From the Dean—Made at Mason

Dear Alumni and Friends,

If you walk the halls of the Nguyen Engineering Building this fall, you’ll see posters with the tagline, “Made at Mason.” The posters show recent grads with inventions they made while students. I’m always excited to see our students with their inventions, but it’s not just inventions that are made at Mason.

When our students come to Mason they may not know many classmates or faculty. When they leave, they have a global network of friends and future colleagues. Relationships are made at Mason.

When they enroll, our students choose a pathway to a high-demand profession in IT, computer science, or engineering. They learn skills for success in their professions. Careers are made at Mason.

When our students stay up late, study hard, solve problems, participate in student organizations, engage in research, and earn their degrees, they make memories. Memories are made at Mason.

When they graduate, we hope our new alumni think about what they made at Mason. We hope they come back and visit. We hope they tell us what they made at Mason, and how Mason made them.

In this annual report, you will see examples of research, teaching, and scholarship organized by our seven areas of expertise. Embedded into these stories are some of the relationships, memories, and careers that are made at Mason. I hope you enjoy reading our annual report. Learn about what we are making at Mason, and how Mason is making a difference.

Best Regards,

Kenneth S. Ball, PhD, PE
Dean, Volgenau School of Engineering

ABOUT THE COVER

Recent systems engineering graduates (from left to right) Samuel Miller, Amr Attyah, Andrew Tesnow, and Maribeth Burns display a prototype of a device they developed for their senior design project last spring. The device measures tibial shear force and provides biofeedback to prevent ACL tears before they happen. For more details, see page 18.
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If you followed your favorite NFL team on ESPN this past season, there’s a good chance Brian Burke, MS Operations Research ’15, provided the reporters you saw on camera with in-game analysis information. Since joining ESPN in June 2015 as a senior analytics specialist, Burke has worked to ensure reporters receive best-in-class football analytics from his home office in Reston, Virginia.

Burke had an unorthodox start for a career in sports analytics, flying combat missions in the Navy after graduating from the U.S. Naval Academy. After leaving the Navy in 2005, he was a single dad with two young children at home. In the evenings, once the kids were in bed, he devoted time to his hobby—football analysis. In 2007, his hobby turned into a website, AdvancedFootballAnalytics.com. That’s when Burke started to receive national attention that led to him becoming a regular sports contributor to the New York Times while working as a defense contractor.

His passion for sports led him to Mason’s Department of Systems Engineering and Operations Research in the Volgenau School of Engineering and to associate department chair Andrew Loerch.
With their similar backgrounds (Loerch is a retired Army colonel who specializes in military operations research, and is a New York Giants fan), Burke found a mentor and decided to enroll at Mason.

“I decided to make the night job into the day job and go for it full time,” Burke says.

While in the program, Burke took advantage of course electives focused on military topics because of his naval background. He finds there are similarities that can be drawn by studying military tactics as they relate to sports analysis.

“The best thing about sports is that it’s a great training laboratory for analytics and analysis,” he says. “It doesn’t matter if you’re looking at two companies, two teams, or two countries. It’s just numbers at the end of the day.”

Burke now teaches sports analytics as an adjunct professor in Mason’s Data Analytics Engineering graduate program.

When he’s not analyzing football, he spends time flying a Cirrus SR-20 and training for triathlons.

*A version of this article by Kathy Dodd appeared in Mason Spirit magazine.*
Statistics Chair Extends Research with **Fulbright Scholarship**

Known for its medieval cathedral, the city of Aachen, Germany, places predominant economic focus in the 21st century on science, engineering, information technology, and related sectors.

William Rosenberger, a University Professor and Department of Statistics chair, received a Fulbright Scholarship to travel to Aachen to pursue his research on randomization. While there, he conducted collaborative research at the RWTH Aachen University Medical Center. He also finished the second edition of his book, *Randomization in Clinical Trials: Theory and Practice*.

Rosenberger has been cited for his theoretical contributions to statistics in the areas of experimental design and sequential analysis that have been recognized locally, nationally, and internationally. The Fulbright award created an opportunity for him to extend this work and team up with others.

The faculty at RWTH Aachen are involved in a $3.42 million grant from the European Union on methodology for clinical trials of rare diseases. Rosenberger collaborated with them on problems involving the use of randomization in very small clinical trials.

Clinical trials explore whether a medical strategy, treatment, or device is safe and effective for humans and may show which medical approaches work best for certain illnesses or groups of people. Statistical studies play an important part in clinical trials by allowing researchers to form reasonable and accurate inferences from collected information and make sound decisions in the presence of uncertainty.

“Some of the diseases are so rare there is no cure,” says Rosenberger. “The statistical methodology for a disease with as few as 50 cases in the world is much different than that of a more prevalent disease.”

Despite such small numbers, Rosenberger believes there are compelling reasons to study these diseases. “About 6,000 to 8,000 rare diseases affect 30 million people in the European Union, and about 50 percent of these people are children,” he says.

Because many of the diseases are life-threatening and alternative therapies may not exist, there may be ethical imperatives to maximize the number of patients receiving experimental therapies.

Fulbright scholarships to Germany are increasingly rare; only seven were funded in 2015. Funding a Fulbright to do research in statistics is even more rare, but Rosenberger’s work is unique, and the medical center at Aachen is one of the few places that studies randomization methodology.

Faculty and doctoral students from Aachen also visited Mason to continue the research with Rosenberger. “The ongoing collaboration should lead to developments that could have a major impact on the public health in both the U.S. and Europe,” Rosenberger says.

*A version of this story by Martha Bushong appeared on the Volgenau School website.*
Keeping Our Heads in the Cloud

The Internet, smartphones, and tablets—all cloud-connected tools—increase our productivity and interconnectedness, but they also make us less secure. And it’s not just our personal privacy that is at risk. Intellectual property, financial transactions, aviation, energy grids, medical devices, automobiles, and national security face threats as never before.

Twenty-five years ago, before the words cybercrime and cybersecurity existed as part of our everyday vocabulary, before major corporations like Home Depot and Anthem experienced data breaches, George Mason University established the Center for Secure Information Systems with one researcher and a handful of students. That began a journey that led cutting-edge research and saw George Mason emerging as a national leader in cybersecurity education and research.

“Today, cybersecurity is in our DNA,” says University Professor Sushil Jajodia, the center’s director. “Almost every school or college at Mason has some program that deals with information security. But it wasn’t always that way.”

continued
Now cybersecurity is everywhere and Mason’s center, the first academic center in security at a U.S. university and one of the National Security Agency’s original Centers of Academic Excellence in Information Assurance Education, has earned additional recognition, garnered millions in research funding, and educated scores of students. The changes in the cybersecurity field during the last 25 years have created unprecedented opportunities for Mason and its researchers.

In 2014 Mason was ranked seventh in the nation for cybersecurity by the Ponemon Institute, and this year Universities.com has named Mason to its Top 10 grad schools for cybersecurity. The university also recently partnered with the U.S. Army Reserve Cyber Private Public Partnership Program to create educational pathways for future “cyberwarriors.”

Unconventional Risks, Innovative Solutions

The threats continue to evolve and they are becoming more sophisticated. To the experienced cyber criminal, the act of taking down an entire network system is very much a game between the defender and attacker.

To combat these threats, the field of cybersecurity must constantly change,” says Jajodia. “As researchers, it is our job to understand and even set the rules of this game so that we can outsmart the attackers before they have the opportunity to create severe damage.”

Tackling these unconventional, technology-enabled security risks requires innovative solutions, but technology alone won’t solve the problem. Cybersecurity needs to be informed by criminology, psychology, law, diplomacy, data analytics, and more. Mason’s programs draw their strength from a multidisciplinary approach.

“The cybersecurity industry is no longer focused solely on technical experience,” says Mason computer scientist Angelos Stavrou, director of the Center for Assurance Research and Engineering in the Volgenau School of Engineering. “It has moved from the backroom to the boardroom, and security leaders need to manage the business impact of security incidents.”

Educating Future Leaders

Over the years, Jajodia has supervised many students who have gone on to become tenured professors at U.S. universities, the nation’s military service academies, and foreign universities. Other former students have founded their own companies and assumed leadership positions in international corporations. A notable example is Peng Ning, PhD Information Technology ’01. Ning came to the United States from his native China to work on a PhD. He is now a tenured professor at North Carolina State University, where he researches issues in cloud computing security, with an emphasis on cloud infrastructure security. He is currently on leave working with an R&D team at Samsung Mobile in Santa Clara, California, developing smartphone technology that will enable users to separate personal and professional data without using two devices.

Twelve degree programs within the Volgenau School deal with some aspect of cybersecurity; the newest is the BS in Cyber Security Engineering, which started in January 2015.

“We have worked with industry leaders to develop this program, and it’s by partnering with these leaders that Mason is able to best prepare students for today’s challenges as well as tomorrow’s,” says Dean Ken Ball of the school’s new degree program.

Increasing Economic Opportunities

Given the number of national security agencies, government contractors, and information technology leaders in Northern Virginia, it is not surprising that the Washington, D.C., metropolitan area has emerged as a cybersecurity hub.

Ironically, the cyber threats are also creating economic opportunity, and Northern Virginia stands to benefit. President Barack Obama's budget proposal for the 2016 fiscal year seeks $14 billion for cybersecurity efforts across the U.S. government.

“Mason's proximity to Washington, D.C., makes it a natural center of this kind of research activity,” says Stavrou. “Our academic instruction has a research-to-practice mindset. Our partnerships with government and industry have helped our students and faculty take products from the academic research setting to the marketplace.”

In 1990, Jajodia saw a need and decided to act. He now finds great satisfaction as he looks back and sees the advances in the cybersecurity field. “Where there are needs,” he says, “there are opportunities for research, which informs education and practice.

“Cybersecurity is Mason’s crown jewel. Its success is a testament to the quality of the work, our students, and our research.”

A version of this story by Martha Bushong appeared in the fall 2015 issue of Mason Spirit.
Imagine burglars have targeted your home, but before they break in, you’ve already moved and are safe from harm.

Now apply that premise to protecting a computer network from attack. Hackers try to bring down a network, but critical tasks are a step ahead of them, thanks to complex algorithms. The dreaded “network down” or denial of service message never flashes on your screen.

That’s the basic idea behind new research by George Mason University researchers, who recently landed some $4 million in grants from the Defense Advanced Research Projects Agency (DARPA). George Mason’s researchers are leading an effort that includes Columbia University, Penn State University, and BAE Systems.

“Our research is vital as a real-world solution to these attacks, which are one of the most critical cybersecurity threats today, crippling online businesses with downed websites, financial losses, and damaged client relationships,” says Angelos Stavrou, who leads the research team and teaches in Mason’s Management of Secure Information Systems Program.

Widespread Problem
The most common approach cyber criminals use is to flood a server with requests because servers can only handle so much traffic before shutting down.

Denial-of-service attacks hit record highs last year, up nearly 150 percent, according to cybersecurity firm Akamai. These attacks last between 6 and 24 hours and cost $500,000 or more, another survey notes.

Responding to this threat is akin to an arms race, says Daniel Fleck, who’s part of the Center for Assurance Research and Engineering (CARE). Companies and governments put scores of servers into play to fight off the attacks. Seconds count for mission-critical systems, especially for the military. Hackers step up their efforts to counter the numerous servers.

“It’s an arms race no one wants to be in,” he says.

What’s Next
Mason researchers are working on the next step in fending off computer hackers. It’s a method called “shuffling” in which hackers and regular users are quickly separated through a series of splits that eventually isolate the bad actors.

Solving one problem means another will spring up, making the field an exciting one.

“In security, you actually have an adversary,” Fleck says. “You wonder what they’re going to do when you solve the problem.”

A version of this story by Michele McDonald appeared on Mason’s news website.
Making sustainable cities, towns, and structures by seeking solutions to environmental problems that matter.

Ed Dalrymple (center) explains the process of asphalt reclamation to students in Associate Professor Burak Tanyu’s geotechnical engineering class at Cedar Mountain Stone Quarry.
Civil Engineering Students Have a Blast at Cedar Mountain Quarry

When college students say they had a blast, they typically don’t mean watching 20,000 lbs. of explosive power blast 40,000 tons of rock, but that’s how senior civil engineering student Rachael Wright described her field trip to Cedar Mountain Quarry.

Wright was one of 40 students from Associate Professor Burak Tanyu’s geotechnical engineering class who donned bright orange hard hats on a crisp fall morning and toured the 1,500-acre quarry just south of Culpeper in the Shenandoah Mountain foothills.

“It was thrilling to see the explosion,” says Wright. “I had seen a quarry explosion on video before, so I wasn’t expecting it to be so exciting. But seeing a video is nothing like being there, watching rocks fly forward, seeing dust billow out from the rubble, and feeling the force of the explosion through the air before hearing it. It was surreal.”

Tanyu designed the field trip to teach students about geological formations and what it takes to make the rock aggregate that forms the basis of many Virginia roads. His class combines two fields of study, geotechnical engineering and geology, that are often separate. Geotechnical engineering focuses on soil and geology focuses on rock.

The class gives prospective geotechnical and civil engineers a background and understanding of the earth’s history and processes so they can understand the implications of how these relate to engineering problems such as earthquakes and landslides, as well as make educated assessments for suitable ground conditions, and select appropriate soils and rocks for construction.

“Rather than merely memorizing the most common rocks we might see in our work,” says Wright, “we are learning how they get there, how to describe them, and what it means when we see certain formations. This class isn’t just teaching us about geology. We’re learning when it’s important to learn more and seek advice from an expert.”

The students saw the rock before the blast in its natural formation and after the blast as small pieces of rock that could be used in construction. It changed hundred-ton rocks that aren’t useful for construction into sizes that can be used for the aggregate in highways and roads.

“We could recognize the texture of the quarry walls and minerals we had covered in class in the rocks on the site,” says Wright. “We saw things in the field we had talked about in class. It was interesting to watch them place explosives, learn the reasoning for what they wanted to happen, then watch massive rock formations explode into small pieces.”

Tanyu was able to arrange this field trip when the owner of Cedar Mountain Quarry, Ed Dalrymple, asked him for an onsite meeting. Dalrymple wanted to discuss the details of a research project that focuses on developing sustainable solutions to expand roadway designs in Virginia.

“The people at Cedar Mountain Quarry told me they had never hosted such a visit because most researchers do not bring their students to these meetings,” says Tanyu. “I saw the opportunity to kill two birds with one stone, and I know the students benefitted.”

A version of this story by Martha Bushong appeared on Mason’s news website.
Hurricane Sandy revealed how vulnerable traditional hurricane protection methods are when it smashed New York Harbor with 32-foot-high waves in 2012.

At least 185 people in the United States, Canada, and the Caribbean died from the hurricane, which caused $65 billion in economic losses.

“The traditional approach was to rely solely on hard engineering structures, which are expensive and sometimes ineffective,” says water resources engineering professor Celso Ferreira of the Sid and Reva Dewberry Department of Civil, Environmental, and Infrastructure Engineering. “After Hurricane Sandy, there was a big move to look at a hybrid approach that uses nature to enhance flood defenses.”

Ferreira and his student team pulled on waders and hip boots last summer to begin installing instruments that measure wave action, storm surges, tides, and other details in the marshes of the Chesapeake Bay. It’s hot, muddy work with more than a few mosquitos.

Marshes provide natural protection from the flooding that hurricanes bring. But which plants work best, how many, and how far they should stretch from the shore were questions asked by this team of Mason civil engineers. To find the answers, they used more than $500,000 in grants from the Department of the Interior, the National Fish and Wildlife Foundation, and the Thomas F. and Kate Miller Jeffress Memorial Trust for Interdisciplinary Research. Their findings could change the way coastal areas are protected from hurricanes.

The team investigated “how we can effectively use nature-based defenses for engineering coastal defenses so we can maximize protection when a hurricane hits. Plants need to be in the right place at the right time,” says Ferreira, who grew up surfing in his native Brazil and found combining his love for water with engineering to be a natural fit.

Ferreira was working on his doctorate in 2008 at Texas A&M University when Hurricane Ike hit the Texas coast, prompting him to study hurricanes.

The team will be working on this project for at least the next two hurricane seasons. Peak hurricane season is generally from mid-August to mid-September for the East Coast and Eastern Caribbean, and mid-August to early November for the Western Caribbean.

A version of this story by Michele McDonald appeared on Mason’s news website.
Civil Engineering Students Serve Large Charismatic Clients

By Martha Bushong, Director of Communications

Designing an object to enrich the lives of six four-legged female clients who weigh as much as 10,000 lb., can move at speeds of 30 mph, and are apt to eat 125 to 150 lbs. of food daily is an unusual class assignment for civil engineering students.

When zookeepers at the Smithsonian's National Zoo in Washington, D.C., were looking for additional designs to consider for elephant enrichment, they contacted Liza Durant, chair of Mason's Sid and Reva Dewberry Department of Civil, Environmental, and Infrastructure Engineering at the Volgenau School of Engineering.

The school had a connection with the zoo through alumna Paige Babel, BS '15. An elephant animal keeper at the zoo, Babel studied civil engineering and environmental science at Mason. So when the conversation about enlisting the help of future engineers began, she immediately thought of Volgenau.

"We were looking for intellectually curious students and hoping for a structurally sound piece. We also knew that to build an enrichment object it would take a lot of outside knowledge about construction," says Babel. "Our Asian elephants have all kinds of objects in their space, but we thought the students might come up with ideas we hadn't thought about."

As part of the assignment, students from Durant’s Environmental Engineering class visited the Elephant Community Center at the zoo to meet the six elephants, observe their species-specific behaviors, and ask the zookeepers pertinent questions.

The students appreciated information that the zookeepers shared and the insight they provided. "Being there with a particular assignment made me observe their behavior more closely," says Paula Young, BS ’17. "I was surprised at their trunk dexterity and never thought about them not being able to see things that are above them. All of this will be good to know as we design our object."

For the next several weeks teams of four to six students worked on designs for objects that they thought elephants would want to use or play with. At the end, the class presented the plans in hopes that the National Zoo would choose one or more of their designs for the elephants. Young’s group ultimately recommended an “Elephant Skin Spa” design using a tower of street sweeper brushes that the animals can rub up against.

“There's no right or wrong answer to this assignment,” says Durant. “It's more about how the teams approach the problem and what they develop. Whatever the outcome, I know the students are learning valuable engineering skills.”
GLOBAL CONNECTIONS
Making global connections by encouraging our faculty and students to think globally.
Computer science and mathematics major Dawite Ewnetu did not touch a computer until he attended high school in Virginia. Born in northwestern Ethiopia, he grew up in a rural area with no electricity or clean water. Some of the schools he attended had as many as 120 children in one classroom.

“My father encouraged me to get an education,” Ewnetu says. “He told me and my brothers and sisters that the one with the best grades would receive a gift. My father encouraged all of us to be self-sufficient but also to help others.”

When he began his studies at Mason in 2012, Ewnetu knew he would need to work to help pay his bills.

“Soon after coming to Mason, I got a letter from the financial aid office that told me I owed the school money—a lot of money that my family didn’t have. I was lucky enough to find a job as a math tutor,” says Ewnetu.

His work as a tutor led him to choose a major in mathematics. Then, after taking an introductory programming class in Python (a high-level computer language), he became interested in computer science and decided to double major.

In addition to being an outstanding student, Ewnetu says he always looks for ways to inspire others, whether he is in the United States or in Ethiopia. In the United States, he participates in the Mariam College Access Program, where he helps high school students prepare for college. In Ethiopia, he started a project called Help Street Kids in Ethiopia, to help children who work and live on the streets of Bahir Dar.

“The kids have to work to help support their families,” says Ewnetu. “They sell items and clean shoes. Sometimes they have no place to sleep at night, or any place to store their belongings.”

After graduation he returned to Ethiopia to build shelters for these children. The design is a simple, three-sided structure with a roof and some shelving on the sides. Ewnetu set up a GoFundMe site to solicit donations, collected used clothing, and asked Ethiopian Airlines to help with the cost of flying the clothing overseas.

“When I go home for the summer I want to do more than visit my family. I want to help my community,” says Ewnetu.

A version of this story by Martha Bushong appeared on Mason’s news website.
In 2015, the Universidad Carlos III (UC3) de Madrid, the Mason Global Center, assistant professor Vasiliki Ikonomidou, and former bioengineering academic advisor Anya Sailey laid the groundwork and established a transferrable curriculum for an exchange student program. Through this agreement, four Mason bioengineering students will study in Spain in 2017. And in fall 2015, Volgenau’s Bioengineering Department received its first UC3 exchange students, David Martos-Ruiz and Marina Martinez-Hernandez.

The exchange program with University Carlos III de Madrid not only offers bioengineering students a unique cultural opportunity to spend a semester or a whole year abroad while seamlessly integrating with their study plan, it also offers an important educational opportunity. Bioengineering is a very wide subject, making it very difficult, if not impossible, for a single department to cover all aspects of it. By combining the offerings of both universities, students from both sides have a wider range of choices to pursue the parts of bioengineering they are most interested in.

So far, we have had a wonderful experience with the first exchange students visiting Mason from Spain, and we are looking forward to welcoming more next year, as well as sending more U.S. students to Madrid.

Sailey sat down with Martos-Ruiz and Martinez-Hernandez and asked them to share their thoughts about their experience.

**How did you learn about the direct exchange opportunity with George Mason University?**

Martos-Ruiz: There are two major universities in Madrid. Students choose UC3 due to its robust exchange program, and the opportunity to study abroad in the United States. Top students receive scholarships to study abroad in universities across the United States.

**What are some major differences you’ve noticed between the environments of UC3 and Mason?**

Martinez-Hernandez: Both universities are very large. Both are very diverse in terms of international exchanges and study-abroad options. At Mason, students are required to complete mandatory homework assignments, whereas at UC3, the learning environment is more self-paced and independent.

**What do you think of the social experience at Mason? Were you able to make friends easily?**

Martos-Ruiz: Yes, it was very easy to make friends at Mason. Living on campus greatly assisted us in meeting new people. Joining on-campus student clubs and activities such as Azucar (Salsa Club) and intramurals (basketball) was very beneficial to this process as well.
Did you feel engineering course work at Mason was able to supplement your knowledge from UC3?

Martinez-Hernandez: There were several course offerings and lab placements at Mason that were not available at Carlos III. This experience can hopefully assist us in terms of career development, such as finding a job or an internship. Job prospects are greater in the United States than in Spain, so this study-abroad experience can be used as a stepping stone to joining the industry.

A version of this story appeared in the spring 2016 Bioengineering newsletter.

### Cost Comparison

<table>
<thead>
<tr>
<th>WHERE</th>
<th>GEORGE MASON UNIVERSITY</th>
<th>UNIVERSIDAD DE CARLOS III MADRID</th>
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<td>$5,376 in-state; $15,699 out-of-state</td>
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| **TOTAL WITHOUT MEALS OR PERSONAL EXPENSES:** | **Instate:**
  Tuition and fees only: $5,866–$5,988  
  Tuition/fees/Housing: $9,583–$10,868  
  **Out-Of-State:**  
  Tuition/fees/Housing: $19,906–$21,191 | **Instate:**
  Tuition/fees/Housing on-campus/Airfare: $10,105–$10,801  
  Tuition/fees/Housing off campus/Airfare: $8,201–$9,001  
  **Out-Of-State:**  
  Tuition/fees/Housing on campus/Airfare: $20,428–$21,124  
  Tuition/fees/Housing off campus/Airfare: $18,524–$19,324 |

Marina Martinez-Hernandez (left) and David Martos-Ruiz attended Mason’s Celebration of Student Scholarship in spring 2016.
In the Laboratory of Nanotechnology—Tiny Particles Have Far-reaching Implications

In the Laboratory of Nanotechnology, researchers study particles thinner than a hair on an infant’s arm and smaller than a droplet of sea mist particles that are attachable to a single molecule.

Bioengineering professor Carolina Salvador Morales is the director of the lab, located at the Krasnow Institute for Advanced Study. Her laboratory focuses on the design and applications of a wide range of carriers at the nano- and micron-size scale to treat a number of devastating diseases, including cancer. This type of research holds the promise for revolutionizing the way scientists approach common societal problems—from creating novel cancer theranostics to nanopesticides.

“Fundamentally we aim to understand what mechanisms form the carriers so we can control their physical and chemical properties to manage diseases more effectively than standard treatments,” says Salvador Morales.
She believes the more researchers can understand about the physico-chemical aspect of nanocarriers, the more effective those carriers will be in medical and industrial settings.

Because the research projects are highly translational, Salvador Morales’s team collaborates closely with hospitals, industries, and federal research laboratories in the Washington metropolitan area. Though she works with many experienced international collaborators, she sees her role as a teacher to undergraduates in the lab as one of her most important roles.

“My goal is to create the next generation of young scientists,” Salvador Morales says. “I want my students to experience science in the most meaningful and magical way. I want them to understand the medical problem they are addressing and develop research strategies to generate innovative solutions so that one day the scientific discoveries made in the lab can benefit society. I’m strict, but they know when they leave my lab, they will be scientists of high caliber.”

One of Salvador-Morales’s undergraduate lab technicians, Alex Nixon, worked in the nano lab while he was a full-time bioengineering student.

“It fascinated me that the work I did as an undergraduate could be used as a medical test in the future,” he says. “One of the biggest things I’ve learned, and one of the things my mentor constantly reminds me about, is research is not a nine-to-five job.”

Working in the lab can mean arriving at 6 a.m. to carry out a reaction and staying as late as 2 a.m. to centrifuge and wash the nanoparticles, as well as being in and out of the lab at normal hours.

“While it’s crazy to be working until 2 a.m. some nights, what’s even crazier is that I’m perfectly okay with it. In fact, I love those nights,” says Nixon.

A version of this story by Martha Bushong appeared on Mason’s news website.
Do you know someone with a torn anterior cruciate ligament (ACL)? If you answered yes, it’s not a surprise. According to NCAA statistics, 1 in 13 female athletes experience a torn ACL. It’s an epidemic that few people are talking about.

Few that is, except for an enterprising team of students in the Volgenau School of Engineering’s Systems Engineering Program. Even though each of these students is an athlete, the project tested their problem-solving abilities, not their physical prowess.

Team members Amr Attyah, Maribeth Burns, Sam Miller, and Andrew Tesnow, all systems engineering majors, started by building a simulation model of the knee. They then introduced failure mechanisms—five noncontact and three contact ones. The ACL can be torn through contact (getting hit in the knee) or through noncontact means (turning weirdly or landing a jump incorrectly). This engineering team focused on ACL tears due to low knee flexion angle, the angle between the femur and the shin.

“Everyone thinks ACL tears are the result of contact, but 70 percent are the result of noncontact movement, like landing from a jump, stopping short, or moving quickly from side-to-side,” says Miller.

Based on the failure mechanisms, the students started to experiment with ways to prevent ACL tears. The whole idea was to reduce the force placed on the ACL from the shank, or shinbone.

“The ACL can only handle 2100 newtons. So anything over 2100 newtons will tear the ACL,” says Attyah.

Before the students could solve the problem they had to explore other engineering fields.

“We had to become fluent in biokinematics and knee anatomy to better understand the problem,” Tesnow recalls.

At least six main factors impact the tibial shear force (TSF), so the students looked for ways to address each factor. For example, ground reaction force—the force between the ground and the foot—can be reduced by an energy-absorbing material.

“Even padding in the shoe is not enough,” says Attyah.

The students found that form and position of the body while landing, stopping short, and cutting are also key factors. Flexion angle needs to be below a certain threshold. If there is too little, the quadriceps pull the shank forward and the hamstring and calf muscles cannot counteract it. Then the shank slides out from under the femur.

Finally the team proposed coupling angle and acceleration sensors in a knee sleeve with pressure sensors in the shoe. Based on data from the sensors, a tiny microcomputer calculates an estimate of the TSF. When the TSF exceeds a threshold, it beeps to alert the user of the danger approaching.

The goal is to provide athletes with real-time feedback of their body position and form while landing, stopping, and cutting in a game so they can adjust the way they play. This is more useful than gait analysis video in a controlled lab, for which athletes wear special clothing, or form training, in which they jump over cones in a sterile gym.

The simulation model of the biofeedback system seems to be working fine. The students are rapidly developing a prototype and have started their testing.

“This was the hardest thing I have ever done in my life,” says Burns, the team leader. “We were so naive when we started. The project kept getting more complex. We ran into dead-ends everywhere we went. Thankfully, our systems engineering faculty provided guidance and encouragement that helped us use our knowledge and skills. I have so much more confidence in myself as an engineer and as a person. And hopefully we can help some athletes stay in the game.”
Amr Attyah wears the prototype of a device developed from a senior design project. The project, “Design of a System for Identifying Risk and Mitigating ACL Flexion/Extension Injuries,” won first place at the 2016 General Donald R. Keith Memorial Capstone Conference held at the U.S. Military Academy at West Point, and second place at the 2016 PITCH-IT Competition at George Mason University.
Bioengineering major Sameen Yusuf (below) traveled to Nicaragua and Nepal with the organization Engineering World Health to help hospitals in underprivileged areas repair their equipment. At Mason she worked with Nathalia Peixoto, associate professor of electrical and computer engineering, to make a low-cost oxygen analyzer (right) that is powered by hearing aid batteries.
Real-World Experience
in the Developing World

Bioengineering major Sameen Yusuf has traveled to Nicaragua and Nepal with the organization Engineering World Health to help hospitals in underserved areas repair their equipment. As a result of these activities she developed a low-cost analyzer that measures oxygen concentration in neonatal incubators—an important device, because too much or too little oxygen can harm premature infants.

“Being at Mason really developed my support network,” says Yusuf, whose family came to the United States from Pakistan when she was two years old. “Everyone who has worked with me from my freshman year has supported me in finding what I really cared about.”

Low-levels of oxygen are a leading cause of pre-term infant mortality in the developing world. To address this problem, health care workers need to monitor oxygen levels, but the equipment is usually bulky and costly.

To reduce costs in constructing her oxygen analyzer, Yusuf powers the mechanism with hearing aid batteries (17 cents each in some U.S. stores). A microcontroller board measures the voltage, which spikes or dips depending on the amount of oxygen to which the battery is exposed. Yusuf wrote the software that reads the output and displays it on an LCD screen.

“She didn’t come up with the idea [of using hearing aid batteries], but she ran with it,” says Nathalia Peixoto, an associate professor of electrical and computer engineering at the Volgenau School of Engineering. “She did not tweak it a little; she tweaked it a lot. I didn’t know she could make an oxygen measurement device for less than $5. Now she can.”

The price point is key if the device is to be used in underserved areas.

“It’s really developed my engineering skills,” Yusuf says of her trips to Nicaragua and Nepal. “It made me think about, when designing a device, what materials am I going to use? Are these materials accessible in the developing world?”

Yusuf, who plans to pursue a master’s degree in engineering or public health, hopes to work for a nonprofit that develops low-cost diagnostic devices.

A version of this story by Damian Cristodero appeared on Mason’s news website.
ROBOTICS AND AUTONOMOUS SYSTEMS

Making intelligent robots by teaching them how to move, sense their surroundings, and work as teams to accomplish tasks.
Building a Better Robot

Shakhzod Latipov is full of ideas. He wants to manufacture high-end electronics that will be available at affordable prices. He has a plan, the seeds of which were planted when he was 14, to build a robot that helps do household chores and responds to oral commands.

Mostly, though, Latipov wants to bring the knowledge he receives as an electrical engineering student back to his native Uzbekistan and help the country become more technologically advanced.

"Even if my dream of opening a firm fails, the demand for specialists [in Uzbekistan], especially those who studied abroad, is huge," Latipov says. "Finding a job where I get to show my experience, and innovate and try to come up with something useful will be enough for me."

He chose Mason, he said, because of its highly respected engineering program and its suburban location.

Latipov ordered a remote control and several robot toys that could lift light weights, and used them to build what he describes as a mash-up of the material. A small microscheme (a functional programming system) was used to receive commands from the remote.

Results were mixed. The one-foot by one-foot robot made of plastic could lift up to a pound, Latipov says. But it looked more like boxy truck than a robot, the batteries didn't last long, and the remote had a joystick.

"The future is not about joysticks," Latipov said. "The future is, you think of something or you make commands verbally, and the job is done for you."

Still, he learned a lot from the attempt. "To really learn, studying is not enough," he says. "You have to try yourself, experiment, go online, ask friends, or go to the library. That way you learn and can be more effective."

And perhaps build a better robot.

A version of this article by Damian Cristodero appeared on Mason's news website.
Civil engineering professor David Lattanzi was inspecting a bridge several years ago in his hometown of Pittsburgh when a drunk driver sped past "lane closed ahead" signs and slammed into the final sign—a giant flashing, lighted arrow—the only barrier remaining between Lattanzi and the driver.

The driver walked away from the crash, but Lattanzi and his crew were left shaken.

“I’ve almost gotten killed on the job three times,” he says. “Inspecting bridges is really dangerous for humans, and we don’t get good results.”

He knew there had to be a better way.

It’s no secret that the nation’s infrastructure is crumbling. Inspecting bridges is hazardous, expensive, and well behind schedule. Unmanned aerial vehicle (UAV) inspections are more efficient—about 10 percent of the traditional cost—and offer more exact comparisons from inspection to inspection, Lattanzi says.

Last summer the U.S. Forest Service, which manages 7,500 bridges—more than any other organization in the United

In partnership with the U.S. Forest Service and the University of Alaska–Fairbanks, Assistant Professor Dave Lattanzi’s (below) research team has been fortunate enough to work on inspecting the beautiful Placer River Bridge (right) using unmanned aerial vehicles.
States—took Lattanzi’s idea on a large-scale test drive in Alaska. That test drive included a UAV, or drone, zipping around and snapping photographs of the 280-foot Placer River Bridge, the longest timber bridge in North America, on Alaska’s Kenai Peninsula.

Results from the photographic flyby went to Lattanzi’s Advanced Infrastructure Monitoring Lab at the Volgenau School of Engineering. There they were compiled into a sophisticated 3-D model, which takes about 500 hours of computational time. “You can see the knots in the wood,” Lattanzi says of the footage they gathered. “You can see the grain. You can count the threads on the bolts.”

In fact, the 3-D model’s detail is so precise that the name of the bolt manufacturer is easy to read.

Lattanzi’s method is also more flexible; all the equipment can fit into a backpack, while traditional methods rely upon heavy equipment.

That’s of particular importance to the U.S. Forest Service because, like many of the bridges under its auspices, the Placer River Bridge is off the beaten path where large trucks can’t pass.

The bridge is the only way hikers can reach the Spencer Glacier. A school bus on train tracks brings visitors part of the way to the bridge. The rest of the trek is on foot.

Mason civil engineering doctoral student Ali Khaloo is one of seven students working in Lattanzi’s lab. This was his first trip to Alaska, and he found that overseeing the inspection came with some unusual guidelines, as well as moose and black bear sightings. “We were told to always be in a group of two, no matter what,” says the Iranian native. “I was really surprised that the guide carried a rifle.”

Khaloo, who wants to follow in the footsteps of his uncle, a civil engineer, says the Alaska trip was a one-of-a-kind experience. “It was one of the most beautiful places I’ve ever been to in my life,” Khaloo says. “Spencer Glacier was magnificent.”

Lattanzi says he expects more organizations will follow the lead of the U.S. Forest Service in the next few years, making sure bridges are safe for drivers and pedestrians.

He is also exploring, with the help of a National Science Foundation grant, the use of these 3-D modeling techniques in post-disaster situations, such as inspecting buildings after earthquakes. “Fully realized, this technology will enable post-disaster inspectors to rapidly and accurately estimate structural damage using only a digital camera and portable computer,” says Lattanzi.

A version of this story by Michele McDonald appeared in the spring 2016 Mason Spirit magazine.
Collapsible Worlds

Jyh-Ming Lien is with the Department of Computer Science and, more specifically, the Motion and Shape Computing Group in the Autonomous Robotics Laboratory.

He creates elegant, hypnotizing, and complex 3-D computer models that seem to fold and unfold effortlessly.

“Like the rest of the human race, I like to make and appreciate visually appealing objects,” Lien says. “I simply followed my instinct. If I was not in computational science working on topics related to shape and motion, I would have been in architecture design.”

His recent work provides the underpinnings of a more compact daily life, from collapsible cups to folding furniture. Practical results of 3-D modeling include cars designed to collapse to protect passengers during collisions, bicycles that compactly fold for transport, surgical instruments entering the body in a compact size to minimize the surgical site opening, and satellite antenna umbrellas going into space tiny, but expanding to full size in orbit.

A version of this article by Michele McDonald originally appeared on Mason’s new website.

For his work, Lien was awarded the 2015 Mason Emerging Researcher/Scholar/Creator Award. The award recognizes the very best of Mason’s younger scholars.

Computational Origami Image from the Motion and Shape Computing Group (MASC), courtesy of Jyn-Ming Lien and computer science PhD candidate Zhonghua Xi. MASC’s goal is to develop efficient, robust, and practical algorithms for representing, manipulating, and analyzing massive geometric data of shape and motion.
Gerry Tian always thought her career would be in a STEM field. Of course in the 1990s, nobody in China, or even in the United States, called it STEM.

“Things were much different then. In China the educational system at that time didn't have the variety of fields that it does now,” says Tian. “In my generation a lot of young people had a dream to be a scientist. Also, my parents were both engineers.”

After she finished her undergraduate degree in China, she began looking into continuing her education. She found a good fit with systems engineering studies at what’s now known as Mason’s Center of Excellence in Command, Control, Communications, Computing, and Intelligence, or C4I.

Tian chose control as her field, but says when she first began, the discipline was “at a low point, and there weren’t many people doing research in the area.”

She reasoned that if she approached it from a systems point of view, she could broaden the topic and find meaningful connections. She earned her PhD (also at Mason), and in 2000 went to Michigan Tech and become one of their first research faculty members. Michigan Tech had been known for it's strong undergraduate teaching mission and was beginning to build a research enterprise. Tian's research and tenure dossier became a model for subsequent faculty hires.

continued
Adam O’Connor and his team developed a climate control system for their senior project in spring 2016. The device will monitor HVAC systems by using historical outdoor temperature data and HVAC system performance data, and will enable consumers to know how much it will cost to keep their home or business at a particular temperature.

Tian moved from Michigan back to Mason in winter 2015 and is now a tenured professor and mentor to younger faculty and graduate students. She’s currently finishing her third semester in the Electrical and Computer Engineering (ECE) Department as a faculty member.

Tian’s research involves signal processing and wireless communication, specifically cognitive radio and compressed sensing. She and her team are exploring ways to find more effective and efficient means to transmit and process all of the data that has to go through the airways. They are looking at how to minimize distortion and make the systems flexible, responsive, and economical. Both the theory and the application of the research uses sophisticated mathematical models to build the system so it can be manipulated and optimized.

“The demands for wireless communication are much different in 2016 than they were in 2000, or even in 2006,” says Tian.

Smartphones have been a game changer. Now people don’t want to simply talk through wireless, they want to watch movies, stream video from sporting events, send pictures to friends, unlock cars, and more. The airwaves/frequencies are full, and getting more and more crowded. How do you find the bandwidth for all of that?

One application Tian is working on, “cognitive radio,” allows for dynamically searching for spectrum opportunities using owned frequencies when they are not in use. Another application involves using higher frequencies that were considered unusable in the past.

Tian says the assistance she’s found at Mason has benefitted her work and that of the students she mentors.

“Everyone here is very helpful,” she says. “They really want us to succeed. I do my best to provide guidance to young faculty. Coming in from another university has also given me perspective.”

A version of this story by Martha Bushong appeared in the ECE newsletter.
Climate Control Analytics
Promote Sustainability

By Martha Bushong, Director of Communications

There’s a saying in Virginia, “If you don’t like the weather, wait a few minutes—it will change.” Temperature fluctuations can cause climate control systems to work overtime, and we don’t always understand the effect on budgets until it’s time to pay the bill. But what if there was a system that monitored your heating and cooling system and provided information to help conserve energy and save money?

In spring 2016 Adam O’Connor and his team decided to create such a system for their senior design project. They call it Climate Control Analytics (CCA).

“At its heart, CCA is a data acquisition system,” said O’Connor. “We are developing a sensor network to capture key data points in the HVAC system, its building, and the surrounding environment.”

It works like this: The sensor network feeds data to a central database system—the Sensor Output Database (SOD). The SOD functions as the central data hub, or the file cabinet of the software system’s separate entities—a web dashboard user interface, a central control that coordinates all system processes, and the active control system.

If the SOD is the file cabinet, the web dashboard is the assistant that helps users generate HVAC system performance and consumption reports. The team designed the CCA to collect and store data for 10 years—the expected lifespan of HVAC equipment.

The active control system allows users to see how much it will cost to set the thermostat for any particular temperature set point. It does this by modeling the indoor temperature with a system of differential equations and using a sliding window multi-linear regression outdoor temperature model to predict daily outdoor temperature curves.

By using historical outdoor temperature data and HVAC system performance data, the CCA system will enable consumers to know how much it will cost to keep their home or business at a particular temperature, even in Virginia where it can be winter in the morning, and summer by lunchtime.

The project was awarded a Patriot Green Fund student research grant through the Office of Sustainability.
PHILANTHROPY
Promoting the welfare of others by giving generously to worthy causes.
Mason is Making a Difference—Successful Philanthropy

By Linda Kovac, Director of Advancement and Alumni Relations

In Fiscal Year 2016 our donors made a difference by enriching the student experience, maintaining faculty excellence, and improving existing facilities. We thank them for their continued support and encourage support from others.

continued
Enriching the **Student Experience** Through Scholarships

This year we added new endowed scholarships to our portfolio of 30 existing awards. Many of our students are first-generation college students. They juggle multiple competing demands to complete their education. Scholarships lighten the financial burden and allow them to focus on academics.

**Washington Apple Pi Scholarship Endowment**

Washington Apple Pi, a community of Apple iPad, iPhone, and Mac users—people with a common aim to improve knowledge and enjoyment of Macintosh computers and Apple mobile devices—established an endowed scholarship to support computer science students.

**The Dr. H. Gilbert Miller Noblis Scholarship Endowment**

The endowment provides scholarship support for graduate students pursuing a master’s degree or PhD in data analytics or systems engineering. The scholarship honors Miller, who was a tireless advocate for the school and a champion for science, technology, engineering, and math education for students of all ages.

Maintaining **Faculty Excellence**

Fellowships, professorships, and chairs provide discretionary dollars to keep salaries competitive and allow faculty to enrich their teaching and scholarship for the benefit of the school and its students.

**Beck Foundation Faculty Fellow**

A gift from Charlotte and Buddy Beck established the Beck Foundation Faculty Fellow. “Through the award of its faculty fellowship, the Beck Foundation is pleased to support the school’s vision—producing scholars that impact the well-being of society,” said Buddy Beck, president of the Beck Foundation. “Under the leadership of Dean Ball and Department Chair Oscar Barton, the dynamic growth of this engineering program has been nothing short of spectacular.”

Elham Sahraei joined Mechanical Engineering as the first Beck Faculty Fellow. Sahraei has been a research scientist at the Impact and Crashworthiness Lab of Massachusetts Institute of Technology since 2014. “The Beck fellowship was an important factor in my decision to choose Mason,” says Sahraei.

**Bill and Eleanor Hazel Endowed Chair**

Bill Hazel was the founder of William A. Hazel Construction, a Northern Virginia site development and construction company engaged since 1958 in the construction of residential and commercial buildings, public works and institutions, and a network of roads throughout the region. The endowed chair honors the late Mr. Hazel and his wife, Eleanor Hazel, and their commitment to education and the future of the region.

Elise Miller-Hooks joined the Department of Civil, Environmental, and Infrastructure Engineering as the first Hazel Endowed Chair. Before coming to Mason, she served as program director of the National Science Foundation’s Civil Infrastructure Systems Program in the Engineering Directorate.

A prolific writer and frequent speaker, Miller-Hooks has written approximately 350 peer-reviewed articles, reports, conference presentations, and invited lectures. She serves as chair of the TRB Transportation Network Modeling Committee, and on the editorial boards of *Transportation Science, Transportation Research-Part B*, and the *Journal of ITS*. Miller-Hooks was a professor in the Department of Civil and Environmental Engineering at the University of Maryland and was on the faculty of Penn State and Duke Universities.
Improving Existing Facilities
The school’s growth creates an urgent need for more space. To assist us, Micron Technology became our partner and stepped forward to help us convert outdated classrooms and offices into innovative learning and design labs built for collaborative teaching and research.

Micron Foundation contributed a seed grant to help us refurbish space in Bull Run Hall on the Science and Technology Campus. These renovations are part of an effort to expand the school’s laboratory-based engineering programs at the campus in Prince William County. Micron Foundation considers this $25,000 gift seed funding for the $2 million+ renovations. By making this initial gift, the company hopes to encourage others to fund this critical project.

Future plans include completing and equipping a new multi-use Class 1000 clean room in the Institute for Advanced Biomedical Research building; finishing and equipping other new laboratories and offices in that building; and renovating 5,270 square feet of existing classroom space in Bull Run Hall.

This is the first of many renovations to the Science and Technology Campus and evidence of our commitment to creating more jobs for Virginia’s 21st-century economy.

FAST FACTS
Renderings of proposed changes to Bull Run Hall (above) on the Science and Technology Campus show the innovation studio for multidisciplinary research teams. Free-flowing spaces (left) encourage collaboration and interactive learning.

School Snapshot
Students
4,917 undergraduates
1,837 graduates
6,754 total

Academics
10 undergraduate majors
9 undergraduate minors
17 master’s degrees
3 undergraduate certificates
21 graduate certificates
7 PhD offerings

Faculty
206 full-time faculty

Alumni
Our alumni enjoy the highest average starting salaries of all Virginia public universities, and more than 80 percent of them are employed within six months of graduation.