Industrial & Systems Engineering
at Rutgers

ise news

inside

Industrial & Systems Engineering at Rutgers

Since the 1980s, the U.S. industry and society as a whole have been shaken by transformative changes initiated by advances in computing, communication, and automation sciences. Rutgers' Department of Industrial and Systems Engineering is among the leading institutions that have made the integration of human, machine, and information common grounds for research and education. Emphasizing its core competency in reliability, quality engineering, and systems engineering, the department is pushing ahead with new endeavors in emerging technical areas and focusing on educating the next generation of engineers and technology leaders.

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RUTGERS
School of Engineering

Advanced Manufacturing is On the Move

With exciting innovations in tools, materials, and management systems, advanced manufacturing is impacting industries as diverse as aerospace and defense, energy, motor vehicles, and medicine.

At the Department of Industrial and Systems Engineering at Rutgers School of Engineering, teaching and research in the areas of production and manufacturing prepare students to determine the most effective way to use people, machines, materials, information, and energy to develop a product.

Rutgers' Tugrul Ozel, associate professor of industrial and systems engineering, is exploring a broad scope of advanced manufacturing projects that include precision machining, biomedical manufacturing, and laser processing of advanced materials.

As part of his scope of work, he is leading a research group of graduate and undergraduate students in modeling and optimizing manufacturing processes of titanium and nickel-based alloyed parts to achieve high-precision, optimum surface integrity, and prolonged product life for aerospace and biomedical applications.

According to Ozel, these alloys offer superior properties for producing advanced engineered products and are a highly desirable material for jet engines, gas turbine engines, and nuclear reactors due to their superior properties in maintaining strength at extremely high temperatures and pressures.

"Titanium alloys offer favorable strength-to-mass ratios making them highly suitable for lightweight aerospace structural components, various parts of the engine, and the landing gear," he says. "They are also biocompatible and corrosion resistant, making them also suitable for fabricating biomedical metallic implants and chemical reaction vessels."

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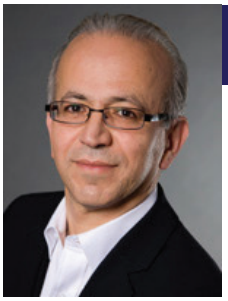
Steve and Kerry Bray Scholarship

Stephen Bray earned his bachelor's and master's degrees in industrial and systems engineering from the School of Engineering. "I can't speak highly enough of my Rutgers education," says Bray. With a $25,000 gift, he recently established the Stephen and Kerry Bray Scholarship.

Bray is a founding partner and president and chief operating officer of KMB Design Group, an engineering firm based in Wall, New Jersey. The company employs many School of Engineering alumni and offers internships for students.

The Department of Industrial and Systems Engineering will select recipients of the scholarship on the basis of need and merit. "We're looking to identify scholarship recipients who are focused on extracting the most out of their education, who show potential, and who are making a concerted effort," says Bray, a member of the school's Industry Advisory Group. "I'm trying to help the next generation of engineers."



Message from the chair

As we prepare to launch a new cohort of ISE professionals into the world, following commencement in May, I am once again inspired by the transformation that happens during students' time with us. Over the course of their studies they learn how to develop and trust their problem solving abilities. They learn to work collaboratively and present their ideas with confidence. And we know that their curiosity will carry over into their professional lives as lifelong learners.

In this issue, you'll have the opportunity to read about some of our graduating seniors' capstone design projects. Two student teams were selected to present their projects at the Institute of Industrial and Systems Engineering regional competition, with Rutgers teams winning first and second places.

We also feature news about our successful partnerships with Lockheed Martin in co-designing a reliability engineering course that trains our students in an area of need for the aerospace giant and with 4Ry in investigating efficient methods of using UAS in crop spraying.

On the research front, Tugrul Ozel's advanced manufacturing research is bringing innovation to precision machining, biomedical manufacturing, and laser processing of advanced materials.

As we celebrate the achievements of our students, faculty, and alumni in this issue, I would like to give special recognition to ISE's long-time professor and colleague, Tom Boucher, who has been with the department since its inception in 1981. Tom will retire at the end of this semester after many years of service as an outstanding educator and researcher. We wish him well as he enjoys time with his wife hiking in Maine and devoting himself to new endeavors.

Mohsen A. Jafari, Ph.D.
Chair, Department of Industrial and Systems Engineering

Weeks Hall of Engineering: Opening Fall 2018

Currently under construction, Weeks Hall of Engineering will be the gateway facility to the School of Engineering on Busch campus. Among the many classrooms, lecture hall, and student touchdown spaces will be a number of labs for advanced manufacturing and sustainable systems and resources. The Manufacturing Pilot Laboratory, pictured above, is dedicated to the assembly, testing, and modification of student prototype projects. This high-bay lab space has a second floor perimeter catwalk for viewing projects below. See more at weekshall.rutgers.edu.

Drone to Table: Innovative Techniques in Crop Spraying

The safe and efficient application of pesticides and fertilizers in agricultural areas is of prime importance for crop yields. This has prompted the use of non-conventional methods for crop spraying with different types of pesticides, including the use of unmanned aerial systems (UAS). Two professors from Rutgers Department of Industrial and Systems Engineering, E. A. Elsayed, distinguished professor, and Kang Li, assistant professor, in collaboration with Arnold Kelly of 4Ry of Chicago, are investigating efficient methods of using UAS in the spraying of pesticides.

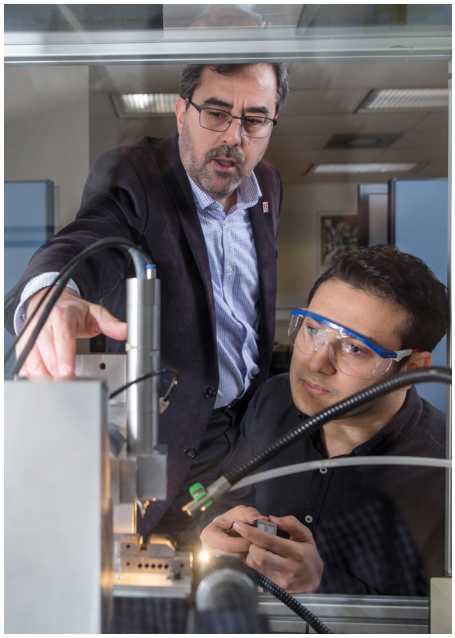
This newly developed approach, based on Kelly's patented method, uses electrostatic atomization and dispersal (ESD) to minimize the spraying time and potential damage of the crop by applying electrostatic discharge to the pesticides.

"The initial results are encouraging and further research, we believe, will lead to commercial development of this unique system," says Kelly.

The project also involves Rutgers graduate students Jonathan Risinger and Timothy Yong, both studying computer science, who have gained hands-on knowledge building, designing, and testing drone technology.

"We have been exploring the potential applications of this system and how it can be used to optimize the spraying of crop fields and when combined with computer vision classification algorithms selectively care for the crop diversity in a field," said Risinger. ■

Advanced Manufacturing is On the Move *(continued)*



Professor Ozel, left, uses a micro-milling machine alongside graduate student Alaaeldin Olleak. Ozel's advanced manufacturing projects include precision machining, biomedical manufacturing, and laser processing.

However, their drawback, Ozel says, is that they are difficult to process with desired surface quality and structural integrity.

With funding from the National Science Foundation and the Department of Commerce's National Institute of Standards and Technology, Ozel's research group has developed various process simulations for precision finish machining of advanced metal alloys. Additive manufacturing of nickel-based alloyed parts using laser powder bed fusion process, more commonly known as metal 3D printing or selective laser melting, is being tested using thermal camera videos.

"We are developing advanced computational simulations to predict in situ process temperatures, microstructural changes, residual stresses, and other important attributes to test performance in a virtual manufacturing setting prior to manufacturing the actual parts," says Ozel.

The group is also developing technically sound methodologies to expand the advantages offered by metal 3D printing to graphene nanomaterials enforced metal matrix composites and other metal-ceramic composites for lightweight metal alloys requiring higher strength in industrial applications.

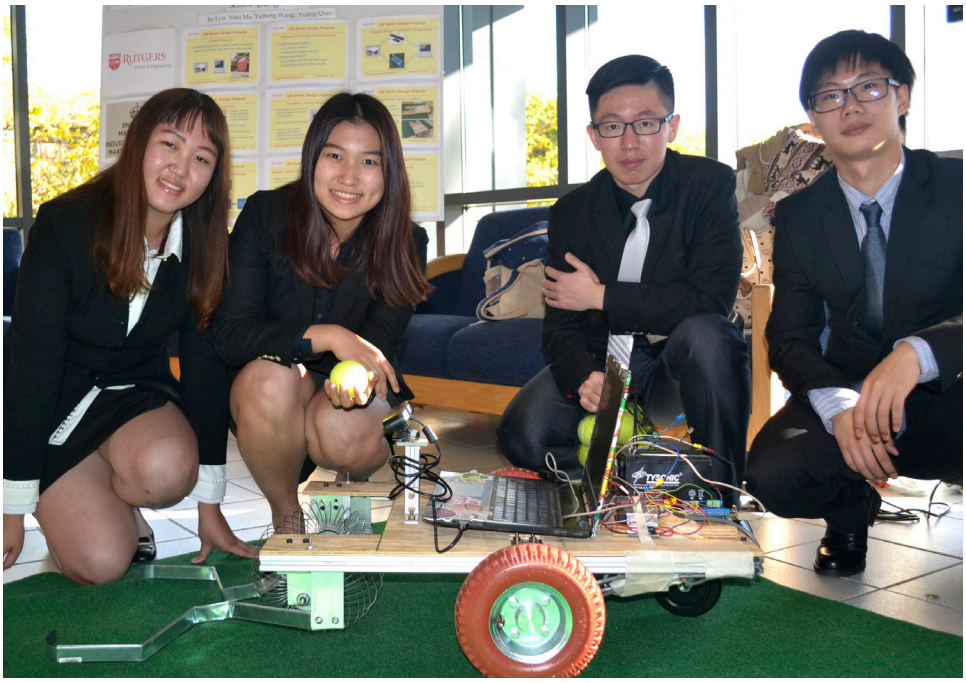
"Metal additive manufacturing is the most industrially relevant development of 3D printing technology, because it enables direct digital fabrication and manufacturing of almost any design—small or large, basic or complex geometries—without requiring any tooling, fixturing, or expensive multi-axis machine tools, and, most importantly, expensive manual labor," explains Ozel.

It is estimated, he says, that metal and metal matrix composite additive manufacturing will create advanced manufacturing jobs and direct digital manufacturing capabilities elevating the manufacturing base of the United States to higher levels and contribute significantly to the gross national production gains in the twenty-first century.

Other areas of manufacturing being studied by Ozel's group include laser processing, micromanufacturing, and biomedical manufacturing. The team has developed techniques for ultraviolet nanosecond pulsed laser processing of polymers for microfluidics applications and lab-on-chip devices. Other results include designing, prototyping, and developing low-cost microneedle array patches for timely drug delivery. Microneedles are composed of an array of micro-scale needle tips filled with a single dose of drugs typically as hydrogels that can be slowly released when microneedle tips penetrate into the skin.

"If they can be produced in mass quantities at a low production cost and safely disposed, they may find wide ranging applications in fighting epidemic diseases with little or no health care professional assistance because they are self-admissible and more accessible," he says. ■

ISE Undergraduate Students Present Senior Design Projects



The annual Design of Engineering Systems course serves as a capstone learning experience for graduating seniors, giving them the opportunity to bring together three years of coursework into a single challenging design problem.

This year's design projects, presented in December, included industry sponsored projects as well as challenging projects related to faculty research. The Union Pacific Railroad invited students to investigate the problem of scheduling trains along bidirectional tracks, where conflicts among trains passing track segments are a recurrent problem. This large-scale, complex project involved a massive amount of data from historical train schedules, says ISE assistant professor and project advisor W. Grace Guo.

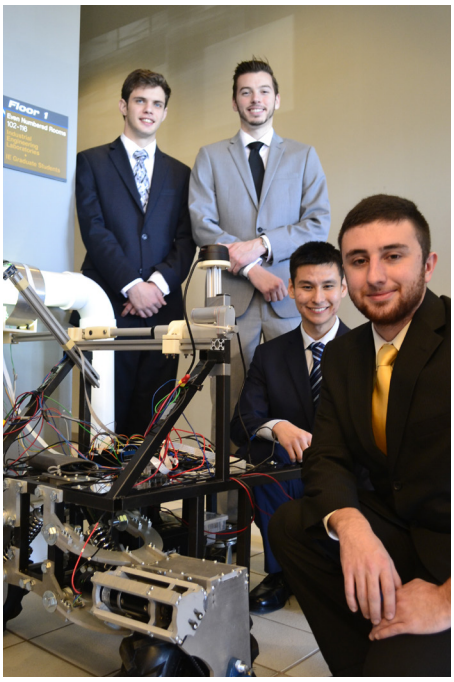
"Using historical data the student team designed a simulation model that could be used to test rules to recover from delays and conflicts and the student team made recommendations for traffic control based on their analysis," said Guo.

Another team, advised by ISE professor and department chair Mohsen Jafari, addressed the design of an energy smart community, one of the research thrusts of the ISE department. By instrumenting selected rooms in a building on campus, the team collected actual data on temperature, humidity, and occupancy usage using wireless sensors. This prototypical building was then used in a simulation model to show how renewable sources of energy can be connected with the electric grid and service buildings and associated electric vehicles.

"These senior design projects emulate what the students will face when they enter the practice of engineering," said Thomas Boucher, industrial and systems engineering professor, who, along with Kang Li, department assistant professor, had overall supervision for the course.

"Although the students use much of what they have learned over the prior three years, they do not know everything that they have to know to solve the problems they encounter," Boucher continued. "In most cases, the students are challenged with extending their knowledge in order to come to a final solution."

"Finally, they have to present their solutions in a public forum where they are challenged by audience questions," said Boucher. "When a student finishes the design course he or she knows how to present their ideas effectively." ■



As a final project before graduating, ISE seniors work in teams to solve an engineering challenge. At an event in December showcasing the teams' work, each group presented their research and devices to faculty, alumni, friends, and family.

ISE News

Two student teams were selected to present their projects at the Institute of Industrial and Systems Engineering regional competition, competing with other schools in the Northeast. The Rutgers teams won first and second place for their respective research projects: Managing Traffic Flow for the Union Pacific Railroad and Highly Mobile Intelligent Tennis Ball Collector. The first place team will participate in the national competition in late May.

ISE undergraduate **Akshay Malavade** was selected to participate in the Rutgers Energy Institute (REI) summer internship program. This competitive opportunity allows students to immerse themselves in a 12-week research project and includes a $5,000 stipend. Malavade will focus his research on the control and optimization of energy systems.

James T. Luxhøj, industrial and systems engineering professor, was inducted into the Virginia Tech ISE Academy of Distinguished Alumni at an April awards ceremony in Blacksburg, VA. Luxhøj is also the recipient of the 2017 Wellington Award from IISE's Engineering Economy Division. The Wellington Award recognizes outstanding contributions in the field of engineering economy. The award is named after Arthur M. Wellington, author of *The Economic Theory of Railroad Location*, in 1887.

In addition, Luxhøj and his undergraduate research assistant **William H. Joyce, Jr.** received a Best Paper Award for their co-authored paper, "Safety Risk Modeling of a UAS for Monitoring Beach Erosion," presented at the 2016 Industrial and Systems Engineering Research Conference.

Thomas Boucher Announces Retirement

The School of Engineering's Department of Industrial and Systems Engineering is preparing to bid a bittersweet farewell to a longstanding faculty member who has been with the department from the very beginning. Professor Thomas Boucher joined the ISE faculty upon the department's inception in 1981. Throughout the past 36 years, he has contributed to the success of the department which is now regularly listed among *U.S. News and World Report's* top ranked graduate engineering programs.

Over the span of his career, Boucher has published over 40 research articles in the areas of automation sciences and engineering economics. In addition, he has authored or co-authored several books—*Analysis and Control of Production Systems*, *Computer Automation in Manufacturing*, and *Design of Industrial Information Systems*.

Boucher also served as editor-in-chief for *The Engineering Economist*, which he credits as one of the highlights of his career.

"By the time my tenure was over this past December, we had raised the profile of the journal significantly," Boucher said. He will continue to hold an associate editor position for the journal which is published jointly by the Engineering Economy Division of the American Society of Engineering Education (ASEE) and the Institute of Industrial Engineers (IIE).

Leaving the School of Engineering, Boucher said he will greatly miss the daily interactions he has with students.

"They're thinking about things, and they're presenting you with challenges. You're trying to give them the best education you can, and so it keeps your mind young," he said.

One of the most rewarding aspects of teaching, he said, is preparing students to be life-long learners.

"In engineering, technology is constantly changing," Boucher said. "The most important thing you can teach a student besides the fundamentals is to have confidence in learning and going beyond the classroom."

Once he retires, Boucher will devote more time to his love for hiking. He and his wife Unn own a home abutting Acadia National Park in Maine, where they have spent their summers during his time off from teaching.

"Over the years we have hiked most of the mountains in the park and continue to enjoy hiking and trying to keep in shape," Boucher said.

In addition to spending more time outdoors, Boucher says it is time to "do some volunteering—paying back." He is considering working for the National Park and plans to pursue other community service opportunities.

Even though he is retiring, Boucher said he will continue his association with his profession and exploring the problems that interest him. Though he has spent the past 36 years working for the Department of Industrial and Systems Engineering, it was always much more than an occupation to him.

"What professors do in our research and in our work can be almost described as a hobby," Boucher said. "It's what we do because we like to do it. It certainty is not a job." ■

ISE Graduates Head Out to New Experiences

As we prepare to say farewell to the ISE Class of 2017 graduates, we sat down with three students to reminisce, reflect, and wish them well on their endeavours. Here's what they had to say:

William H. Joyce, Jr.

Career Plans
I will be working full-time for Lockheed Martin as an associate member of the engineering staff in the reliability, maintainability, and availability department. Also, in the near future I plan on pursuing a master's degree part time.

ISE Preparation
The ISE department has prepared me for this next big adventure through interdisciplinary, business-oriented teaching. I am equipped with a wide range of skills that include concepts in supply chain management, manufacturing, electrical engineering, programming, probability and statistics, quality engineering, computer controls, work design, ergonomics, engineering design, economics, accounting, and much more. The emphasis on teamwork and group projects is essential to business success.

Advice to New Students
Go out and take advantage of the many resources Rutgers has to offer such as CareerKnight, Aresty Research Center, office hours, study groups, tutoring, advising, networking events, and extracurricular activities. ISE gives you the opportunity to go into so many different fields, try and determine the field you're interested in as early as possible. ■

Natalia Soler

Career Plans
After four years of studying, two summers of internships, a semester on co-op, and numerous class group projects, I've decided to start my career at Accenture as a consultant analyst in San Francisco.

ISE Preparation
With industrial and system engineering you have the business world at your fingertips from business, supply chain, manufacturing, data analytics, technology, logistics, and entrepreneurship, to name a few. At Rutgers, the ISE department does a phenomenal job of giving students a well-rounded understanding of all paths, as well as opportunities to test the water through group projects, technical electives, and internships/co-ops.

Advice to New Students
Keep an open mind. The ISE department has courses in diverse fields with different levels of complexity, and with students who bring different talents. Don't get stuck on one class that you may not like—just get through it! It's part of the continuous learning process and I guarantee there will be at least one field that you will learn to love. Be a team player. Group projects are hard, but remember, everyone has something to offer. Most importantly, have fun! ■

Sarah Abdelaziz

Career Plans
I will be working for Amazon as an area manager in the operations department. Ultimately, I would like to continue my education after working in industry for a few years. I am excited to take what I've learned into the real world.

ISE Preparation
With the wide variety of classes offered in the undergraduate ISE curriculum, I feel extremely prepared to tackle any challenges I might face in my career. One of the great things about this department is the support the professors give to the students. They are such a great resource and are always willing to advise and assist students.

Advice to New Students
Try to make personal connections with the professors to gain more insight into the different career options we have as industrial engineers. Be fully engaged in all of the classes, regardless of your current interest in the topic, because you never know when the information will be of value to you in the future. ■

Farnaz Farzan, Ph.D.: Modeling Solutions

"Opportunities come out of unexpected places and conversations. Be open to new things and opportunities will follow."

Farnaz Farzan is an advisor in enterprise integration and smart grid strategy at Quanta Technology, helping clients such as utilities establish and integrate plans that align business and technology. Prior to that she was a senior consultant in market and policy development at DNV GL, developing advanced analytics to support power systems' decision-making processes.

Born and raised in Tehran, Iran, Farzan moved to the United States in 2006 to pursue her graduate-level education at Rutgers Engineering, earning a master's degree in mechanical engineering and Ph.D. in industrial engineering.

Read the entire interview with Farnaz at ise.rutgers.edu/news/farnaz-farzan.

Why did you choose Rutgers for your graduate education?

I wanted to come to the US to experience living abroad. I knew Rutgers from my uncle's family, who lived in Staten Island. I had a cousin – ten years older – who'd gone to Rutgers. So I felt a personal connection and I also wanted to be close to family.

How do your Rutgers studies support your career?

Now, as a technical consultant, I draw on my technical background in the projects I work on. I like this work—I get to develop solutions that put different topics and engineering, statistics, and economics models together to make a framework that translates the technical aspects of energy systems into what it means for policy, decision-making, and marketing.

What do you most enjoy about your work?

I enjoy working on large-scale projects that are shaping policy and make an impact. We know human activities are causing climate change, and we know that human activities can slow it down. We're using this knowledge to shape things and make the world a better place.

You have managed several teams as a technical lead in interdisciplinary projects. How would you describe your leadership style?

A key feature of my style is that I encourage each of my team members to have a sense of ownership and accountability. And I want them each to shine and be recognized for their contributions. There is never just one champion on the team who presents results and takes credit.

What do you most value about your School of Engineering education?

My experiences at Rutgers made me more flexible and broadened me. I grew to be more open-minded and have more patience, tolerance, and respect—and appreciation for differences.

Do you have any career advice for new graduates?

Networking is more than a buzzword. My suggestion is to go out there and network, talk to people, and see what's going on. Read about the fields you are interested in. Don't limit or restrict yourself to one thing. Opportunities come out of unexpected places and conversations. Be open to new things and opportunities will follow. ■

ISE Partners with Lockheed Martin to Offer New Reliability Engineering Course

ISE, in partnership with Lockheed Martin, has begun offering an introductory course in reliability engineering to all undergraduate engineering students. Students work in multidisciplinary groups to assess and improve the reliability of complex systems—ranging from unmanned aerial systems to driverless cars.

Lockheed Martin, a designer and developer of complex defense systems, hopes the course will provide engineering students with the tools they need to excel in future internship and employment opportunities.

"We know firsthand the importance of educating our future workforce in these areas," said Trevor Reitz, manager of Lockheed Martin's reliability and maintainability program. "Our future success—and our nation's technological advantage—depend on a constant supply of highly trained, highly capable technical talent."

Student reaction to the course has been very positive. Jenna Holland, studying materials science and engineering, says the course is already demonstrating real-world value.

"Recently, I applied to a company for a reliability engineering internship and was contacted specifically because I have this skill set. They told me that it was something they were looking for, but were concerned they wouldn't find."

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Industry Demand Drives New Energy Systems Engineering Graduate Degree

Climate change, renewable energy, smart grids, clean vehicles, and long-lasting batteries–these are among the challenges and innovations that are driving the world in the twenty-first century. Skilled engineers are needed to lead the way along with focused education programs like the School of Engineering's new master of engineering degree in energy systems.

This program offers a multi-disciplinary approach to innovate and drive the world's clean energy future, by integrating technology and science with business, IT, public policy, and regulatory study. It is also a collaborative program resourced through six engineering departments, the Edward J. Bloustein School of Planning and Public Policy, and the Rutgers School of Business.

Spearheaded by ISE department chair Mohsen Jafari, this new degree allows students to explore the many facets of a dynamic and expanding field by combining diversified coursework with hands-on learning, powering the world forward toward clean, efficient energy independence. Research opportunities in R&D settings and hands-on learning are key components of this program. Laboratories and research centers include clean energy and environmental research and business incubation centers, a state-of-the-art energy simulation lab, and a multi-disciplinary research center that brings together public agencies, private industry, and communities to build sustainable and resilient energy solutions. ■

For admissions information, visit soe.rutgers.edu/energy-systems-engineering.