his research in 3-D printing human tissue.

Carnegie Mellon University
College of Engineering

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SHERMAN AND JOYCE BOWIE SCOTT HALL fits like a jigsaw piece into Carnegie Mellon University's campus, and was designed with the university's culture of collaboration and sustainability in mind. The building officially opened April 30, 2016.

The building spans multiple disciplines, housing the Wilton E. Scott Institute for Energy Innovation, the Department of Biomedical Engineering, the Engineering Research Accelerator, the Disruptive Health Technologies Institute, and a nanotechnology research facility.

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CARNEGIE MELLON UNIVERSITY ENGINEERING

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