ME Connections

A publication of The University of New Mexico's
Department of Mechanical Engineering

Fall 2019

FROM THE CHAIR

The Department of Mechanical Engineering at The University of New Mexico enters the 2019-2020 academic year with a cheerful outlook.

Student success has always been at the forefront of our mission. The department is shaping a culture of continuous improvement and self-reflection as we move forward. Our faculty and student researchers continue to push forward the frontiers of research, to help address societal challenges in sustainability, security, and human wellbeing. It is a really exciting time to be here.

In this issue of ME Connections, we highlight some of our recent accomplishments and present a sampling of our educational initiatives, cutting-edge research, and community engagement.

Special thanks go to Christos Christodoulou, dean of the School of Engineering, for his strong support of the ME department, and to Kim Delker, School of Engineering marketing manager, for her invaluable help in preparing this publication.

Yu-Lin Shen
on behalf of the entire ME family

Chabi receives 2019 Women in STEM award

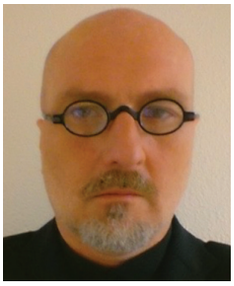
Sakineh Chabi, assistant professor in the Department of Mechanical Engineering, is one of the recipients of UNM 2019 Women in STEM awards.

The Women in STEM awards are in their fourth year and are presented by Advance at UNM, a five-year National Science Foundation grant to recruit, retain and promote women and minority STEM faculty. The awards help UNM women tenure-track and tenured assistant and associate STEM professor to establish new lines of research and to develop research collaborations.

Chabi's research project in conjunction with this award is titled "Design and Synthesis of Artificial Leaf for Solar Fuel Generation." Her work aims to synthesize a fully integrated membrane-based artificial leaf. Artificial photosynthesis is a technology that uses sunlight to convert water and carbon dioxide into renewable fuels, such as hydrogen, methanol, and hydrocarbons, which can be used directly as transportation fuels, raw materials for industry, or for electricity generation in fuel cells.

Chabi said she's "very grateful to receive this award, and I appreciate the support by the Women in STEM committee. I plan to use this funding to test new materials and get preliminary data. The results will be used to support proposals to the NSF, and other agencies."

Vorobieff selected as Halliburton Professor



Professor Peter Vorobieff has been appointed the Halliburton Professor starting fall 2019.

This three-year appointment is in recognition of his excellent accomplishments in research, education and leadership in our department. The Halliburton Professorship was established in 1982 by the Halliburton Foundation, and the endowment was subsequently expanded by the addition of funds from the State of New Mexico.

The three most recent past recipients are Professors John Russell, Andrea Mammoli, and Marc Ingber.

STUDENT AWARDS

Two ME students who attended the 2019 Region IV AIAA student conference in March won awards. **JOSH LUDWIGSEN**, a senior, won second place among undergraduate students and a $300 prize from the AIAA Foundation, for his paper "Analysis of the Fractal Dimension of a Dense Particle Curtain for Multi-Phase Flow Analysis." **DANIEL FREELONG** took third place among the graduate students and a $250 prize for the paper "Reflections of a Shock Wave off a Sparse Curtain of Particles." Both students are advised by Professors Peter Vorobieff and C. Randall Truman.

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Undergraduate student **RACHEL STARKWEATHER** is the recipient of the Charles Gilbert (Gib) Richards Undergraduate Mechanical Engineering Scholarship. Richards was a professor in the department from 1964 to 1998. He is known and remembered as one who earned and deserved the esteem of faculty and staff and, in particular, the love and gratitude of the undergraduate students. The scholarship was established in memory of Richards by his family.

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Graduate student **IRMA ROCIO VAZQUEZ** is the recipient of the 2019 New Mexico Hispanic Women's Council Scholarship, and the 2019-2020 Summa Academia: Innovation in Graduate Education Scholarship.

Undergraduate student **LAITH ALQAWASMI** won a prestigious scholarship from the New Mexico Space Grant Consortium (NMSGC) and graduate student **JAMES YOUCHISON** won a fellowship from NMSGC. Both students are working, starting in Fall 2019, with Professor **TARIQ KHRAISHI** on research of direct interest to NASA.

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The research project "Microfabrication of MEMS Electro-Thermal Actuators" conducted by students **ELIZABETH ARMISTEAD**, **ZACHARY BROUNSTEIN** and **MURALI DUGGINA** from Professor **NATHAN JACKSON**'s MEMS course, won the first-place poster award at the 2019 Engineering Expo.

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The following students won awards at the 2019 School of Engineering Annual Awards ceremony in the spring:

KAITLIN O'DELL received the Mechanical Engineering 2019 Outstanding Sophomore Award.
JARED KIRSCH received the Mechanical Engineering 2019 Outstanding Junior Award.
GREGORY VIGIL received the Mechanical Engineering 2019 Outstanding Senior Award.
AFROZA SHIRIN received the Mechanical Engineering 2019 Outstanding Graduate Student Award.

Colombian researchers partner with UNM to conduct drone rotor simulations

A type of unmanned aerial vehicle (UAVs) known as drones is the subject of increased scientific research as their use increases and becomes more diverse. Recent news stories have featured drones being used to transport medical supplies in Africa, deployed by police to crime scenes, and in a halftime light show at Super Bowl LIII.

Unique features of rotorcrafts, explained Associate Professor of Mechanical Engineering Svetlana Poroseva, are the ability to take off and land vertically, and hover in the air. This makes them effective for use in residential areas and in agriculture for sowing, spraying, irrigating, and monitoring crops.

"Computational Study of Small Rotor at Hover Using CFD and UVLM" was published by Poroseva in collaboration with her colleagues Ph.D. student Andrés Pérez and Associate Professor of Mechanical Engineering Omar Lopez from the Universidad de los Andes in Bogotá, Colombia, and industry partner Jaime Escobar from the Colombian company Advector Unmanned Systems. Student support was also provided by Departamento Administrativo de Ciencia, Tecnología e Innovación de Colombia.

The paper compares accuracy and affordability of two different computational methods to simulate small rotors in hover flight. Testing and comparing preliminary rotor designs in simulations before their production is an important and necessary step in a quest for better drones and other rotorcraft, she explained, but this process can be very expensive. The methods compared were Computational Fluid Dynamics (CFD) simulations using commercial software, and the unsteady vortex lattice method (UVLM). Because of the complex calculations and the amount of data generated by their simulations, Poroseva and her colleagues used various resources, including the systems at the UNM Center for Advanced Research Computing.

"Overall, UVLM with the proposed viscous correction produces results close to those from CFD simulations and experiments. Thus, this method is a suitable tool to study aerodynamics of small rotors. Moreover, the computational cost of UVLM is much less than that of CFD simulations, making this approach affordable alternative to CFD," the research concludes.

Pleil selected as UNM Center for Teaching Excellence Fellow

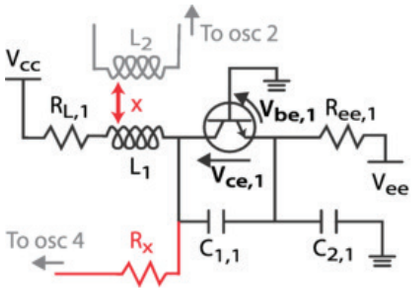
Matthias Pleil, lecturer III and research professor, was selected to participate in the 2019-2020 CTE (Center for Teaching Excellence) Fellowship program.

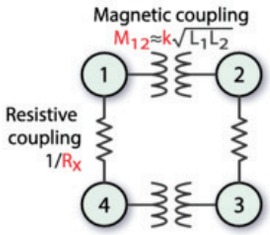
The program focuses on the instruction of large introductory courses, with a particular emphasis on practices that engage students and help foster student success. The selected Teaching Fellows receive a monetary award while work on course improvement administered by the UNM Center for Teaching and Learning. Pleil is targeting the courses ME160 - Mechanical Engineering Design I and ME260 - Mechanical Engineering Design II for better implementations of active learning.

Synchronization researchers dive into the 'messy'

Most people see the ocean waves and vaguely wonder why some are big and some are small — or look into a roaring fire and are curious as to what makes the flames move as they do — with seemingly no rhyme or reason.

For most, these are passing curiosities to which little thought is given outside the moment. Just a mystery of life. But for those who study the issues of complexity and synchronization, they aren't content with not understanding the patterns. They want to understand seemingly strange behavior in the hopes of perhaps being able to predict it in the future.





Postdoctoral researchers Karen Blaha and Fabio Della Rossa are two such researchers, studying the field known as synchronization, working under Francesco Sorrentino, associate professor in the department of mechanical engineering.

They are two of the authors on a paper recently published in Physical Review Letters called "Cluster Synchronization in Multilayer Networks: A Fully Analog Experiment with LC Oscillators with Physically Dissimilar Coupling," which explored the synchronization — all together or in pairs — of electronic circuits that communicate by two methods — via wire or wirelessly.

Co-authors on the paper are Sorrentino, Mani Hossein-Zadeh and Ke Huang, from the Department of Electrical and Computer Engineering, and Louis Pecora from the U.S. Naval Research Laboratory.

Synchronization, they explain, is a simple yet complex idea that is found in many human systems, including biology, human behavior and all branches of science and engineering. It starts as one action, such as a lightning bug lighting up or a person clapping at a concert, and continues as systems become linked or synchronized, leading to a swarm of bugs lighting up or an entire crowd of thousands clapping.

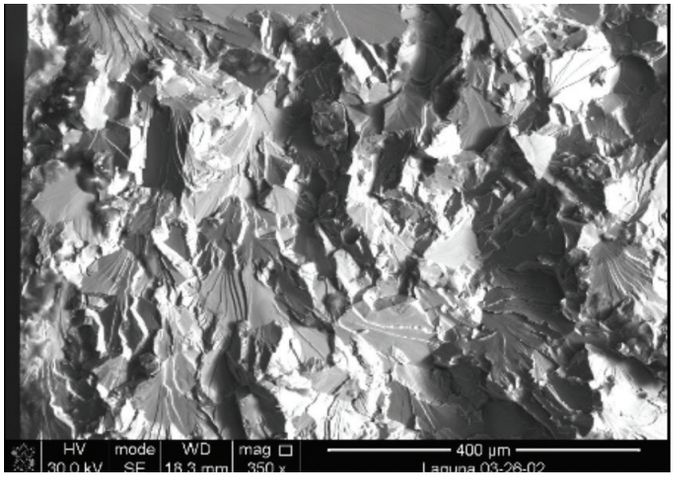
Della Rossa explained that one very visual example of this idea can be found in the Millennium Bridge in London, which was found shortly after its construction to have "synchronous lateral excitation." As people walked on the bridge, it had a natural sway motion, which caused people on the bridge to sway in step to counter the effect, which worsened the sway as more people participated. This effect was not anticipated by the engineers who designed the bridge.

Blaha and Della Rossa said although the effects synchronization are found in almost everything, from the systems in the human body to love (Della Rossa is the author of a book called Modeling Love Dynamics, which attempts to apply mathematical models to explain romantic attraction), it is generally not well-studied or anticipated by scientists or engineers, who often find the non-linear aspects of the field of study "messy." That's what they would like to change.

Using mathematical modeling, or what Blaha calls "playful mathematics," they would like to eventually develop models that can help scientists account for synchronization in their research, leading hopefully to more precise results.

"Many researchers want to avoid complexity, but systems we very much want to understand like the brain exhibit great complexity, so it's a challenge we need to embrace," Blaha said.

RESEARCH HIGHLIGHTS



Professor **TARIQ KHRAISHI** has been involved with Sandia National Laboratories (SNL) on two different research projects. One of them is on experimental testing on Hiperco, a magnetic metallic material. Fatigue testing under different frequencies was performed along with tensile and indentation testing. Also, scanning electron microscopy was performed on the fractured specimen surface. The second project involves dislocation dynamics simulations. He recently gave a presentation titled "Dislocations and Plasticity: A Primer" for SNL scientists/technical staff members. His research group is developing additional capabilities to enable proper effects of physical boundary conditions on crystal plasticity.

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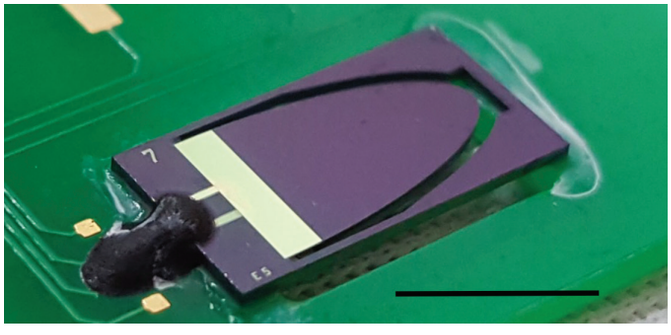

Professor **NATHAN JACKSON**'s team is working on developing multifunctional piezoelectric thin films for MEMS applications. His group is currently focused on developing 1) novel non-linear dynamic vibration energy harvesters, 2) development of MEMS aerosol generators or atomizers, 3) high Q-factor acoustic resonators, 4) flexible/stretchable piezoelectrics for tactile sensors, and 5) high intensity ultrasound transducers. The applications are focused on developing next generation IoT components as well as developing BioMEMS to diagnose or treat disorders and to improve quality of life. He is currently developing novel non-linear dynamic methods to increase the bandwidth of vibration energy harvesting devices at the MEMS scale.

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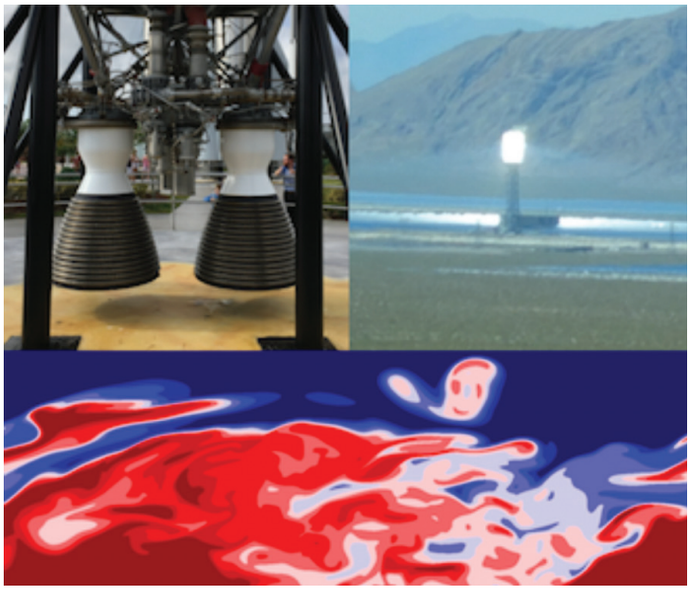
The so-called supercritical fluids may behave like both gases and liquids when very high pressures are reached. Seemingly exotic, supercritical fluids are actually all around us already, in diesel engines, rocket engines, and many power plants. "Supercritical fluids defy our everyday experience, blending seamlessly between liquid and gaseous states," says Assistant Professor **DANIEL BANUTI**. Using supercomputers, he develops models for the simulation of these kinds of flows. "It's really fascinating, on the one hand there is still so much to learn about the fundamental fluid physics, on the other hand our results are directly applicable for practical engineering in rocket engines or carbon-neutral power generation."



New Mexico Research Spotlight Forum highlights engineering mechanics, dynamics

Five professors from the Department of Mechanical Engineering gave presentations on March 5 at the New Mexico Research Spotlight Forum – Engineering Mechanics and Dynamics. The purpose of the forums is to provide an overview of research and needs on specific topics to foster collaboration between Sandia National Laboratories and its academic alliance schools including UNM.

At each forum, Sandia researchers provide an overview of the topic, then faculty working in the area give brief presentations on the research they are doing in the area. Each forum concludes with a networking event where researchers can learn more about each other's work and discuss collaborations.

The five presenters from our department and their presentation titles are:

- Sakineh Chabi – Engineering multifunctional materials
- Nathan Jackson – PiezoMEMS resonators
- Svetlana Poroseva – Modeling and simulation of complex flows and systems
- Yu-Lin Shen – Micromechanics of deformation and damage
- Peter Vorobieff – High-speed compressible hydrodynamics and multiphase flow studies

UNM, Sandia partner for NOMAD summer program

The Department of Mechanical Engineering was a partner and host for the 2019 Sandia National Laboratories' Nonlinear Mechanics and Dynamics (NOMAD) Summer Research Institute. The summer program, which brings together about 20 graduate students and 30 research mentors from around the world, including Sandia and UNM, was held June 17-August 1, at UNM Mechanical Engineering Building. The program seeks to tackle research challenges in the field on nonlinear mechanics and dynamics. Tariq Khraishi, professor of mechanical engineering, was the UNM lead in this program.

This year's project list included:

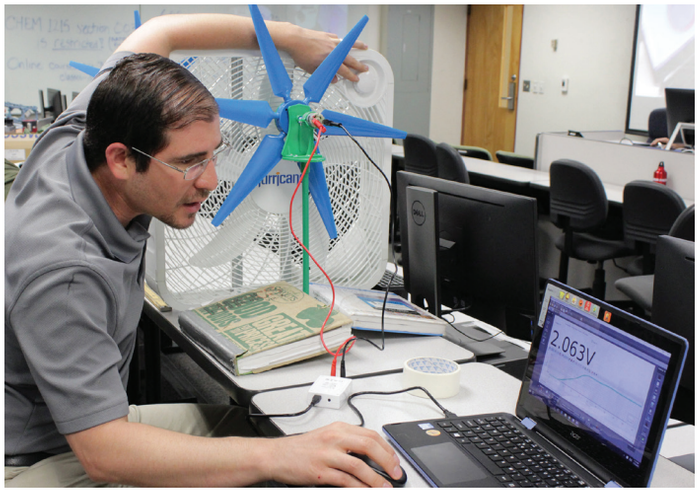
- Mechanics of bolt loosening under dynamic loads
- Investigation of electrical contact chatter in pin-receptacle contacts
- Force reconstruction at mechanical interfaces

- Modeling and experimental validation of a pylon subassembly mockup with multiple nonlinearities
- Development of reactive potentials for molecular dynamic simulations
- Indentation of heterogeneous materials: Factors affecting the indentation results and a comparison to bulk material testing
- Validation of puncture simulations with various probe geometries

NSF program helps students transition to UNM

On a sweltering mid-July morning, Arturo Sanchez is hanging out by a fan. But the fan was not there to keep him cool. Instead, it was being used as a learning device to simulate wind and record the resulting voltage onto a spreadsheet.

Sanchez, a mechanical engineering student at The University of New Mexico who transitioned into the program from Central New Mexico Community College (CNM), is one of the students taking part in supplemental funding of a parent National Science Foundation STEP project called "STEPs in the Right Direction: Transforming Engineering/Computer Science Education at The University of New Mexico."



The goal of the STEP supplemental funding, called STEPS, is to encourage community college students to make the jump to pursue four-year engineering and computer science degrees. This is done through offering students eight-week paid internships at companies or projects where they work with other students and under the supervision and direction of a faculty member.

The STEP program started in 2011. STEP stands for STEM Talent Expansion Program. It was funded at the School of Engineering for $2 million to improve retention and graduation rates in the School's programs. The key to the parent project, and its supplemental funding, is to show budding engineers what engineers actually do in practice — using internships and real-world projects — in the hopes that they will stay in the field.

Research Lecturer III in the department of mechanical engineering Ahmed Ali Hasan, who spent 27 years at Sandia National Laboratories in R&D, has been teaching a mechanical engineering course (ME150) related to the STEP project. He said that he has been able to bring his vast experience into the classroom. "The students have a better understanding of an engineering degree, learning the philosophy of engineering and how to approach a problem," he said. "That benefits them in the classroom, but also in everything from home to politics."

He said the majority of community college students in the STEPS project have decided to go into engineering after completing the internship. "It's been helpful in building a bridge from a two-year degree to a four-year degree."

Among the projects and technologies the ME150 students have worked on are CNC machines to produce prototypes for customers, 3D printers, robotic arms, automation equipment and smart sensors.

The project targets those interested in pursuing STEM degrees, but who may not often have a strong idea of what an engineering program looks like or how to use the engineering principles in real life. "Teaching students in a hands-on way is more effective," said Hasan. "They make mistakes and find the information on their own. That's how we create scientists and those with critical-thinking skills."

The NSF STEPS project ends Sept. 30, but it's had a great impact, said the director of the project. "The vast majority of the two-year institute students who participated in STEPS have kept their interest in pursuing an engineering career, which is the original goal of the funded project," said Tariq Khraishi, principal investigator on this grant and the previous parent grant since 2011, and a professor of mechanical engineering.

FSAE places in top 25, has eyes to future

For two decades, The University of New Mexico's Formula Society of Automotive Engineers team has been designing, building and racing a Formula-style car for competition in an international contest. Students spend an intense year working on the machine, applying their classroom knowledge to the real world.

The team results over the years have varied, with the team placing as high as No. 5 in the U.S. and 18th in the world. Although winning is important, director and mechanical engineering professor John Russell says it's never been just about the outcome, but about what students learn from this real-world engineering lab.

The 2019 team competed in Lincoln, Neb., in June, placing No. 24 out of 80 teams. Russell said the overall result — although not the program's best result historically — was admirable, considering the caliber of teams and the difficulty of competition. "It's a very difficult competition, and the judging can be very harsh," Russell said. "On top of that, it rained, complete with lightning and thunderstorms. That changed the way the car performed. We hadn't practiced under those conditions."

Even if the weather wasn't one of them, there were some bright spots. The team finished the endurance race, which many teams do not finish, and not finishing that competition severely impacts the final score (endurance is 37% of the final score). The team won first place for their technical drawings, which are evaluated on how accurately the drawings depict the design of the car. UNM's team also placed seventh in fuel economy and ninth in acceleration. This year was also the first time the car had an electric throttle, a feat that few cars at the Lincoln competition achieved. And the continuing quest to put the car on a diet was successful, with the car weighing 50 pounds less than last year at 455 pounds. "That is a major step forward, and we would like to get it down even more," Russell said.

Although hindsight is 20/20, and the team can identify places that they could have improved, the program is looking straight toward the year 2020, when it is expected that the program will have a new home, in the basement of the remodeled Farris Engineering Center. In 2018, a $1.5 million gift from the estate of Dana C. Wood, a School of Engineering alumnus, was made to benefit FSAE. From the gift, a 7,000-square-foot space in the basement of Farris Engineering Center will be dedicated to the program, along with some updated equipment.

Although the space won't be ready for use by the incoming 2020 team, construction is anticipated to begin in fall 2019, with completion in the next year, Russell said. Even though the Lincoln competition is barely behind them, the 2020 team, which worked alongside the 2019 team, is already hard at work and feeling optimistic about next year's contest.

In addition to the combustion engine car, the program is also building an all-electric car, which they hope to have a working prototype of next year.

Lobo Launch team debuts at Spaceport America Cup, places No. 5 overall

The University of New Mexico's Lobo Launch rocket team placed No. 5 overall and No. 3 in its height class out of 120 teams from 14 countries in the June 18-22 Spaceport America Cup near Las Cruces, NM.

Fernando "Doc" Aguilar, a longtime Air Force engineer who worked as a launch controller on rocket launches at Cape Canaveral, has been directing the rocket program the last few years. The team launched the first rocket in 2017, then decided to take things in a different direction for the 2019 launch.

He said making the rocket smaller and more standardized helped the team greatly. He said that even though the rocket went 600 feet higher than the 10,000-foot target, it performed well and landed with barely a scratch the first time in competition.

UNM's team launched first, which Aguilar said was his doing.

"That was the old launch controller in me knowing that the longer you wait to launch, the more that can go wrong," he said. "A lot of teams don't get to launch at all."

The build process for the 2019 rocket was fairly smooth, but there are always bumps. He said in testing, the rocket overshot its 10,000-foot target by considerable amounts. Deciding that adding weight wasn't an option without sacrificing stability, the team decided to add a fifth fin to increase drag.

Aguilar said the Lobo Launch team will begin designing the 2020 rocket in the fall, likely using much of the design from the 2019 rocket to compete in the 2020 Spaceport America Cup.

Last year, students also started construction on a much larger rocket — about 50 feet tall — which students still hope to finish and launch for testing and training purposes in the fall.

Solar Splash places No. 4 in nation

The University of New Mexico's Solar Splash team finished in fourth place overall in the national Solar Splash contest in Springfield, Ohio, in addition to winning other awards.

Solar Splash was held June 11-15, with 17 solar-powered boat teams from around the world submitting entries into the competition.

UNM's team earned third place in the solar slalom event and also won the Teamwork Award for best coordinated group effort.

The team was led by faculty advisors Peter Vorobieff, professor of mechanical engineering, and Jane Lehr, professor of electrical and computer engineering.

Vorobieff said that he was pleased overall with the team's performance. Even though the goal was to place in the top three teams, he said that UNM landed in fourth place, not because of any problems with UNM's boat performance but because of the high-quality competition, including an unexpectedly strong performance from Stevens Institute of Technology, which took the No. 3 spot this year.

He said that the team intended to experiment with a new hull that was made of wood and student-designed (the current hull was purchased from Gheenoe and heavily modified). The team actually did finish that wooden boat but decided that there was not enough time to test it out before competition, so they will save that for next year's team.

"We took the conservative approach this year," Vorobieff said. "We're hoping that the new hull will have a lot less drag."

Instead, this year's team made incremental improvements to the array and the boat, with the goal being to improve reliability and making the boat lighter.

For the third year in a row, the team used solar cells from Albuquerque-based SolAero Technologies, which Vorobieff said are the highest-quality space-grade cells and unique among other competitors. "Nobody has anything close to our solar cells," Vorobieff said.

In 2017 and 2018, UNM's team won best solar display using those cells.

He said previously, the team had used a water-cooled mechanism to regulate the temperature of the cells, but a rule change this year prevented them from including that feature.

The team will likely need to replace cells for next year's boat and plan to reach out to SolAero again for additional solar cells next year.

In addition, Vorobieff is grateful to all the supporters, especially Roger Koerner, David Menicucci and ExxonMobil.

He said the eventual goal for Solar Splash would be to establish an endowment so that funding the team isn't dependent on raising money year to year.

ME Connections

Department welcomes new faculty, staff

DANIEL BANUTI joined the Department of Mechanical Engineering as an assistant professor in August 2019.

He received his master of science in mechanical engineering from RWTH Aachen University, and his Ph.D. in aerospace engineering from the University of Stuttgart, Germany. After several years as a research scientist at the German Aerospace Center (DLR) in Göttingen, he joined Stanford's Center for Turbulence Research and later at Caltech/Jet Propulsion Laboratory as a post-doctoral researcher. His research focus is understanding and modeling of real and supercritical fluids for energy and propulsion applications.

GOWTHAM MOHAN joined the Department of Mechanical Engineering as an assistant professor in August 2019, after being a postdoctoral researcher at the Department of Thermal and Fluid Engineering, University of Twente, Netherlands. He received his Ph.D. from the Australian National University, Canberra. He holds a master degree in sustainable energy engineering from KTH Royal Institute of Technology, Stockholm, Sweden. His research areas include solar thermal technologies, carbon emission mitigation and energy storage.

KAYDRA TOWNSEND joined the ME department in May 2019 as an administrative assistant II. Kaydra is a UNM alum with a bachelor's degree in interpersonal communication.

Welcome to the Department of Mechanical Engineering!

ME offers alternative ways to earn UNM credits

ONLINE MASTER'S PROGRAM IN SPACE SYSTEMS ENGINEERING

In the 2018-19 academic year, the Department of Mechanical Engineering launched a fully-online master's program in space systems engineering, leading to a master of science in mechanical engineering. This program is one of the first master's-level space systems engineering programs in the country. The space systems engineering concentration was developed to proivde graduates with the advanced skills to further their career in the aerospace industry. All couses for the space systems engineering program are offered in an eight-week format. **For program details, visit http://mespaceonline.unm.edu**

ME DESIGN 1 OFFERED FOR HIGH SCHOOL STUDENTS

UNM offers a great opportunity for high school juniors and seniors interested in pursuing an education in mechanical

engineering to start early with the dual-credit/concurrent enrollment course ME 160L. Students can learn how to take an engineering design concept in the imagination stage and produce an engineering technical drawing. Students will learn how to sketch by hand and untilize state-of-the-art design software, SolidWorks, culminating in a team project design, documentation, and final presentation. The spring semester offering is held after school at no cost to high school students.

Learn more at advisement.unm.edu/dual-credit/

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Cheers to our Mechanical Engineering Advisory Council!

The Mechanical Engineering Advisory Council meets twice a year to provide critical support and advice to the department, as well as assist in identifying resources to meet the department's strategic goals. The current 14 members of the council (many of whom are ME alums) are:

Mike Dexter (council chair)
Mark Andrews
Tennille Bernard
Mary Brown
Tony Byers
Ken Christensen
Theresa Cordova
Dan Crouch
John Farris
George Friberg
Raven Goswick
Bill Miera
David Rosprim
John S. Thurman

Council members visit the student design team in April.

INSPIRED BY ALL THAT WE'RE DOING?

Help us achieve even more by making a gift to our department or one of our programs! Contact Leslie Currie at leslie.currie@unmfund.org or give online at engineering.unm.edu/give/me-funds.html to learn about all the ways you can support our department.