



AEROSPACE

DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING

RESEARCH IMPACT



THE OHIO STATE UNIVERSITY
COLLEGE OF ENGINEERING

2019

Message from the Chair

VISH SUBRAMANIAM



The Department of Mechanical and Aerospace Engineering at The Ohio State University builds on its diversity of people and ideas to cultivate a range of advancements in mechanical, aerospace and nuclear engineering

From gears to cancer research, our **mechanical engineers** are experts in an array of specialty areas. Our strengths in both aeronautical and astronautical engineering boost the impact of our **aerospace engineers**. And, with an on-site nuclear reactor—and high-achieving graduates throughout industry and government—our **nuclear engineers** value collaboration.

To best showcase the unique achievements of each of our programs, we have created separate research publications. In this *Research Impact: Aerospace*, you will see samples of our advancements in aerospace engineering over the past year.

We have established an Air Force Research Laboratory collaborative center (page 4), are investigating Martian missions (page 6) and are expanding our gas turbine research (page 8).

All of this was accomplished with our talented students, who continue to be our primary focus. They are involved in every facet of our research and we foster a spirit of collegiality among faculty, staff researchers and students.

I invite you to read to discover our recent cutting-edge innovations.

Vish Subramaniam

Chair, Mechanical and Aerospace Engineering

Professor, Mechanical and Aerospace Engineering

DEPARTMENT AT A GLANCE



DEGREES CONFERRED

Academic Year 2018 – 2019

BS	199 MECHANICAL	72 AEROSPACE	
MS	80 MECHANICAL	11 AEROSPACE	6 NUCLEAR
PHD	23 MECHANICAL	6 AEROSPACE	4 NUCLEAR

STUDENT ENROLLMENT

Autumn Semester 2019

BS	621 ME MAJOR	647 ME PRE-MAJOR	164 AE MAJOR	309 AE PRE-MAJOR
MS	107 MECHANICAL	20 AEROSPACE	3 NUCLEAR	
PHD	146 MECHANICAL	38 AEROSPACE	22 NUCLEAR	



Air Force Research Lab to Establish \$3M Collaborative Center for Aeronautical Sciences at Ohio State

The Air Force Research Laboratory's Aerospace Systems Directorate (AFRL/RQ) has selected a team of researchers led by The Ohio State University to establish a Collaborative Center for Aeronautical Sciences (CCAS). The goal of the CCAS is to establish a flourishing, comprehensive, versatile and synergistic partnership with AFRL/RQ. Project partners include the University of Minnesota and Virginia Tech.

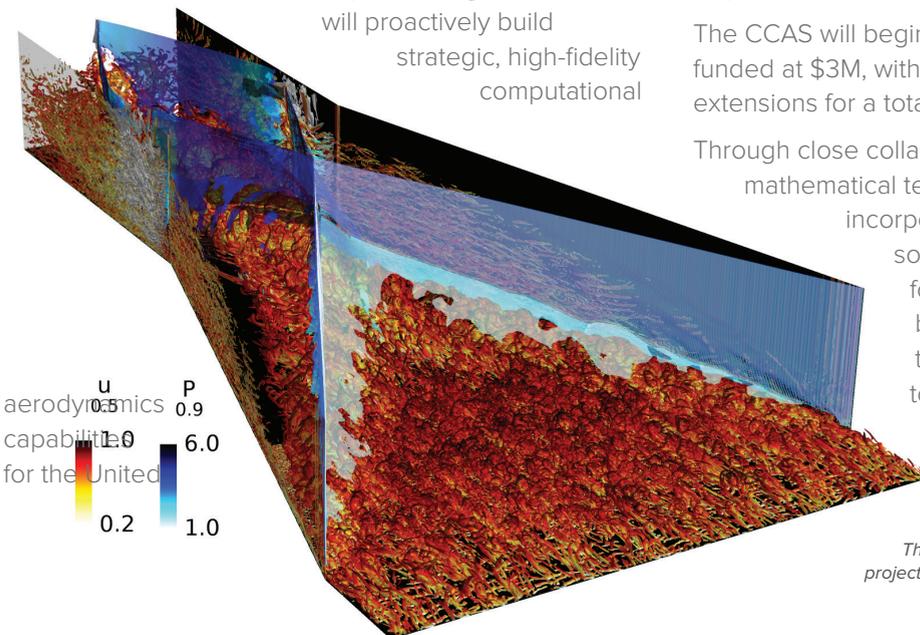
States Air Force. A special emphasis will be placed on evolutionary and disruptive research in high-speed aerophysics, fine-scale turbulence and control, non-linear fluid-structural interactions and high-fidelity computational technologies.

Principal investigator of the virtual center is Professor **Datta Gaitonde**, who directs the High Fidelity Computational Multiphysics Lab in Ohio State's Department of Mechanical and Aerospace Engineering.

The CCAS will begin with an initial five-year effort funded at \$3M, with two subsequent two-year optional extensions for a total funding amount of \$5.4M.

Through close collaboration with AFRL/RQ, advanced mathematical techniques will be developed and incorporated into massively-parallelized software and subsequently transitioned for use by AFRL and its broad user base. The CCAS will deploy these tools for physics-based analyses to address emerging challenges in the highly unconventional aerospace vehicle design

The cooperative agreement will proactively build strategic, high-fidelity computational



The team will complete analyses as part of the project.



The Collaborative Center for Aeronautical Sciences will examine the physics of a variety of defense-related multidisciplinary problems.

environment, where multiple non-traditional factors must be considered.

CCAS activity will help reduce the prohibitive expense, and acquisition costs, associated with ground and flight-testing. A particularly crucial objective of the CCAS is to nurture and develop the next generation of aerospace research professionals with proven scholarly

accomplishments and possessing the advanced multidisciplinary skills required for the future aerospace workforce. Students funded by CCAS will be provided internship opportunities at AFRL to foster deep and lasting direct relationships with engineers performing basic and applied research.

Faculty member lands funding from NASA to investigate Martian mission descent

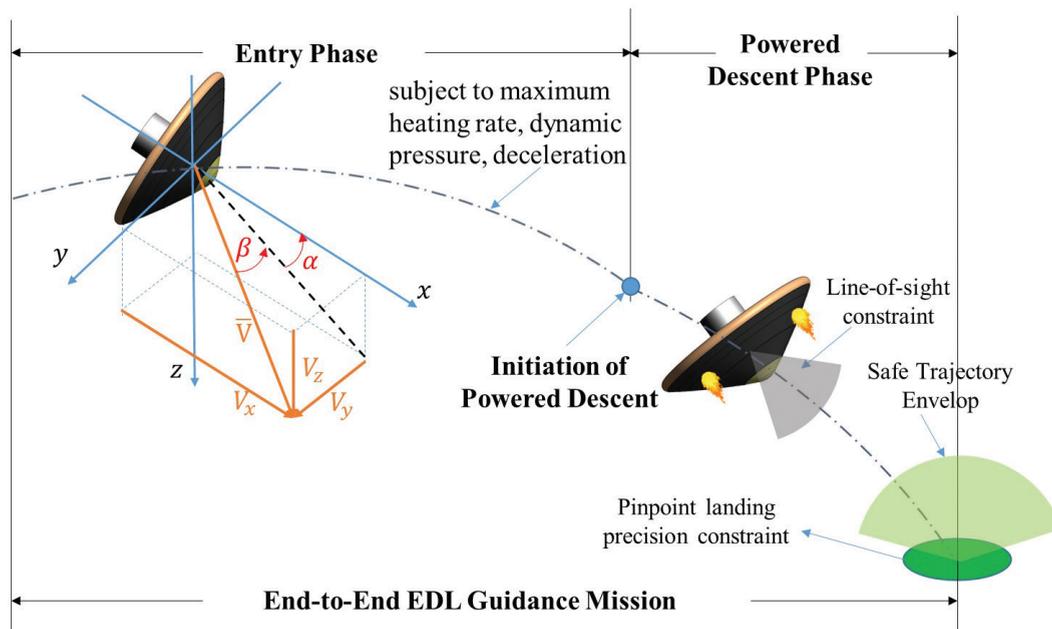
A human mission to Mars requires precision—not just to get there, but to make a designated pinpoint landing at near-zero speed at the end of a supersonic flight. All while minimizing fuel consumption.

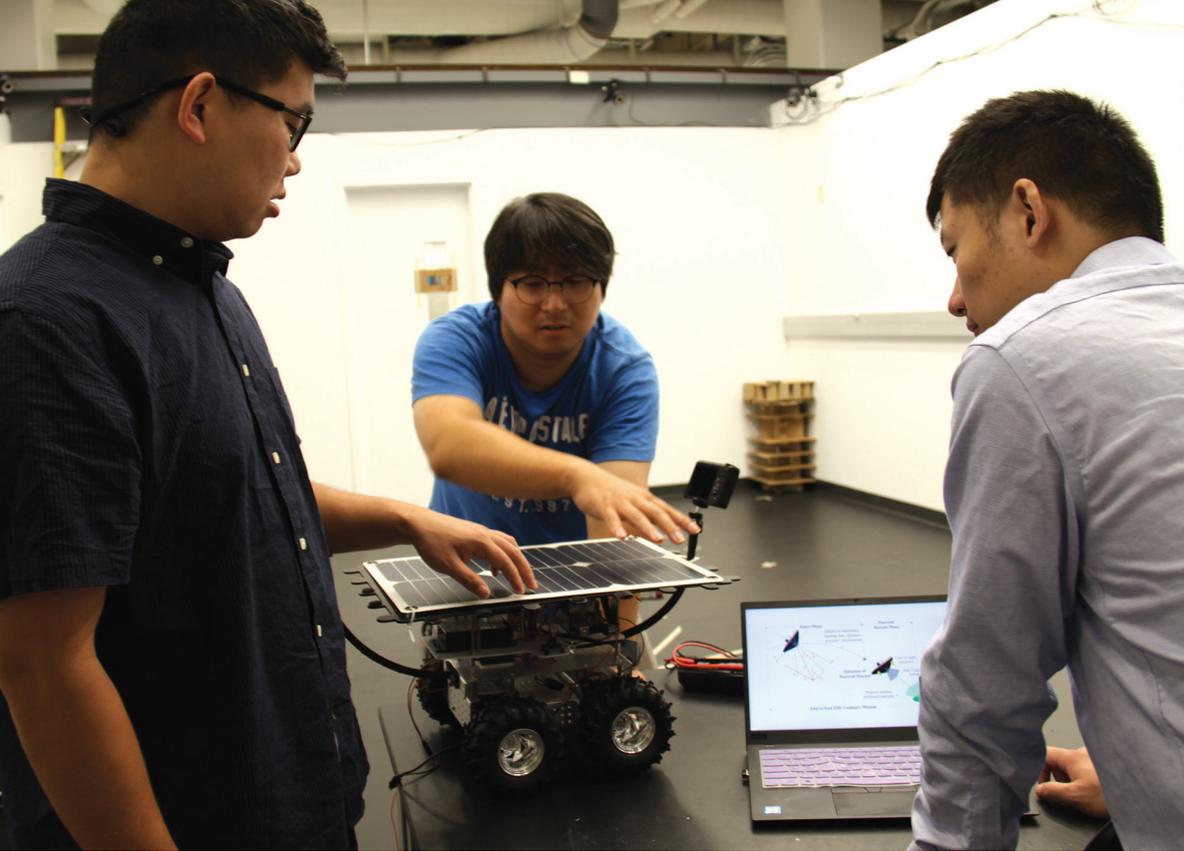
Stepping up to the challenge is Assistant Professor **Ran Dai**, who has received a three-year Early Career

Faculty for Space Technology Research Grant from the National Aeronautics and Space Administration (NASA) to investigate precision planetary landing.

The nearly \$600,000 grant will be used to develop an optimized spacecraft landing approach with powered descent. Entitled “Optimized Entry and Powered Descent

Precision Planetary Landing





Doctoral students, left to right, Changhuang Wan, Myungjin Jung and Sixiong You are integral to the Martian mission descent project, along with robotic and drone projects in Assistant Professor Ran Dai's lab.

Guidance for Precision Planetary Landing”, the project will build on Dai’s expertise in developing theoretical and computational techniques to advance the understanding and applications of control and optimization methodologies of space vehicles.

“The supersonic retro-propulsion system to decelerate the vehicle at supersonic speed consumes significant amount of propellant,” said Dai. “It becomes a challenging task to achieve a high-precision landing while conserving fuel during the descent phase.”

In pursuit of the research goal, Dai will create computational models, optimized algorithms and virtual simulations of the mission, as well as conduct experimental verification.

The NetJets Assistant Professor will complete the project by planning a proposed end-to-end mission strategy, applicable to multiphase space tasks. This additional investigation will provide beneficial insight to onboard planning of challenging space missions.

According to NASA, Dai’s project is one of 11 university-led proposals selected for the study of innovative, early-stage technologies that address high-priority needs of America’s space program. The program enables early career faculty to focus their specific expertise on selected NASA challenges to accelerate potential disruptive solutions for the agency.

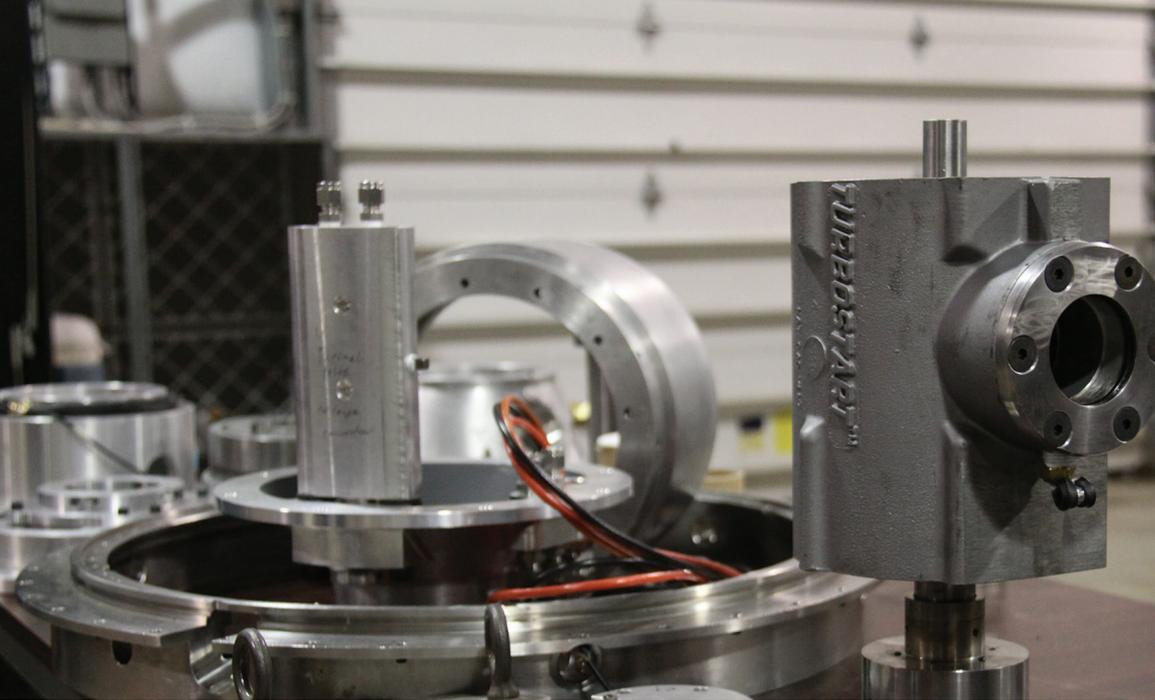


New Pratt & Whitney Center of Excellence expands gas turbine research

In 2018 the Ohio State University expanded its investigation of jet engines and gas turbines, thanks to a collaboration with aerospace manufacturer Pratt & Whitney. A multi-year agreement will setup the Pratt & Whitney Center of Excellence in the Gas Turbine Laboratory, located at the Department of Mechanical and Aerospace Engineering's Aerospace Research Center.

D'Souza, center left, and Mathison, center right, along with lab personnel display a shroud component similar to the ones that will be used in the turbine blade rub research





Air motor and assembly parts for turbine rig at the Gas Turbine Laboratory

The center's activities will focus on the development of an innovative high-temperature rig in which turbine engine blade tip rub experiments can be conducted. Turbine blades operate within a structured casing in the engine—required minimal clearance between the two poses a risk for the blade's tip rubbing on the casing, resulting in potential performance degradation or even system failure.

“Ohio State's Gas Turbine Lab has a great deal of expertise in blade tip rub research,” said **Kiran D'Souza**, assistant professor and principal investigator of the center. “We're proud to partner with Pratt & Whitney to investigate solutions to this industry-wide issue.”

Associate Professor **Randall Mathison**, co-principal investigator, further described the center's research initiatives. “The goal of the center is to develop a better understanding of blade tip rub dynamics and material

characterization at design-speed and engine-relevant temperatures.”

Professor Emeritus **Michael Dunn**, also a co-principal investigator with the center, brings over 50 years of gas turbine expertise to the research initiatives.

Faculty and staff at the laboratory will operate the center, which has an initial term of October 2018 – December 2023.

The new center joins the department's Pratt & Whitney Center of Excellence in Gearbox Technology, housed in the Gear and Power Transmission Research Laboratory.



Commercializing research: Ohio State-developed software aims to support industry

Associate Professor **Mrinal Kumar** and his team are one step closer to possibly commercializing research they developed at The Ohio State University. Team “Point Prognostics” is designing software to optimize maintenance schedules for industrial equipment.

The team successfully completed the 2019 I-Corps@Ohio program, an eight-week program aimed at helping selected faculty and student teams determine if their intellectual property could be the basis of a startup company. In all, 13 teams from Ohio research universities and organizations participated in this year’s competitive program.

The I-Corps@Ohio process helps researchers get out of their “academic bubble,” said Kumar.

He and doctoral student **Rachit Aggarwal** are creating a closed-loop forecasting framework for system prognostics and decision support. They are advised by industry mentor Mike Downing.



Kumar, Downing and Aggarwal

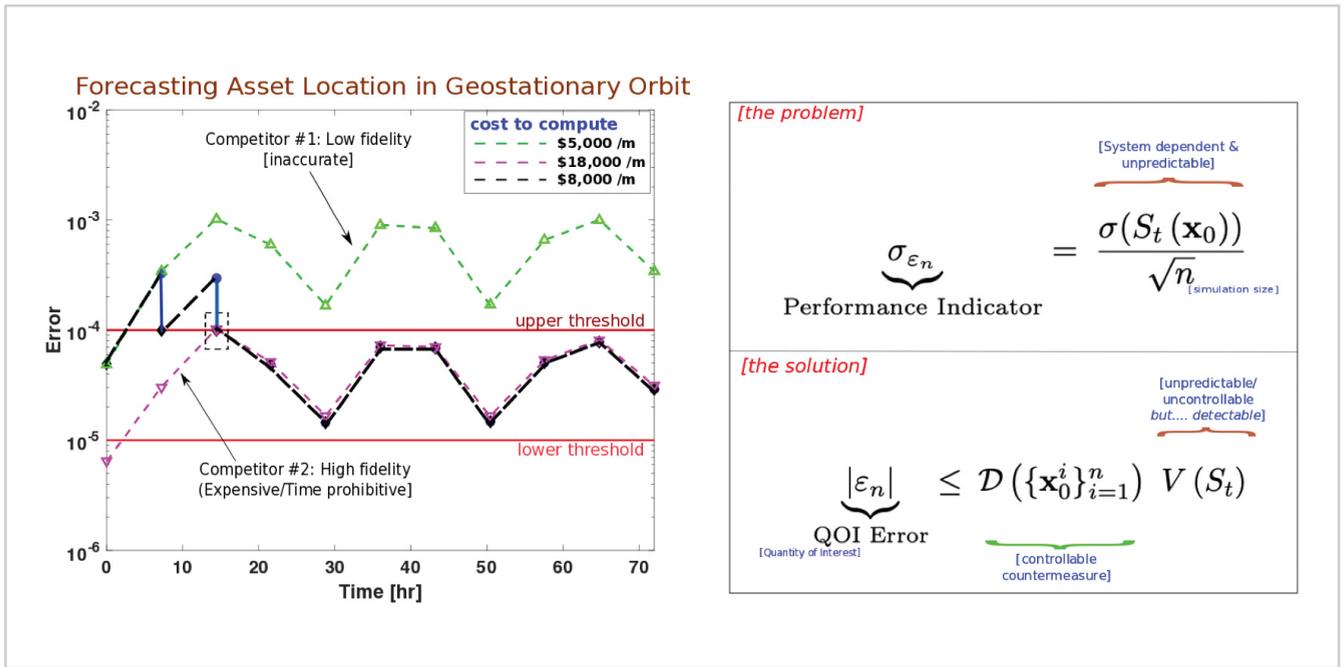
“The software is designed to optimize maintenance schedules for equipment, which is intended to reduce costs by preventing unexpected shutdowns and premature repair,” said Kumar.

The solution is built upon a robust, scalable computational platform capable of delivering trustworthy forecasts of key performance indicators as established by the client.

“As researchers, we are often too focused on solving problems at the ‘fundamental level’ and do not necessarily look at the other side—whether this might actually be something that people or companies can use,” Kumar said.

The team’s software platform offers controllable accuracy, according to Kumar. This translates to confident decision making, as well as optimization of system performance, maintenance schedules and failure avoidance. The intended results? Savings in time and cost.

As part of the I-Corps@Ohio program, the team conducted a customer discovery process. They



A comparison of solutions for a space forecasting problem (left) and why it works

identified thirteen potential segments to which their product offers a value proposition.

“One of the top segments to emerge lies within the pharmaceutical sector,” commented Kumar. “There, the controllable accuracy offered by our simulation platform can speed up the process of new drug discovery.

“Another segment of high impact concerns the prediction of the failure of critical, access-restricted components in the oil and gas sector. Promise has also been shown for application in the aerospace industry, where our tools can bring about a paradigm shift in the way aircraft engine failure prediction is performed.”

Most of the teams that finished I-Corps@Ohio will continue the process they began in the program before deciding whether to create a startup company or otherwise license their products. Five Ohio State teams participated in the 2019 cohort.

I-Corps@Ohio, an initiative of the Ohio Department of Higher Education, is a statewide program that helps Ohio faculty and graduate students determine the market potential of their technologies and assists with the launch of startup companies.

– with contributions from Ohio State News

FACULTY RECOGNITION AWARDS

Brain cancer research supported by grant from The Mark Foundation



Assistant Professor

Jonathan Song has received a \$187,000 grant from the Mark Foundation for Cancer

Research. The grant will support his development of a preclinical disease model to precisely interrogate how brain metastases obtain vasculature through the co-option of pre-existing blood vessels.

“Brain metastasis is not only very significant clinically, it is also quite challenging to study experimentally,” commented Song.

Song directs the Microsystems for Mechanobiology and Medicine laboratory, which applies microtechnology, principles from tissue engineering and quantitative engineering analysis for studying physical dynamics of tumor and

vascular biology. He is also a member of the Molecular Biology and Cancer Genetics Program at the The Ohio State University Comprehensive Cancer Center – The James.

Based in New York City, The Mark Foundation for Cancer Research is dedicated to accelerating cures for cancer by integrating discoveries in biology with innovative technology.

Haythornthwaite Foundation Research Initiation Grant advances Zhao’s research



Assistant Professor **Ruike Zhao** is one of four recipients of the American Society of Mechanical Engineers

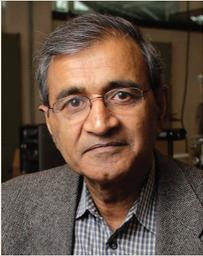
(ASME) Applied Mechanics Division 2018 Haythornthwaite Foundation Research Initiation Grant. Bestowed in recognition of excellence in theoretical and applied mechanics

research, the grant provides early-career faculty funding in support of their research objectives.

Her current research project on the development of magnetic-responsive soft materials will benefit from the grant. Project applications include soft robotics, flexible electronics and biomedical devices. A total of \$20,000 will be used by Zhao for the purchase of specialized laboratory equipment in support of the project, which proposes to combine an experimental approach with theoretical and numerical methods to investigate the macroscopic response of magnetically active soft material under external stimulation.

The studies will enable the fundamental understanding of coupled mechano-magnetic interaction of magnetic-responsive soft materials and facilitate the rational material, structure and stimulation design for reliable functional smart devices.

First-of-its-kind book highlights nature-inspired product development



The shark skin effect, gecko adhesion and self-healing materials. These advanced biomimicry topics are

among examples highlighted in **Bharat Bhushan's** newest book, *Biomimetics: Bioinspired Hierarchical-Structured Surfaces for Green Science and Technology*, Third Edition, published by Springer.

The book is the first of its kind on biologically-inspired structured surfaces. It may serve as a textbook for courses in biomimetics and applied nanotechnology, and, according to Bhushan, is intended for use by novices as well as experts in the field, practitioners, solution seekers and the curious.

Since the book's previous editions, there have been considerable advances in the emerging field of biomimetics, and related products are now commercially available.

Bhushan, an Ohio Eminent Scholar and The Howard D. Winbigger Professor, is renowned for his work in advancing the field of

biomimicry, the study of the imitation and development of nature-inspired systems and structures. Most recently he reported on the efficiency of bee and wasp stingers, citing the potential ability to develop microneedles based on their function.

Rizzoni delivers keynote at Symposium of International Automobile Technology 2019



Mechanical engineering Professor **Giorgio Rizzoni** shared his

expertise in mobility as a keynote speaker at the 16th edition of the Symposium of International Automobile Technology (SIAT 2019). The conference was held in Pune, India January 16-18, with an agenda focused on recent advances in automotive safety.

Rizzoni, who directs The Ohio State University Center for Automotive Research, delivered his keynote presentation during the session on autonomous and connected vehicles.

It was Ohio State's first keynote presentation at the symposium.

The symposium attracted national and international experts, industry leaders and regulators from the automotive segment. Additionally, officials from the government of India with two of its ministries directly participated in theme sessions.

While at the conference Rizzoni connected with the local leadership of Cummins Inc. and Eaton Corporation to discuss ongoing projects. He also had the opportunity to spend time with academic partners at the Indian Institute of Technology – Bombay and the Cummins College of Engineering for Women.



Horack to step into senior associate dean role



In January 2019, Professor **John M. Horack** began serving as Senior Associate Dean in The Ohio State University's

College of Engineering. The senior associate dean's primary role is to work in tandem with Dean David B. Williams to manage growth and optimize operations.

Horack arrived at Ohio State in 2016, when he was named the inaugural Neil Armstrong Chair in Aerospace Policy. He is a tenured professor in the Department of Mechanical and Aerospace Engineering and holds a joint appointment in the John Glenn College of Public Affairs.

Before coming to Ohio State, Horack served as the vice president for Space Systems at Teledyne Brown Engineering, vice president for research at the University of Alabama in Huntsville and vice president of the International Astronautical Federation. He spent nearly two decades as a NASA civil servant. Horack was a co-founder, president, and chief product architect of Mobular Technologies, Inc.

He is the author or co-author of over 100 scientific papers, conference proceedings, and publications across subjects including space policy, atmospheric physics, and high-energy astrophysics.

Singh builds collaborations with institutes in India



Mechanical engineering Professor Emeritus **Rajendra Singh** represented The Ohio State University during

a visit to India during November 2018. Singh is well-respected internationally for his research, teaching and consulting work in machinery vibration, acoustics, nonlinear dynamics and digital signal processing, with applications to vehicles and geared systems.

While in India Singh covered a broad agenda, organized by Ohio State's India Gateway. Topics of focus included visits to highly regarded institutions, faculty development, women in STEM and industry collaborations.

He partnered with Nikhil Tambe, PhD, director of India Gateway, to

forge new relationships with a variety of organizations. Conversations with senior leadership at academic institutes focused on collaborative engagements in India and the effectiveness of a consortium model.

Mazumder recognized for service as a journal reviewer



The review process is instrumental to the success of publishing a journal article. Professor **Sandip Mazumder** has

been honored with three awards for service as a reviewer.

Over the course of two years, Mazumder received three recognitions from Elsevier. In 2017 he was awarded for his involvement in the Journal of Quantitative Spectroscopy and Radiative Transfer and the International Journal of Heat and Mass Transfer. Then in 2018, he received an award from the International Journal of Thermal Sciences.

Reviewers work to evaluate journal article submissions to ensure the quality of the research, identify any invalid results and prevent ethical breaches by identifying plagiarism

and research fraud. Elsevier, a global information analytics business, provides a service in which researchers can volunteer to review papers in their areas of expertise. It is a lengthy and time-consuming process, one that requires the utmost care, but is rarely recognized.

Inaugural Charles F. Kettering “BUG” Award presented to UAS researchers



In honor of the 100th anniversary of the dawn of unmanned aerial systems (UAS), the Engineers Club of Dayton in collaboration

with the Sinclair College National UAS Training and Certification Center recognized The Ohio State University’s Aerospace Research Center as pioneers in the field of UAS technology. The inaugural presentation of the Charles F. Kettering “BUG” Award coincided with the exact date—October 2—of the first flight of the U.S. Army Signal Corps’ first aerial torpedo, dubbed “BUG” in 1918.

The award is presented to an individual or organization that has demonstrated outstanding improvement or advancement in UAS technology or systems.

Professor **James Gregory**, director of the Aerospace Research Center, and Research Scientist **Matthew McCrink**, both leaders in the interdisciplinary Unmanned Aircraft Systems group, represented the center at the awards ceremony. The two led the university’s effort to set a world speed record in 2017 for an unmanned aerial vehicle (UAV) of any size. Ohio State’s UAV flew autonomously with sustained average speeds of 147 mph over an out-and-back course approximately 28 miles long, which also set a record for the longest UAV flight over an out-and-back course.

STUDENT RECOGNITION

Aerospace students shine at AIAA student conference

Department aerospace students went three-for-three taking home top honors at the 2019 American Institute of Aeronautics and Astronautics (AIAA) Region III Student Conference.



Winning first place in the undergraduate category was **Collin O'Neill** (advisor: Mo Samimy) with his presentation "Active Flow Control in a Compact High-Speed Inlet/Diffuser Model." Graduate student **Braxton Harter** (advisor: James Gregory) won first place in the master's category with his presentation "Lagrangian Coherent Structures in Optimal Vortex Ring Formation." Second place in the master's category went to **Nicole Whiting** (advisor: Mo Samimy) for her presentation "Design of an Experimental Facility for Characterization of Dynamic Stall."

As first place winners, Harter and O'Neill have also earned a trip to the AIAA SciTech Forum in January 2020 to compete at the national level with other regional winners.

According to its website, the conference encourages students in aerospace-related fields to discuss research, exchange knowledge and generate interest in the field of aerospace engineering. This year's event was held at Cleveland State University and was represented by schools across the Midwest.

Tseelmaa Byambaakhuu awarded Best Paper and Best Presentation at ANS Student Conference

Nuclear engineering PhD student **Tseelmaa Byambaakhuu** received two awards at the 2019 American Nuclear Society (ANS) Student Conference. She received best paper and best presentation awards for her article "Comparison of IpCMFD with Other CMFD Based Acceleration Schemes."

Byambaakhuu's research centers on stabilizing neutron transport utilizing coarse mesh finite difference acceleration. Her paper and accompanying presentation compared popular application methods of this approach with a new approach developed at Ohio State.

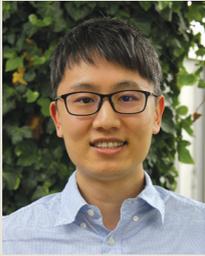
"This was an incredible opportunity to present Ohio State research to industry and research institutions, at the same time learning about the variety of



research taking place across the discipline of nuclear engineering,” she commented.

The conference was held during April 2019 at Virginia Commonwealth University. Representatives from American and international institutions were in attendance.

Distinguished Presidential Fellowships awarded to Anand Nagarajan and Meng-Hsuan Tien



Anand Nagarajan has a passion for numerical modeling and **Meng-Hsuan Tien** advances nonlinear dynamics. The mechanical engineering doctoral students will now be able to do even more, thanks to their selection as a distinguished Ohio State Presidential Fellows.



The most prestigious award given by the Graduate School, Presidential Fellowship awardees are described as embodying the highest standards of scholarship in the full range of Ohio State's graduate programs. The esteemed designation will provide the scholars with full-time financial

support for one year to allow for completion of their dissertations unimpeded by other duties.

Under the direction of Assistant Professor Soheil Soghrati, Nagarajan has devoted his dissertation work

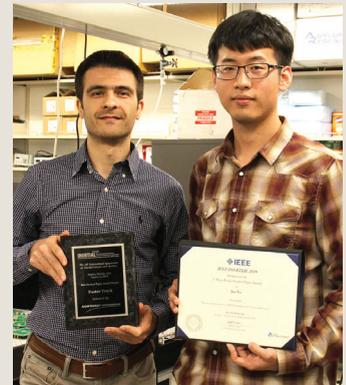
to creating an efficient numerical framework for the automated generation of high-fidelity simulation models of novel materials. Tien, who is advised by Assistant Professor Kiran D'Souza, focuses his research in the area of nonlinear dynamics. He creates novel computational methods for the analysis of piecewise-linear nonlinear dynamical systems.

They join the ranks of a number of department students who have received the Presidential Fellowship, including 16 over the past five years.

Department students win Best Paper at IEEE conference

Mechanical engineering graduate students **Jun Yu** and **Keivan Asadi** took home the award for Best Student Paper at INERTIAL 2019, the Institute of Electrical and Electronic Engineers (IEEE) Sixth International Symposium on Inertial Sensors and Systems.

The two graduate researchers, advised by Hanna Cho, submitted their work titled “Frequency and Stabilization in a MEMS Oscillator with 1:2 Internal Resonance.” MEMS—short for mechanical resonances in microelectronmechanical systems—can be used in a variety of applications, from transportation technologies to biomedical functions.



The symposium was held in Naples, Florida during April 2019. Attending representatives included industry leaders and research institutions from across the globe. The MEMS work was also recognized at the IEEE International Frequency Control Symposium & European Frequency and Time Forum. There, Yu was honored as a finalist for best paper.

RESNA selects Einstein as winner of student scientific paper competition

Graduate student **Noah Einstein** aims to innovate with a purpose toward accessibility. The mechanical engineering graduate student's scientific paper on wheelchair propulsion data was selected as one of four winning student submissions for the RESNA (Rehabilitation Engineering and Assistive Technology Society of North America) 2019 Annual Conference.

Entitled "SmartHub: Manual Wheelchair Data Extraction and Processing Device", Einstein's research focuses on extracting propulsion data from manual wheelchair users. Utilizing such data results in opportunities to reduce upper body injuries and allows users and clinicians to have a broader understanding of wheelchair utilization outside of the clinic. He is advised by Sandra Metzler.



The recognition earned the master's student the opportunity to present his paper in a conference platform section. Additionally, he received free conference registration and accommodation, a one-year RESNA student membership and the publication of his paper on the RESNA website.

American Society of Mechanical Engineers scholarship will support PhD candidate's gas turbine research



Mechanical engineering graduate student **Arif Hossain's** recognition continues for his research on innovative cooling architectures for next-generation gas turbine engines.

In addition to a Young Investigator Award bestowed in June 2018, Hossain has received the 2018-

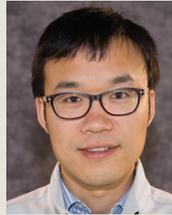
2019 Student Scholarship from American Society of Mechanical Engineers (ASME) in support of his education. The \$2000 funding was awarded by ASME's Gas Turbine Segment and its Gas Turbine Institute's Honors & Awards Program.

The innovative research project, part of Hossain's dissertation work, utilizes additive manufacturing techniques in the design and testing of gas turbine cooling methods. Hossain is advised by Professor Jeffrey Bons, director of the Turbine Aerothermodynamics Lab at the College of Engineering's Aerospace Research Center.

NEW FACULTY APPOINTMENTS



Qadeer Ahmed
Research Associate
Professor



Sheng Dong
Research Assistant
Professor



Lian Duan
Honda Endowed Associate
Professor in Aeroacoustics



**Golnazalsadat
Mirfenderesgi**
Assistant Professor of
Practice



Brian Ritchie
Assistant Professor of
Practice



Satya Seetharaman
Assistant Professor of
Practice



Jeremy Seidt
Research Associate
Professor



Stephanie Stockar
Assistant Professor



David Talbot
Assistant Professor



Punit Tulpule
Research Assistant
Professor



Zhenyu Wang
Research Assistant
Professor

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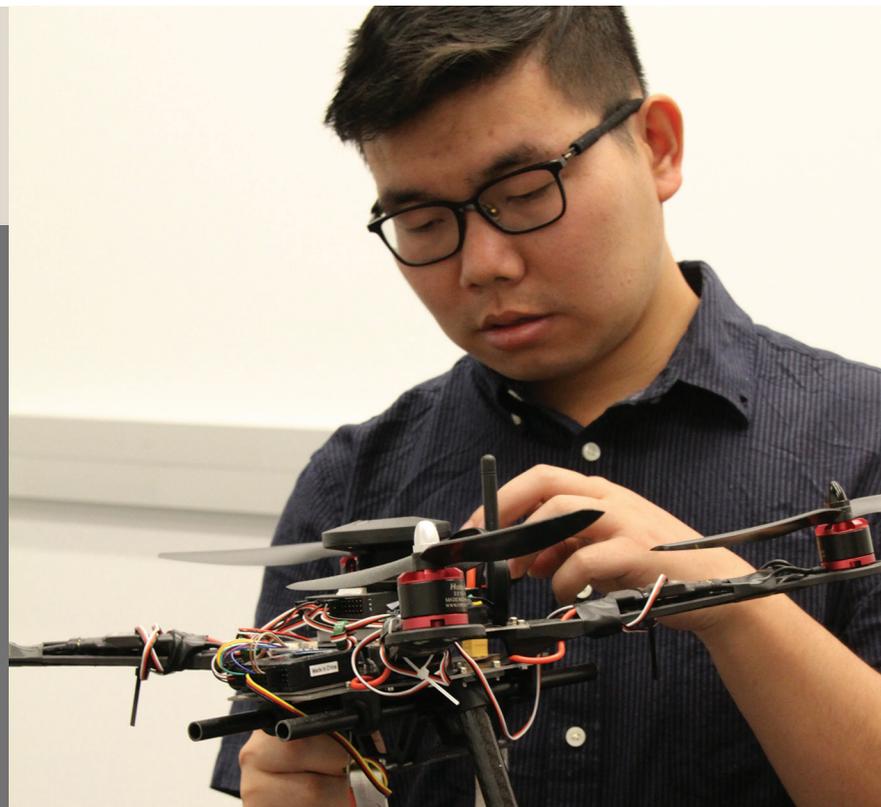
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Aerospace graduate student Changhuang Wan investigates techniques that advance understanding and applications of control and optimization methodologies in the Automation and Optimization Laboratory. Learn more about the lab's newest project on page 6.