THE UNIVERSITY OF NEW MEXICO SCHOOL OF ENGINEERING

SPRING 2009

UNM engineering

Diversity Drives Discovery

From the Dean

Diversity Drives Discovery

The UNM School of Engineering has a strategic commitment—one that underpins all others—to diversity in all of its dimensions. Diversity is a strength and the source of great creativity, innovation, insight, and excitement. At the SOE, diversity drives discovery.

At its essence, diversity is about differences. Appreciating that there are such differences, and that they give rise to different understandings, beliefs, and ways of framing problems, is one of the most important things students can learn.

Our multicultural environment enriches virtually every program. Students develop a breadth of concepts and thinking from this cultural diversity. This understanding and appreciation of differences prepares them well for the increasing globalization of technology. In this issue, you'll discover how diverse our students are. You'll also learn how Engineering Student Services offers a variety of services and programs to help these diverse students succeed.

Diversity extends to other important dimensions, particularly in a university. Intellectually exciting problems almost always occur at the intersections of multiple fields. Interdisciplinary programs lead to new methods, new insight, and new knowledge. Collaborative research can result in an explosion of ideas, especially when it spans across campus, across the country, and engages industry. In this issue, you'll read about a multi-college, interdisciplinary collaboration on nanoscale composites and learn how UNM computer scientists are borrowing from tomography to analyze Internet censorship in China.

Another aspect of diversity is the artful combination of teaching, research, service, and practice. An article on the NSF Smart Lighting Engineering Recent Center integrates all four elements in a collaboration that is creating brilliant innovations and a rich educational milieu for students and researchers. An article on the NSF Engineering Research Center on smart lighting shows brilliant innovation as well as the integration of all four of these elements.

The challenge of diversity in any of its dimensions is to deal with the inherent complexity. However, it is just that struggle to understand and benefit from complexity that will make the difference between a good education and a great education. At the UNM School of Engineering, taking full advantage of all aspects of diversity is the engine for a great education, current and future discoveries, and connecting those discoveries to the world.

Joseph L. Cecchi
Dean of Engineering

Points of Pride

■ **Chemical and Nuclear Engineering Professor Jeff Brinker** has been selected by the Materials Research Society for recognition with the distinguished title of MRS Fellow. Brinker and other 2009 Fellows will be recognized at the 2009 MRS Spring meeting in San Francisco.

■ **Civil Engineering Assistant Professor Andrew Schuler** has been awarded the 8th Annual Paul L. Busch Award from the Water Environment Research Foundation (WERF). For his proposed work on improved trace organic compound removal through improved biofilms, the WERF Endowment for Innovation in Applied Water Quality Research will provide Schuler $100,000 to make the most of recent advancements in materials sciences for the improvement of submerged attached growth systems.

■ **Electrical and Computer Engineering Professor Vince Calhoun** and his team from the Mind Research Network announced that it's now possible to differentiate between patients suffering schizophrenia and bipolar disorder using a single fMRI scan and to do so with a high degree of accuracy.

■ The National Science Foundation (NSF) recently announced that **Electrical and Computer Engineering Assistant Professor Yasamin Mostofi** has received a 2009 CAREER award. Her proposal is aimed at developing the foundations of sensing and navigation in mobile cooperative networks from a compressive sampling perspective.

■ Three faculty in the **Mechanical Engineering Department** have recently been awarded a Department of Defense grant to purchase a state-of-the-art sputtering system. The high vacuum sputtering system offers extremely precise thickness and uniform deposits of metals, ceramics and thin films. This system will be used to grow multi-scale carbon structures and thermal barrier coatings. The award complements a current grant from the Army Office of Research.

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Civil Engineering Assistant Professor and Regents' Lecturer Mahmoud Taha is developing new blast-resistant composite materials. See page 8.

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Managing Editor
Tamara Williams

Writing
Megan Fleming Writing & Creative Services and Tamara Williams, UNM

Design
Brian Hurshman, Sparkplug Studio

Photography
Eric Swanson (cover, pages 1, 2-4, 7-12, back cover), Chris Corrie (inside front cover), Tamara Williams (pages 1, 16)

School of Engineering, Centennial Engineering Center, Room 3071
MSC01 1140, 1 University of New Mexico, Albuquerque, NM 87131-0001
505-277-5521
www.soe.unm.edu

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Diverse services for a

UNM School of Engineering students are a diverse group with varied cultural, academic, and ethnic backgrounds. Many are the first in their families to pursue a college education. They range from traditional students to employed professionals returning to complete their education. And they come from various locations—pueblos and rural areas in New Mexico, small and large cities throughout the US, and other countries. A student body this diverse has many different needs.

> The mission of ESS is to increase retention and graduation rates in the School of Engineering.

That's why Engineering Student Services exists: to provide academic resources, professional development advice, and community building experiences for students pursuing engineering and computer science at UNM. "The mission of ESS is to increase retention and graduation rates in the School of Engineering," says Steve Peralta, director of Engineering Student Services. "ESS does this with one-on-one advisement, community building, and activities that encourage leadership skills, diverse ideas, and teamwork."

ESS serves students like Margaret Hauer well. A senior in mechanical engineering, Hauer is Vice President of the UNM Society for Women Engineers and is active in the Hispanic Engineering and Science Organization. She participates in numerous ESS activities, receives academic advisement from ESS, and has earned several scholarships administered by ESS. She says their support has made all the difference in her education. "I would not have done all the things I did at UNM without getting involved from the very beginning,

Diverse student body

which ESS encouraged," she says. "I believe ESS plays a big role in the success stories of UNM engineering students."

Developing the Pipeline

The ESS team is responsible for everything from recruiting new students to helping SOE graduates with career placement. They look at their wide range of responsibilities as creating a steady stream of students interested in pursuing engineering and computer science. "Developing the pipeline is important because we really want to get more students into technical fields," explains Peralta. "Even at a very early age, we try to encourage, excite, and engage kids in math and science."

The recruiting and outreach process starts with the very youngest learners—even kindergartners—and extends through high school. The 15-member ESS team, as well as SOE faculty and advisors, make presentations for elementary, middle, and high school students; help with science fairs; attend high school college fairs; and coordinate the School's annual open house. ESS also offers summer science and math pre-college programs, including two intensive four-week summer residential programs that help high school students prepare for the rigors of UNM's engineering and computer science curricula.

The ESS pipeline efforts are a success, as evidenced this past fall when 487 pre-majors (freshmen and sophomores not yet admitted to a specific department) enrolled in the SOE. "This is the same number that the SOE had at its highest level. It represents an increase of 12 percent each year over the past three years," says Peralta.

Nicole Baty embodies the pipeline. As an 8th-grader she joined the Pre-College Initiative (PCI) offered by the National Society of Black Engineers (NSBE) at UNM. The PCI encourages K-12 students' interest in math, science, and engineering through activities and leadership building.

Steve Peralta, director of ESS, with Nicole Baty, a sophomore in chemical engineering, president of the UNM NSBE chapter, and manager of the chapter's PCI program.

ESS Program Coordinator Carlon Ami works with students Anthony Pomo and Christel White in the computer lab.

The program ignited her passion for engineering. Now she's a sophomore in chemical engineering, president of the UNM NSBE chapter, *and* manager of the school's very successful PCI program. "UNM NSBE-PCI showed me how and why people are passionate about science," she says.

Orientation and Advisement

ESS advisors smooth the transition to college by involving all incoming SOE freshmen and transfer students in a special engineering orientation, which includes advisement, team building exercises, classroom and lab tours, as well as an individual meeting with an ESS professional advisor.

Admission to the SOE as a pre-major is unique—at UNM and throughout the nation. "At other engineering schools, beginning students usually have to wait until they complete their math and science prerequisites before they begin working directly with the engineering staff and faculty," says Peralta. "Here we combine a focused orientation, internal advisement, and in-person meetings to meet individual student needs."

Scholarship Support

Finding funding for college can be a student's biggest challenge. It can be an even greater hurdle in New Mexico, where a significant number of college-bound students come from families who are at or below the poverty level. Fortunately, through ESS, students have access to financial aid counseling, scholarships from a variety of federal, private or corporate funding sources, and other resources to help them finance their education.

Elsa Castillo manages the SOE General Scholarship program in collaboration with SOE Associate Dean for Academics Chuck Fleddermann. Castillo has streamlined the process so that students can apply for a variety of SOE endowed and private scholarships administered through ESS by submitting just one application. She processes the information and forwards it to the SOE academic departments, which offer additional scholarships. These SOE scholarships usually supplement others offered at the university level.

The ESS team and SOE faculty work on other ways to help students finance their education through proposals, grants, undergraduate research, graduate fellowships, and outside resources from foundations, corporations, and individual donors. "We work hard to help students fund their education so they can concentrate more on their coursework," says Castillo. "However, because not all deserving SOE students can be accommodated, we are continuously seeking additional funding from private or corporate sources."

Iris Gallegos, a senior in mechanical engineering, has taken full advantage of ESS scholarship programs and Castillo's guidance. "Elsa has been a tremendous help and I'm grateful for everything she's done for me," says Gallegos. Based on her merit and academic excellence, Gallegos has been awarded three separate scholarships, some for several years in a row. "The scholarships provided through ESS have been an enormous help," she says. "With the scholarships I have received, I don't have to work and I am able to focus more on my studies."

> In terms of overall diversity and the student programs offered, UNM SOE is outstanding. It's an excellent school.
>
> Vince Cordova, section head at Procter & Gamble

In return, Gallegos participates in the new SOE Scholars Program developed by Castillo. The program requires scholarship recipients to volunteer a few hours a semester as a way of giving back to the school and organizations supporting their education. "The value of these interactions has been great," notes Gallegos. "I met some of the scholarship donors in person and was able to thank them for their generosity."

Diverse Student Organizations

The SOE student body reflects New Mexico's multicultural population and strong Hispanic heritage. More than 47 percent of SOE undergrads are Hispanic, Native American, Asian, or African American. ESS staff and advisors encourage SOE students to join student organizations and their national affiliates. Four student organizations have offices in the ESS department: American Indian Science and Engineering Society (AISES), Hispanic Engineering and Science Organization (HESO), National Society of Black Engineers (NSBE), and Engineers Without Borders (EWB).

These organizations offer valuable support, educational and professional opportunities, as well as social outlets. Students don't have to be part of an ethnic or minority group to participate, and the organizations accept students from other schools and colleges.

Support organizations for women include the Women in Science and Engineering (WISE) program and the Society for Women Engineers (SWE), which provide networking, mentoring, enrichment activities, and career development.

Native Americans in Science, Technology, Engineering and Math (NASTEM) is a resource program that helps recruit and retain Native American students in the science, technology, engineering, and math (STEM) disciplines and in business. It's also an important resource for students, offering financial assistance, career development services, mentoring, and social networking.

Recently, NASTEM began offering $1,000 scholarships to Native American students in STEM disciplines and business. Maurice Thompson, NASTEM program coordinator, says the goal is for many of the Native American students to return home after graduation. "One of our primary missions is to provide a pool of students for tribal and native communities. We want the students to go back to their communities with their degrees and provide assistance."

Diverse Career Opportunities

At the end of the ESS pipeline stand corporate recruiters like Vince Cordova, section head at Procter & Gamble. Part of his job is to recruit for the company's Product Supply Division, which includes purchasing, engineering, manufacturing, and logistics. Cordova attends SOE career fairs and actively supports HESO.

The combination of diverse students, interdisciplinary programs, and the focus on integrating teaching, research, and practice makes UNM SOE a great place to recruit students. "Our students are ethnically diverse and study in a multicultural environment so they know how to communicate and work with other types of engineers," explains Peralta. "Companies like P&G want people who already have those qualities."

"The leadership of ESS helps students understand the opportunities offered by companies like P&G and prepares them well for interviews," says Cordova. He adds that P&G's involvement with UNM SOE is a smart investment. Last year P&G hired six full-time employees from the SOE and provided summer internships for two students. "In terms of overall diversity and the student programs offered, UNM SOE is outstanding. It's an excellent school," says Cordova.

Thanks to ESS and its focus on providing a diverse set of services to help engineering and computer science students succeed, Cordova and recruiters like him are sure to find even more highly qualified recruits at the SOE in the years to come. ✦

> The connection to the server was reset while the page was loading.

scaling the wall one word at a time

RESEARCHERS STUDY THE COMPUTER SCIENCE BEHIND INTERNET CENSORSHIP

Type "Falun Gong" into www.Yahoo.cn, the Chinese version of the popular search engine, and you'll probably receive a message like this: "Connection Interrupted. The connection to the server was reset while the page was loading."

It's not your computer or the browser. The problem rests thousands of miles away in China. By searching for "Falun Gong," a religious practice banned by the Chinese government, you've run headlong into the Great Firewall of China (GFC), the Chinese Internet censorship program.

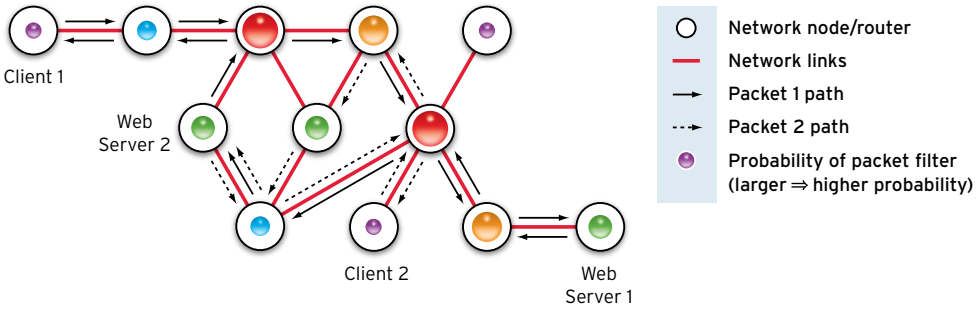
But try that same search several more times and there's a good chance it will get through. That inconsistency in what *should be* a solid perimeter is what's so interesting to Jed Crandall, assistant professor of computer science. For the last year and a half, Crandall and computer science doctoral student Jong Chun Park, along with other collaborators from UNM and University of California, Davis, have been using machine learning, algorithms, and some old-fashioned sleuthing techniques to study the technical workings of the GFC and Chinese Internet censorship. Their findings will shape future Internet policy and help secure networks closer to home.

The Science of Words

The research team's first goal is to understand the computer science behind the GFC. Central to that effort is a list of 130 banned words assembled from the Chinese version of Wikipedia. Two UNM computer science students, Erik Webb and Tamsen Schurman, took the lead in discovering the most recent list. The team prioritizes which keywords to test using a process called ConceptDoppler. Inspired by the weather-tracking tool that uses the mixing of gases to forecast weather changes, ConceptDoppler uses the complex relationship between sensitive concepts and blacklisted keywords to track Internet censorship.

With that list in hand, Park tests how the system works by repeatedly sending keyword requests and mapping their progress through the Internet. "You can see how far a packet goes before it's detected by a filter," explains Crandall. A packet is a piece of a message sent over the network. "If it goes through 14 routers in China and gets censored, then we know it's the 14th hop on that route that's sending the reset." A "reset" is essentially a disconnection forged by the censors, which stops the computers from sharing more data.

Jed Crandall



Similar to computed tomography, where X-ray beams are shot through a medium such as the human brain from different angles to reconstruct the inner topology, network tomography sends packets through a network to learn the network's topology from the outside. Censorship has basically the same effect on web packets containing forbidden keywords as, for example, bones have on X-ray beams. Diagram courtesy of Professor Terran Lane.

Park's testing process has also revealed censorship disparities in the different layers of the Internet. Because of how Internet protocols work and how packets are routed, the application-level behavior of the censor—what users actually see—can vary widely from city to city and even between two computers on the same network. For example, two reporters in two rooms in the same hotel might consistently get different results about whether a page is accessible or not due to effects such as traffic engineering operating on the individual packet level. Park and Crandall are trying to understand these packet-level dynamics and the dramatic effects they can have on the application-level behavior of censorship.

Because Crandall and Park can't conduct their research in China, they enlisted the help of Associate Professor of Computer Science Terran Lane, who took a page from neuroscience. Brain researchers use "computed tomography," a way of measuring what's happening inside the brain from the outside using a CAT scan. In a similar process called "network tomography," Crandall and colleagues use different technologies to measure the network from the outside to get a clearer picture of what's happening inside the Internet in China.

Finding Faults

They've already made several interesting discoveries. Unlike a true firewall that stops everything at the border, the GFC waits to block keywords deeper in the network. The level of censorship also varies based on the time of day and the volume of Internet traffic. Censorship is less efficient when usage is high. And, surprisingly, 28 percent of the tested paths weren't censored at all. "It's like closing access to Albuquerque by putting road blocks on the freeways and leaving all the side roads open," explains Crandall.

The keyword list reveals interesting results, too. Some words, like *Tiananmen Square*, are expected on the blacklist. Others aren't. For example, when *North Rhine-Westphalia*, an area in western Germany, is translated into Chinese characters it appears to contain the word "Falun" and is, therefore, censored. Crandall says such imprecise censorship has wide-reaching social effects—from unintentionally banning innocuous content to heightening self-censorship. He says people won't go to certain web sites because they assume they're broken, and by manipulating blacklisted words, the government can stop news of a protest from spreading. "It's effective, but not in the sense that people normally would think about censorship. It's more of a mass effect," he adds.

While Crandall and Park are focusing on China, Internet censorship is a worldwide issue. "Censorship in the Internet is surprisingly widespread and increasing quickly," says Stephanie Forrest, chair of the Computer Science Department. "Yet, very little is understood about the what, why, where, and how of Internet censorship. Professor Crandall's work on ConceptDoppler is a significant technical advance in Internet measurement, one which is allowing us to begin answering these questions."

The Open Net Initiative, which monitors Internet filtering and surveillance, says there are at least 26 known countries conducting some form of Internet filtering. "If we don't set effective global censorship policies, then the Internet could be transformed into something that's controlled in different domains," warns Crandall.

Results from the research have broad applications. Because the technology used by the Chinese is the same as that behind intrusion detection, results could help researchers and the large ISPs that control the Internet backbone develop better security tools for networks covering large geographic regions. Crandall and Park plan to continue their testing and are developing partnerships with other researchers to expand the scope of their work in hopes of unraveling more clues hidden behind the GFC. In doing so, they'll wield intellect and computing power instead of sledgehammers to bring down the walls that divide people around the world. ✦

禁 Chinese hanzi meaning forbidden, to warn

MIXING MINDS AND METHODS IN MATERIALS DESIGN

Collaborative research yields wide-reaching results

Professor Mahmoud Taha (left) has invited four graduate students to help undergrads in a state-of-the-art structures lab, where he integrates nanotechnology with construction engineering to create blast-resistant materials.

A BLAST ROCKS A SEVEN-STORY BUILDING. THE STRUCTURE RUMBLES AND SWAYS WITH THE EXPLOSION BUT STAYS INTACT. INSIDE THE OCCUPANTS ARE FRIGHTENED BUT UNHARMED. DISASTER HAS BEEN AVERTED THANKS TO SOMETHING YOU CAN'T EVEN SEE …

That scenario will be made possible by super-strong nanoscale composites being designed and tested by a multidisciplinary team of researchers led by Mahmoud Taha, associate professor of civil engineering and Regents' Lecturer.

But the materials aren't the *only* new aspect of the research. New collaborations, a new development process, a new facility, and a new generation of engineers make this research even more promising.

New Diverse Collaborations

Taha has assembled a cross-disciplinary team from UNM and other universities to share their expertise for the research. He says that while managing large collaborative teams can be challenging, bringing together diverse scientific minds has great value. "Multidisciplinary teams produce very good returns and you can see ideas cultivated quickly," he comments.

The team includes experts on material optimization from the University of Illinois at Urbana-Champaign, researchers from the University of Texas San Antonio who focus on blast simulations, and material science experts from Georgia Tech. The core UNM team includes Marwan Al-Haik and Claudia Luhrs, both assistant professors of mechanical engineering, along with Taha and Jonathan Philips, National Lab professor in mechanical engineering. All the team members lend their expertise on nano-characterization and nano-synthesis of materials.

UNM's Center for Higher Performance Computing is central to the team's success. CHPC provides the parallel computation necessary for performing important simulations. Taha says that CHPC's advanced computational ability has helped the team realize achievements at the nano- and microscale that they never thought they'd reach.

Taha and his students use a newly installed universal testing machine which will enable the structural testing of the new blast-resistant composites.

BY RE-DEFINING OUR MATERIALS, WE'RE ESTABLISHING A NEW TREND IN CIVIL ENGINEERING.

MAHMOUD TAHA

The research team's main goal is to produce blast-resistant composites for use in the construction of buildings and bridges that can sustain explosions or serious impacts. "That's just the start," says Taha. "The material would be beneficial for many other applications. Aerospace and automotive manufacturing.... there are *thousands* of applications for the material."

Besides being blast-tolerant, UNM's new materials will be strong, light, long-lasting, resistant to corrosion, and easy to work with. They will be fabricated into rods that can be set in concrete, replacing traditional steel rebar. Their unique structure will also allow engineers to monitor structural behavior.

A New Approach

The materials are innovative and so is the team's approach to creating them. "In civil engineering, it used to be that you would get a brick and be told to design a building with it," explains Taha. "Now we're handing the brick back and saying, "This isn't good enough. We can make a better brick.' That's essentially what we're trying to do."

Nanotechnology lets the team turn the materials development process around and build materials from the ground up to meet certain specifications. The process is called "materials by design" and UNM's team is leading the way. "By re-defining our materials, we're establishing a new trend in civil engineering," explains Taha. "We will not use common trial and error methods to alter our materials as we used to do in civil engineering. Using nanotechnology, we will design our materials to perform the way we desire in a way similar to what we used to do in structural design."

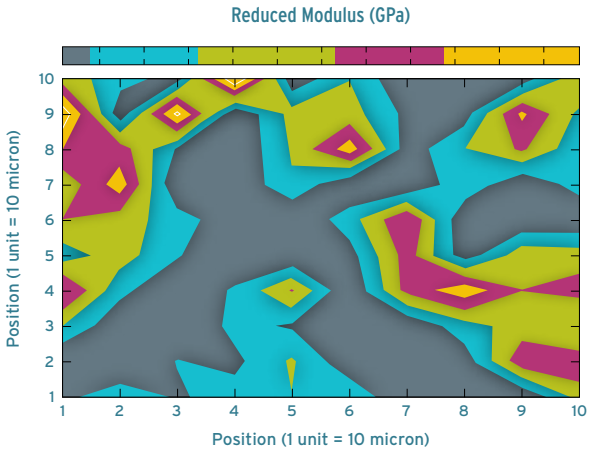
First, the team simulates the material's abilities at the nano- and microscale. As the material starts to show promising characteristics, the team goes into the lab and builds it to their specifications. Then they test the material to see if it can withstand different types and levels of force and loading scenarios such as blast.

Specifically the team is focusing on "topological optimization," a process that helps determine the ideal microstructure of the composite material. The goal is to find the best way to organize carbon fibers and carbon nanotubes to make the material as blast-resistant as possible. To do that, the team is enhancing the microstructure of the fiber composites by using carbon nanotubes in a way that will increase the material's capacity by orders of magnitude.

"We have preliminary work showing that we've produced some very strong materials in blast-based computational models," says Taha. "We are investigating it further, looking for more microstructural optimization possibilities to produce these materials. And we're integrating the computational aspects with our years of experimental investigations." The team just started to publish their findings in scientific journals. They've also filed a patent on the new material through the university.

State-of-the-Art Facility

Taha, Al-Haik, and Luhrs have been awarded a total of $2 million in grants to pursue the modeling, development, and testing of the material. These funds are helping Taha and his team complete the new



Nano-characterization of concrete shows spatial distribution of concrete properties in 10 microns x 10 microns specimen. Work by Taha and his UNM mechanical engineering colleagues.

Claudia Luhrs, (left) assistant professor of mechanical engineering.

Doctoral student Eslam Soliman, (right) monitors a material behavior during a test using the newly installed universal testing machine in the structural lab.

structural mechanics lab in the Centennial Engineering Center. "We are furnishing the new labs with state-of-the-art equipment for large-scale structural testing," says Taha. New equipment for the lab will include loading frames, actuators, large hydraulic pumps, a fracture mechanics testing machine, and computer-based data-acquisition instrumentation. The funds also helped UNM upgrade its nano-indentation facility, originally established by Marwan Al-Haik, to a top-of-the-line testing facility.

The array of new equipment opens up an entirely different level of testing and experimentation for the team. Now they can test full-scale walls, columns, and beams and compare concrete structures reinforced with conventional steel to those reinforced with the new composite material. The team will also be able to monitor the process of failure in the materials and record the failure at realistic loading rates. "Testing small specimens doesn't really represent how structures work. Scale in structures matters," explains Taha. "The behavior of structures at the macro-scale is very different than it is in micro- and nanoscale. We are establishing a multi-scale testing facility. "

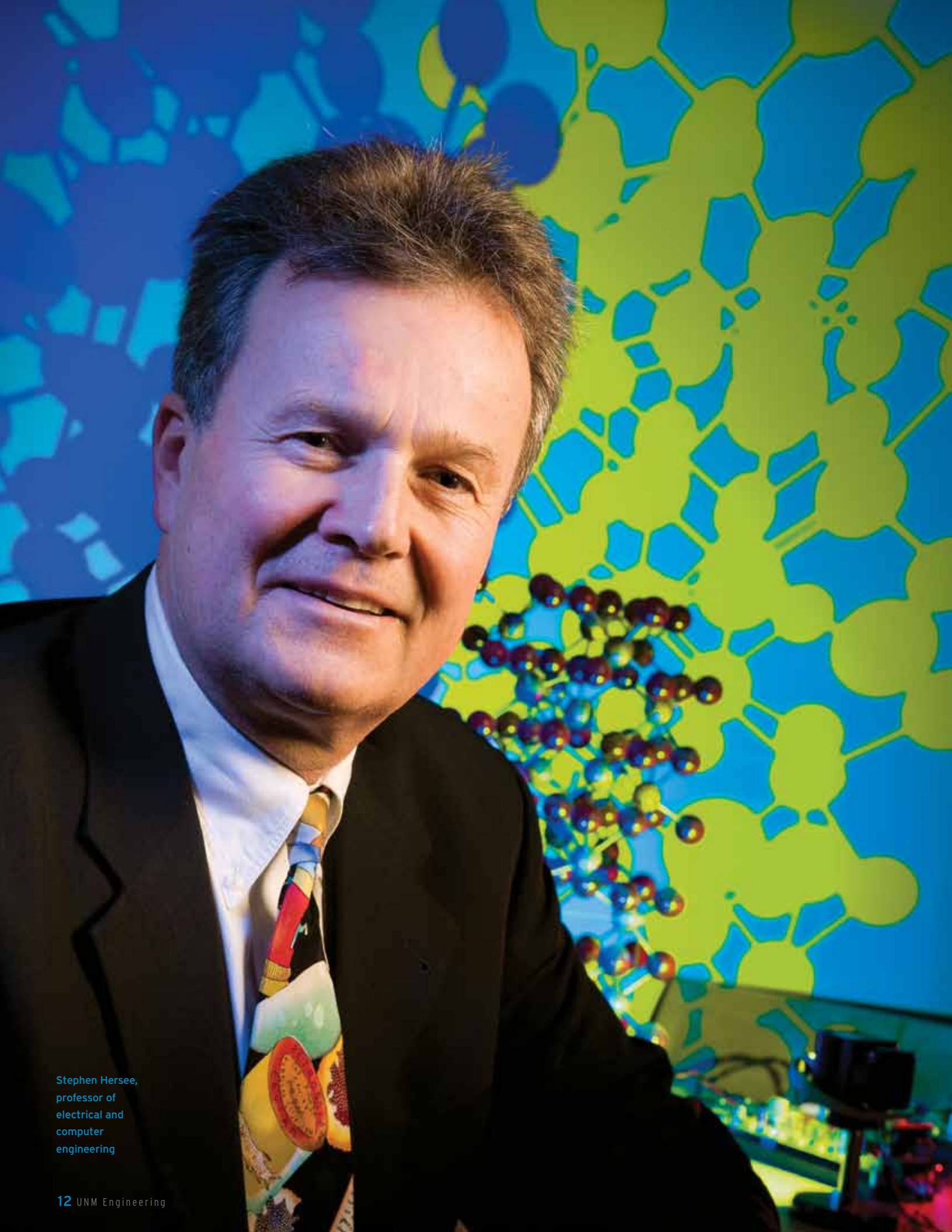
New Generations of Engineers

The new lab will help researchers introduce students to nanotechnology and give them a place for experimentation and observation. This is the first year that Taha has included nanotechnology in his introductory level undergraduate civil engineering materials class. "It's unusual to bring the latest technology and research to undergrads," he says. "But ten years from now, nanotechnology will be the core of materials design. That's why it's important to bring it into the classroom now."

Taha is also changing the way the materials lab is taught. Instead of having one teaching assistant run the lab, Taha has asked three doctoral students and one masters student to help. They get valuable experience and enhance their own education while helping undergraduates conduct experiments in the lab. "There's a lot of collaboration between the two groups and excellent knowledge exchange. The students are enjoying it too," says Taha.

Eslam Soliman agrees. As a civil engineering doctoral student and one of Taha's research assistants, Soliman will be working in the lab. The opportunity will help him advance his own research while giving him valuable collaborative experience with the mechanical and electrical engineering students involved in the project. "We work as a team and that gives us the opportunity to gain knowledge in different fields, which will be a great help for us in the future."

As for the future of the research, Luhrs says the potential is huge. "These kinds of studies enable scientists and engineers to design and manufacture lighter, stronger, less expensive, and cleaner products. Along with other groups devoted to the study of nano materials, we are participating in the design and generation of products that will fulfill the needs of our society." ✚



Stephen Hersee, professor of electrical and computer engineering

New research center will change the way we see – and use – light

In the early 1800s, Englishman Humphry Davy invented the world's first electric lamp, the precursor to the light bulb. Many scientists and inventors refined the design in the ensuing decades, but it wasn't until 1879 when Thomas Edison engineered an oxygen-free bulb with a long-burning filament, that the incandescent light bulb really began to shine.

As years passed, the light bulb's efficiency and longevity improved, but its basic purpose — producing light — remained essentially the same. Now that's changing and UNM SOE is part of a revolution in light. Researchers are adding more capabilities to light, making it more energy-efficient, and using it to communicate. In short, UNM researchers are making light *smart*.

The UNM SOE is proud to be a key member of the new **National Science Foundation Smart Lighting Engineering Research Center (ERC)**, announced last October. An ERC is a prestigious, interdisciplinary center that brings academia and industry together to foster broad-based research and education collaborations that advance technology, increase knowledge, and create innovations that address challenges in society. Fifteen ERCs around the nation not only generate new technology, but also create new workforce opportunities, enhance education for future generations, and spur more competitive American industries.

"Our participation in this center offers a chance for our engineering students and faculty to create energy-saving technologies that will improve our society and create new business opportunities. We are particularly excited that this program will also have a strong focus on outreach, and we anticipate that the new field of Smart Lighting will increase the number and diversity of students entering science, math and engineering education," says UNM President David J. Schmidly.

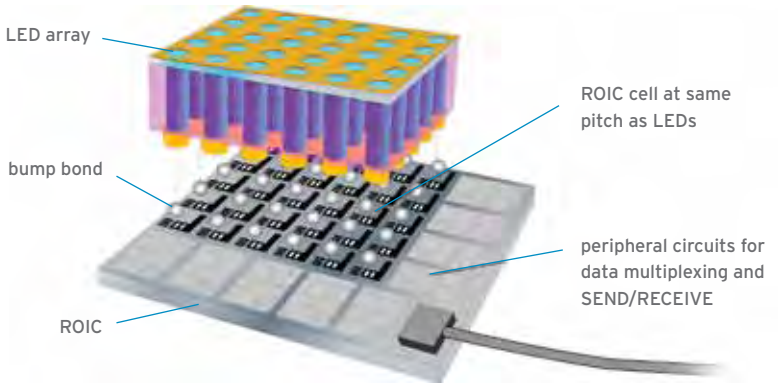
The ten-year ERC program is a collaboration among three core institutions — Rensselaer Polytechnic Institute (RPI), the lead university; Boston University; and UNM — and several support organizations. Collaborative research tasks will be performed with faculty and students at Howard University, Morgan-State University, and Rose-Hulman University. Three international universities have been invited to support the ERC's research and education goals: Chonbuk National University in Korea, National Chiao Tung University in Taiwan, and Vilnius University in Lithuania. The ERC includes large and small industry partners, national associations, and small business incubators that will contribute oversight, assist with strategic development, and offer entrepreneurial opportunities for students.

The UNM ERC Team

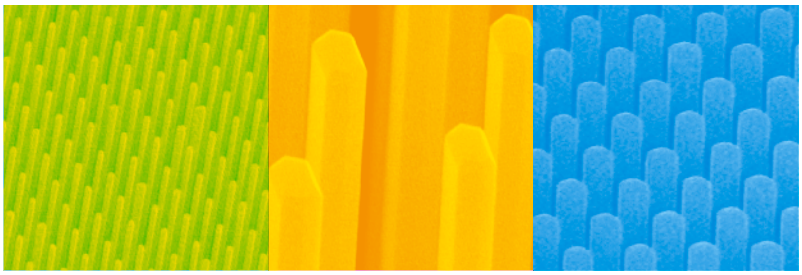
The entire Smart Lighting ERC was granted $15 million for the first five years of this ten-year project. UNM will receive up to $5 million over the next five years. Stephen Hersee, professor of electrical and computer engineering, is the ERC associate director at UNM and also leads the ERC Materials Research Thrust. Several other UNM researchers will provide expertise in nanotechnology, materials, and devices to the team. Hersee notes that the ERC is still looking for more partners to share their research expertise.

Stephen Brueck, CHTM Director, distinguished professor of electrical and computer engineering, and professor of physics and astronomy, will lend his expertise in patterning at the nanoscale. Brueck can put billions of elements into a minute pattern, which other ERC team members will use to build innovative, light-producing devices.

The UNM ERC team also includes Marek Osinski, Gardner-Zemke professor of electrical and computer engineering, professor of computer science, and professor of physics and astronomy. Osinski will contribute his research on nanoparticle phosphors, a synthetic material that lights up when exposed to ultraviolet light. The phosphors can be combined with other devices to create new possibilities for generating light.



A schematic representation of the solid-state, lens-less microscope. Half of the LEDs emit light, which bounces off the object to be imaged. The other half detect light scattered from the surface. The ROIC circuit processes the light-scattering information and sends it to a computer.



SEM images of GaN nanowires grown by a pulsed MOVPE process. Properties of these wires such as length, diameter, and pitch can be controlled over a wide range.

"Nanotechnology offers unprecedented opportunities for tailoring material properties to desirable characteristics," says Osinski. As an example, he says that nanophosphors can be optically modulated at much higher speeds than traditional phosphors. Osinski adds that nanoparticles also will be used to create novel high refractive index materials.

For his part, Hersee will contribute his research into a new form of solid-state lighting using gallium nitride (GaN) nanowire LEDs (light emitting diodes). He focuses on GaN because of its many positive properties: it gives off visible light; has a strong, stable construction; and, in nanowire form, the crystals have no defects that would otherwise have negative effects on devices. He uses a new process being patented by UNM to fabricate the nanowires, each just microns tall. Billions of these nanowires will be grouped and used as minute platforms for building novel lighting devices.

Hersee was the first to produce GaN nanowires with a high degree of uniformity, which is critical to the success of devices that will use them. Previous attempts at nanowire production resulted in what Hersee calls "nano noodles," bent wires of different lengths. "You need uniformity and high quality to be able to cost effectively fabricate many devices in parallel," he says.

Light Gets Smart

The progression from incandescent light bulbs to more efficient compact fluorescent lamps is already taking place. Hersee says that even *more* efficient smart lighting will replace compact fluorescent lamps in the 2010 to 2020 timeframe. He notes that people are quite reluctant to change to the more efficient, compact fluorescent lamps because they produce a much harsher, "colder" light spectrum. "We have to be very aware of human factors when we are dealing with something as important

Applications for smart lighting include traffic lights that "talk" with car headlamps to improve safety and smooth traffic flow.

as lighting," he says. Smart lights will address the spectrum issue by providing a more natural color. In fact, with a smart light users will be able choose whatever color suits them best.

Developing high quality materials that will emit energy efficient light is just the beginning. The ERC's research will produce "smart" lights, devices that not only generate light but emit it at wavelengths which can be modulated to transmit the Internet, play music, and much more. "We've never had anything like this before," says Hersee. "We're replacing something that exists with something that has many more benefits and uses."

A wide range of industries from health care and defense to technology and transportation will use smart lights to make our lives better, easier, safer—and brighter. Applications of the technology include energy efficient lights with a natural spectrum that can exactly mimic the sun; traffic lights that "talk" with car headlamps to improve safety and smooth traffic flow; and overhead lights that can transmit data to digital devices like MP3 players and computers.

Launched late last year, the ERC is still in the planning and organization phases. Members are starting with the big picture to determine what to develop—and how. "We begin at a systems level and then define the technical gaps that we need to fill," explains Hersee. "For example, we start with the question of wanting cars to talk to each other and *then* we figure out how best to do that."

Several research efforts are already well underway. One of the earliest products to feature smart lighting is a solid-state biological imaging microscope that will automate the analysis of biological samples and tests for preventative healthcare. The microscope will be improved in phases, eventually leading to a radically new microscope that will be no bigger than a dime and will feature Hersee's GaN nanowires as the light source. The GaN light will replace the current mercury light-sources that emit inadequate light, which often destroys the biological cell samples being examined. UNM has applied for a patent on the microscope and expects a prototype device in about five years. The ERC's goal will be to use smart lighting and new microscopy paradigms to speed analysis and save health care dollars.

Beyond Research

New technology will be one outcome of the research center. Greater human potential is another. "The scope of the ERC includes a lot more than creating technology," says Hersee. "Part of our responsibility is conducting outreach to create the budding engineers that will go on to the universities and hopefully choose this area as one of their options."

The ERC's educational outreach will start with researchers taking the technology into middle and high school classrooms because the science is so new it's not in textbooks. The UNM team plans to work with the Albuquerque Public School system and teachers around New Mexico to add smart lighting science to the curriculum with the goal of shining a light—literally—on the many career opportunities in science and engineering. The outreach process will also help secure the future of the technology, notes Hersee. "If smart lighting develops like we think it will, we're going to need a lot of engineers. We want to make sure that America is graduating enough engineers to sustain this technology."

ERC outreach efforts will extend to New Mexico's universities and their diverse enrollments. "Nationwide there is a focus on improving diversity in engineering," says Hersee. "So our outreach is dual purpose. We want to generate more engineers, but we need to work especially hard to attract more women, people of color, and other minority students into engineering. Science and engineering will not only benefit by tapping the new intellectual potential that more diversity will bring. But with something so fundamental and ubiquitous as lighting, that touches all of society, we need to have all of our society represented in this revolution in lighting."

Part of the ERC program will be devoted to understanding and promoting the innovative spirit. Graduate and undergraduate students will have the opportunity to take classes on intellectual property development and the technology transfers process. These courses will be coordinated through STC.UNM and intellectual property and business incubation organizations at each of the core partner institutions. Students will collaborate with the ERC's industry partners through internships. Engineers from industry will spend time at the various ERC academic sites. In some cases, the students will become entrepreneurs themselves, taking the technology they helped develop into industry.

Amazing technologies, stronger industries, diverse generations of new engineers—the Smart Lighting ERC is full of potential to create a brighter, smarter future for the world. ✦

How Do Networks Work?

A UNM professor studies the relationship between networks and energy consumption

The relationship between how networks are constructed and how they shape their environment, especially in regards to energy consumption, has long interested **Melanie Moses**, assistant professor of computer science.

A presentation Moses gave on "Network Scaling in Societies" triggered an invitation to contribute an essay to the international science publication *Nature*. Her essay was part of a series on "Being Human" that explores various scientific and academic aspects of what makes people different from other animals. "*Nature* is a very prestigious publication," says Computer Science Department Chair Stephanie Forrest. "For Melanie to be asked to submit an essay is truly an honor and an indication of the caliber of her research."

Published in the February 5, 2009 issue, Moses' essay confronts what *Nature* refers to as "humanity's greatest paradox: how to reduce the demand for energy in increasingly complex, networked and therefore energy-dependent societies."

In her essay, Moses looks at the connection between human networks and their demand for energy through the lens of human reproduction rates. She refers to the Metabolic Theory of Ecology, which biologists use to explain why elephants have many fewer offspring than mice, but also live much longer. The theory states that both are related to the length of the circulatory network needed to provide nutrients to the cells of each animal: the longer the network, the slower the metabolism, and the fewer the offspring. Moses states, "North Americans consume energy at a rate sufficient to sustain a 30,000-kilogram primate, and give birth at the very slow rate predicted for a beast of this size."

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>
> MELANIE MOSES

This takes into account the power we consume through electrical, oil, gas, and other networks. MTE also explains why humans with the most resources tend to reproduce the least: each child in a developed nation takes a great deal of resources, and parents react by having fewer children.

Moses asserts that by getting a clearer picture of how networks function, humans will be able to build more efficient social and infrastructure networks to meet rising energy demands without putting the burden on future generations. Her research combines theoretical and computational approaches with biological fieldwork focusing mainly on ant colonies. Moses and her students study the colonies in the field and then build models in the lab to understand how ants use networks to exchange information and forage for food efficiently. "We use ants as inspiration to develop algorithms to guide efficient search in other domains," says Moses. "Ant colonies, global trade, and cities are all sustained by dynamic networks that deliver energy. We can apply what we learn from studying ants to improve efficiencies in traffic, oil consumption, and how we structure cities." ✦

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Bob Stamm

David Loaiza

Sean Murray

Jamie Reed

Alumni News

Building History

For more than six decades, **Bob Stamm** ('42 CE) has dedicated his time, energy, and resources to the University of New Mexico. His ties to UNM go back even further. "UNM is a big part of my family history," Stamm says. "My father graduated in 1898 and is the first Alumni Association president listed on the clock at the duck pond." Stamm met his late wife, Florrie ('42), at UNM and their two children earned UNM degrees.

Stamm has supported many UNM programs including engineering, architecture, fine arts, education, Presidential Scholars, and Lobo sports. Recently, he added a planned gift to fund a professor in practice shared by the School of Engineering and the School of Architecture & Planning. As an engineer and contractor, Stamm worked closely with architects, so he wants to help UNM's Architecture Program and Civil Engineering's Construction Programs partner in construction technology. Sr. Director of Development Pam Hurd-Knief helped Stamm create his legacy gift, which includes two endowed presidential scholarships. "If you have specific ideas for an estate gift, talk about it while you're still around," he adds.

Stamm's generosity has influenced many, including Jim and Ellen King of Bradbury Stamm Construction who provided funds to name a study area in the Centennial Engineering Center the "Robert J. Stamm Commons." Ellen King says, "Bob has been both a mentor and friend to us and we knew he would be pleased with a gift to the University." Stamm's generosity and influence expands his family's legacy to include future generations of builders, teachers, and artists.

How the Stamm and King Gifts Were Made

Bob Stamm took advantage of a new planned giving opportunity, the Estate Gift Intention Form (EGIF). He outlined his estate gift plans and the gift's value, then wrote endowment agreements detailing how he wanted his gifts used.

Individuals as well as families, businesses, or companies can be honored with naming spaces, programs, scholarships, and positions. These gifts can be of cash, stocks, securities, or tangible property.

SOE's development officers, Pam Hurd-Knief (505-277-0230/ frognm@unm.edu) and Sharen Hart (505-277-5541/ sharhart@unm.edu), can provide more information about the EGIF process and making a gift honoring an individual.

Living the American Dream

In September 2008, **David Loaiza** was selected as a White House Fellow, considered America's most prestigious fellowship program for leadership development and public service. Just 20 years ago, he was an exchange student from Bolivia finishing high school in Santa Fe. Loaiza enrolled at UNM with plans to transfer to another school, but liked his classes, the people, food, and weather so much he stayed to complete four degrees ('92 BSNE, '93 MS, '97 Ph.D., '01 MBA). "The school has a very strong engineering program, especially in nuclear engineering. The classes were small and the professors were so dedicated," he says. Loaiza went on to conduct research at Los Alamos National Laboratory (LANL) and helped shape U.S. non-nuclear proliferation policy. He says the University's connection with the national labs was especially important. "UNM has great relationships with Los Alamos National Laboratory and Sandia. Overall, I received a very solid education at UNM."

UNM Grad Excels at Harvard University

As a first-year MBA student at Harvard University, UNM graduate **Sean Murray** ('04 ME) was recently given a Life Sciences Fellowship. The merit-based $20,000 fellowship is granted to outstanding students and supports the university's increasing focus on health care. Murray plans to use his experience and advanced degree to manage a global medical device company. The fellowship is Murray's second prestigious award. In 2004, he was one of 77 students in the United States to receive a Truman Scholarship, awarded for leadership potential, intellectual ability, and likelihood of "making a difference."

Student News

Grad Student to Study with Nobel Laureates

Chemical Engineering graduate student **Jamie Reed** has been accepted to the Lindau Nobel Laureate Meetings this summer. The globally recognized forum brings together Nobel Laureates with students, post-docs and young researchers from all over the world to exchange ideas and share information.

Keep in Touch. Have you been promoted, taken a new job, or received an award honoring your achievements? Please let us know. Send your update to **UNM Engineering**: soedev@unm.edu or MSC01-1140, 1 University of New Mexico, Albuquerque, NM 87131.

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