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Welcome to this issue of the Mechanical and Aerospace Engineering Department (MAE) newsletter. We have had a great year. Enrollment in the MAE department is still at an all-time high. We continue to be the largest department in the College of Engineering and Applied Sciences (CEAS). Fully 30 percent of CEAS enrollment is in the MAE department. Our faculty research has been attracting external funding at a greater rate, and our graduates are enjoying a very high rate of employment opportunities at competitive salaries.

We welcome Dr. Jinseok Kim to our department. Dr. Kim’s expertise is in the area of computational solid mechanics (finite element method), non-local mechanics, and plate and shell theories. He comes to us from Texas A&M University, where he completed his master’s degree in civil engineering and his Ph.D. in mechanical engineering (look for more about Dr. Kim in this issue).

This fall, we completed another accreditation cycle. Each cycle is six years long. The accreditation is awarded by ABET (ABET stands for Accreditation Board for Engineering and Technology). ABET is a non-governmental organization that accredits post-secondary education programs in “applied science, computing, engineering, and engineering technology.” For those of you who are not familiar with this process, the accreditation agency requires the department to assess student educational outcomes through courses taught in each of its program. The assessment results are used to make improvements in the curriculum. These are documented and a self-study report is sent to ABET before the accreditation visit. The program evaluator reads this report and audits randomly selected transcripts of some of our program graduates to see if we comply with their requirements. A three-day visit is then conducted, where the program evaluator meets with faculty, staff, administrators, and students. For our Aerospace Engineering and Mechanical Engineering programs, this visit was done on September 17-19, 2017. At the end of this visit, we were informally told that no issues were found with either program and we expect our accreditation to continue. Next visit will be in fall 2023. Our success in this accreditation cycle was due to the role that Drs. P. Merati, J. Ari-Gur, W. Liou, J. Montefort, and the rest of our faculty and staff played.

In April 2018, Dr. Sharma will retire from the MAE department after 37 years. We appreciate his service to the department and the university and wish him a wonderful retirement. We have also initiated a search for a replacement for Dr. Sharma’s position. The faculty hired for this position will start in August 2018.

We also awarded the Alumni Excellence Award to Roger Veldman, chair of the Mechanical Engineering Department at Hope College (M.S. 1999, Ph.D. 2001).

This fall, we said farewell to our Office Administrator, Heather Martin, who is now working at the Kalamazoo Nature Center. In her place, we now have the very capable Amanda Hoger who has worked at WMU since 2010. She has experience in working at the WMU Unified Clinics and several department offices within the college. We welcome Amanda to our department. Along with Ann Mathis, our office manager, they continue to provide excellent service to our faculty, staff and students.

We hope that you will find the latest MAE news encouraging. If it’s been awhile since you visited us, please contact us and arrange to visit our department. We also would like our alumni to consider working with their companies to sponsor senior capstone projects. Working with alumni mentors on real-world design projects creates a learning environment for our seniors which is invaluable as they prepare for the working world. Previous sponsors have come from both large and small engineering firms, and have covered a wide variety of topics.

Koorosh Naghshineh, Chair, Department of Mechanical and Aerospace Engineering
Introducing Dr. Jinseok Kim

Dr. Jinseok Kim joined Western Michigan University as an assistant professor in the Department of Mechanical and Aerospace Engineering in August 2017. Kim received his master's degree (2009) in civil engineering and Ph.D. (2017) in mechanical engineering from Texas A&M University. While pursuing his master's degree, he focused on structural engineering. He then joined the Advanced Computational Mechanics Laboratory in the Department of Mechanical Engineering at Texas A&M University.

His field of study is the computational solid mechanics which involves the application of the fundamental principles of solid mechanics to the broad spectrum of engineering problems, state-of-the-art numerical modeling, and the usage of advanced computing technology. His research interests include but are not limited to solid mechanics, computational mechanics, finite element method, plate and shell theories, non-local theories, functionally graded materials, and piezoelectric materials. His current research is on developing a robust micro shell element that accounts for the size effect of micro shells, geometric nonlinearity, and functionally graded materials, and investigating the buckling and post buckling behavior of micro axisymmetric functionally graded plates under thermo-mechanical coupling loads.

He is teaching ME 2580 Dynamics in fall 2017 and spring 2018 terms and encouraging students to deepen their understanding of fundamental principles and practice their skills. His teaching interests include fundamental engineering mechanics, linear and nonlinear finite element method, plate and shell theories, and energy methods.

Kim is looking for graduate students who will engage in new research in the area of non-local mechanics, damage characterization, and/or plate and shell theories. Highly motivated and reliable graduate and accelerated program students in the Department of Mechanical and Aerospace Engineering are encouraged to contact him at jinseok.kim@wmich.edu.
Use of 3D Printing at WMU Helps Borgess Cardiologist Plug Holes in the Heart

Atrial Septal Defect (ASD) is a defect of the heart where there is a hole in the divider wall between the two upper chambers of the heart, or atria. This is a structural defect of the heart that is considered a birth defect or congenital defect. The hole or the opening allows the freshly oxygenated blood that returns to the heart from the lung to mix with deoxygenated blood returning to the heart after circulating through the body. The condition can damage the heart and lung due to excessive volume of blood circulating through the two organs, causing significant cardiovascular and pulmonary diseases. Surgical procedures may be conducted to repair the defect. An alternative approach to the open-heart surgery is through a procedure called cardiac catheterization in which a small tube with a plug device is inserted into the blood vessels and delivered to the heart to close the hole. Such a transcatheter procedure requires only a tiny incision and provides faster recovery in most cases. Cardiologists guide the delivery of the plug device using medical imaging. However, this can be quite challenging as the hole can be of different shapes and sizes and it is quite difficult to visualize other structures that the plug might compromise due to its proximity to the hole.

To enhance patient care in transcatheter ASD repair procedure, Dr. Vishal Gupta, an expert interventional cardiologist and the Medical Director of the Catheterization Laboratory at Borgess Medical Center uses advanced additive manufacturing technology. In a collaborative effort, Dr. William Liou from the Department of Mechanical and Aerospace Engineering at Western Michigan University, then transfers the patient’s heart images to a 3D printed model. Gupta uses this 3D printed patient’s heart model pre-procedure to plan the repair of the hole that best fits the patient’s own anatomy, a precision medicine approach. “This is groundbreaking and quite revolutionary because we have such complex procedures -- where making a 3D model can help us not only pre-plan the procedure but even practice an operation before it is done,” Gupta said. “This gave me that confidence and it gave me the surety that the device is going to be placed accurately where we want it to be placed.” Liou added, “3D printing technologies have uprooted engineering fields from prototyping to making functional parts on airplane engines and on spacecraft in space exploration. We are only beginning to unlock its potentials in applications like medicine.”

In addition, Liou also applied the methodologies that support the 3D printing of the heart to the development of medical engineering computational simulations. By using the anatomies derived from medical images of patients, Liou’s Computational Engineering Physics Lab is working on research to help gain a better understanding of the hemodynamics and biomechanics of the human heart and human brain.
Dr. Rick Meyer together with graduate student Yuliia Sergeeva and a Senior Design Capstone Project group have recently finished initial development of a semi-virtual reality powered wheelchair (SVRPWC) simulator. The simulator consists of an electrically powered wheelchair that sits atop a stationary drive frame, computer to generate a virtual operating environment, and interface between the wheelchair and computer that communicates joystick commands between them. Specifically, the wheelchair joystick electronics are modified to send their commands to the interface as well as receive new commands. The stationary drive frame is a portable aluminum frame with heavy rollers that the wheelchair drive wheels ride on to give the illusion of actual movement while viewing the virtual reality environment. Lastly, the computer uses a game engine to generate the virtual reality environment that is projected to the operator via virtual reality goggles. The simulator is semi-virtual reality because the vision sense is subject to virtual reality but the other senses of movement, hearing, touch, etc. are generated by the rotation of the wheelchair wheels on the stationary drive frame. The simulator is being used for the development of operator assistance technologies, such as collision avoidance and navigation assistance, in a safe environment. Further, operators with tremor from Parkinson’s disease are of special interest with tremor filtering identification and filtering already implemented. The use of a virtual environment means that new assistive ideas can be investigated rapidly; there is no need to expend the time or expense to construct a physical device. The work was made possible by a Faculty Research and Creative Activities Award from WMU’s Office of Vice President for Research.
WMU’s spacecraft design team, the Western Aerospace Launch Initiative (WALI), presented the preliminary design of its first satellite to the Air Force Research Laboratory at the 2017 Small Satellite Conference at Utah State University. The team is designing a 15 kg satellite, known as a CubeSat, to demonstrate on-orbit assessment of electric propulsion system health. The WMU Plasma Spectroscopy CubeSat is currently preparing for flight selection review in anticipation of a launch in 2019-20.

The WALI team, which includes students from aerospace, mechanical, and other engineering majors at WMU, is performing all aspects of the satellite design, fabrication, and testing process. Students are working as subsystem teams to develop the CubeSat structure, power system, attitude determination and control system, communication system, command and data handling system, and thermal control system. The WALI team is led by MAE faculty members Dr. Jennifer Hudson and Dr. Kristina Lemmer.

WMU was selected in 2016 as one of 10 universities nationwide in the Air Force Research Laboratory’s University Nanosatellite Program. Through this program, WALI members have had several opportunities to present their work to aerospace industry leaders, including at the Small Satellite Conference and an upcoming flight selection review in Albuquerque, N.M., in January 2018. For more information about the CubeSat project, please visit https://wmich.edu/engineer/wali.
Dr. Daniel Kujawski, a professor in MAE department and a founder of “Durabilika” a startup company, has been awarded $50,000 by National Science Foundation (NSF) through the national I-Corps program to develop a fatigue analysis software based on multi-scale non-destructive hardness measurements. The NSF program aims to transfer university research ideas into viable small business startups that can solve real world problems for their future customers. Principal Investigator Kujawski and Industry Mentor Steve Tokarz oversaw the young team throughout the program, ensuring focus was maintained on the future business prospect. In the Summer of 2017 the “Durabilika” team traveled to San Francisco, Calif., to experience the startup culture in the legendary Silicon Valley. Student team leads Conner Knepley (mechanical engineering) and Amruth Raj (computer science) together with Kujawski and Tokarz completed more than 110 face-to-face interviews with potential future customers during a 7-week business incubator program. The team received an award from the I-Corps faculty for its excellence in the conducted interviews. After traveling more than 15,000 miles by air and an additional 1,200 miles by road, the team transformed its research project from a highly technical research concept into a viable business that will solve customers’ problems of the future. The team is currently working on raising funds to produce a prototype of their software solution but credits the NSF I-Corps program for pushing them outside their comfort zone and truly accelerate the development of their soon to be start-up business.

Durabilika – Who We Are

Durabilika is developing a “Material Fatigue Analysis Package” that consists of a multi-scale hardness indentation test data and an advanced software algorithm. The package provides small to medium manufacturers with a streamlined solution for determining the fatigue properties of a given material. By simply measuring the surface hardness of a material, Durabilika can predict critical fatigue properties that are essential for intelligent design decisions throughout the product development process.

Research conducted at Fatigue and Fracture Laboratory has found a strong correlation between the surface hardness of a material and its critical fatigue properties. The novelty of this fatigue prediction methodology is the inclusion of multi-scale hardness testing data in the material property analysis. Looking at the material on both the macro- and micro-scale allows design engineers to account for material factors in their fatigue analysis previously unachievable.

Micro-scale hardness measurements can account for hardness distribution among grains, residual stresses, and heat treatment, thereby providing a reliable representation of the final product life. These detailed material properties increase the accuracy of early design simulation and can reduce verification testing to a few studies. These fatigue properties are essential in the design of mechanical components, allowing engineers to make data-driven decisions about the best solution for their product design. This will be achieved by focusing on the utilization of multi-scale hardness and micro-compression data to predict basic mechanical and fatigue properties of surface treated components such as gears, shafts, 3D printed components, coatings, micro foils, and bone structures.

Comments from Durabilika Student Team Members

Conner Knepley: I am a senior in the mechanical engineering program at WMU. I graduate in December 2017 and have already accepted a job as a sales engineer for Rockwell Automation! My experience as the entrepreneurial lead for the Durabilika research team during the NSF I-Corps program transformed me from a technical engineering student into a business-minded, well-rounded engineer pursuing a future career as a sales engineer. The summer experience was pivotal in my career development and granted me a clearer focus on where I want to take my engineering career.

As the entrepreneurial lead during the NSF I-Corps Program, I was responsible for leading our team through the intensive 7-week program. I was responsible for planning and executing more than 100 face-to-face customer interviews and debriefing the teaching staff on the lessons learned. Every week, I presented to a San Francisco cohort of around 75 students, mentors and entrepreneurs by updating them on the status of our business development project. The entrepreneurial experience took me across the nation and altered the way I approach my career every day. I am honored to continue my work with the Durabilika team at WMU!

Amruth Raj Hanumanthagowda: I am a graduate student in the computer science program at WMU. I am from Bangalore, India. I worked at Schneider Electric for nearly four years as UI lead before coming here. My experience as the co-entrepreneurial lead for the Durabilika research team during the NSF I-Corps program transformed me from a technical lead into a project leader who can better understand what the customer really wants and what is required in the market. The summer experience expanded my knowledge on how to talk to customers and understand what the market really wants.

As the co-entrepreneurial lead during the NSF I-Corps program, I was responsible for co-leading our team through the intensive 7-week program. I was responsible for planning and executing face-to-face customer interviews and assisting in creating the presentations for the teaching staff. I helped my team build the business model canvas and also helped the team better understand the needs of the market. This experience improved my approach in solving any technical problem. I also gained knowledge on how the management side of any project works. I believe this experience will help me in my career and am thankful to WMU and Durabilika for providing me this opportunity.
Matthew Baird’s Internship Experiences at JPL and GRC

Matthew Baird, a Ph.D. student in the Department of Mechanical and Aerospace Engineering, has received a NASA Space Technology Research Fellowship. Part of the fellowship is to participate in annual NASA experiences. This past summer, Baird had opportunities both at NASA’s Jet Propulsion Laboratory and NASA’s Glenn Research Center. Baird’s Ph.D. research focuses on electric propulsion and his work is supervised by Dr. Kristina Lemmer at the Aerospace Laboratory for Plasma Experiments. Specifically, he is researching oscillation modes in magnetically shielded Hall thrusters.

Below is a firsthand account of his experiences:

Shortly after the Spring 2017 semester ended, I flew to Pasadena, Calif., and spent three weeks working at NASA’s Jet Propulsion Laboratory with Dr. Robert Lobbia. There, I wrote a LabVIEW program for capturing hundreds of gigabytes worth of high speed data for accelerated carbon deposition testing of magnetically shielded Hall thrusters. I also simulated and constructed a wideband high-power amplifier for extended lifetime tests of the Hall Effect Rocket with Magnetic Shielding (HERMeS) hollow cathode. Additionally, I learned how to start up and operate the magnetically shielded H6 Hall thruster.

After my three weeks at the Jet Propulsion Laboratory, I drove to Cleveland, Ohio, where I spent 10 weeks at NASA’s Glenn Research Center with Dr. Wensheng Huang. I worked alongside electric propulsion scientists and engineers to prepare the 15-foot-diameter vacuum facility 5 for testing and to establish the data acquisition for capturing more than 120 individual experimental measurements. I also became familiar with the testing and operation of the NASA Next Space Technologies for Exploration Partnerships (NextSTEP) X3, a three-channel nested Hall thruster. I learned high-speed video capturing techniques used for studying the oscillatory behavior of the Hall thruster. Additionally, I used the Aerospace Laboratory for Plasma Experiments’ (ALPE) newly developed High-speed Dual Langmuir Probe system on the X3 Hall thruster to measure time-resolved plasma plume properties.

Overall, these experiences will help me with my Ph.D. research, understanding physics related to plasma oscillations inside a magnetically shielded Hall thruster. I look forward to applying my new knowledge and skills at the Aerospace Laboratory for Plasma Experiments and sharing them with my fellow lab mates.
Dr. Kristina Lemmer and Dr. Claudia Fajardo recently were awarded a $318,000 grant to be used in research in labs in the mechanical and aerospace engineering department. The award from the Defense University Research Instrumentation Program will be used to purchase equipment that will help understand complex ionization processes, combustion processes and fluid decomposition. The equipment also will be used to educate engineers and scientists in using state-of-the-art laser diagnostic and imaging equipment.

This equipment will support research in the ionization processes for alternative propellants used in electric propulsion systems in the Aerospace Laboratory for Plasma Experiments, run by Lemmer, assistant professor of aerospace engineering. The system will also provide the means to study non-thermal plasma interactions with surfaces. Additionally, Lemmer and Fajardo will use the system to study plasma-enhanced combustion, and ignition and combustion stability of lean mixtures will be studied in Fajardo’s Combustion and Flow Research Laboratory.

The National Science Foundation has awarded a grant expected to total $111,834 to Western Michigan University. This project is through the EAGER program, Early-Concept Grants for Exploratory Research, at NSF and is titled “Collaborative Research: Science-Based Exploration of Invariant Signatures of Architecture, Engineering, Construction Objects to Enable Interoperability of Building Info Modeling.” It will function under the direction of Dr. Xiaoyun Shao, associate professor of civil and construction engineering, and Dr. Pnina Ari-Gur, professor of mechanical and aerospace engineering.

In August 2017, Professor Tianshu Liu gave a keynote lecture entitled “Skin Friction Structures Extracted from Surface Pressure Gradient Fields – Extended Application of PSP” at the 6th Germany-Japanese Joint Seminar in Stuttgart, Germany. The conference was organized by the German Space Center and Japanese Aerospace Exploration Agency. The meeting focused on the latest development of optical measurement techniques in aerodynamics supported by both the German and Japanese governments.

After the meeting, Liu visited the German Aerospace Center located in Gottingen, giving a talk on hypersonic heat transfer measurements and discussing with the center’s scientists various topics in aerodynamics. He also visited the German-Dutch Wind Tunnels located in Gottingen and toured their hypersonic facilities, aeroacoustic wind tunnel and transonic wind tunnel.
Faculty Sabbaticals

Sabbatical leaves are intended to promote the professional growth of the faculty and to enhance their scholarly and teaching effectiveness. Such leaves must be used only for specific planned activities involving study, research, scholarship, or creative work of mutual benefit to the faculty member and the university. WMU tenured faculty members with six years of service at Western Michigan University who have not had a sabbatical leave for a period of at least six years are eligible. A faculty member may apply for either a two-semester or a one-semester leave. During the 2017-2018 academic year, the following faculty from the Department of Mechanical and Aerospace Engineering were granted sabbatical leave:

Dr. Pnina Ari-Gur is spending her sabbatical leave in fall 2017 in the Surgical Technologies Lab at the Centre for Hip Health and Mobility of the University of British Columbia, in Vancouver, Canada. Collaborating with teams of engineers and surgeons, she is bringing in her medical materials expertise to the group. Her major focus is on the study of trauma bone repair by using ‘nano-gel’ that enhances bone growth and repair. There is a great demand for a good solution for bone repair and research groups around the globe are working toward finding a successful approach. Ari-Gur’s project is based on her experience with a collaborative dental project with scientists from the Russian Academy of Sciences. At the University of British Columbia, the collaboration with interdisciplinary teams of clinicians, surgeons and engineers has been beneficial for her research, where the material’s performance needed is highly demanding, requiring biocompatibility (mechanical, chemical, and biological) as well as strength under dynamic loads. She plans on submitting a proposal to the National Institutes of Health later in 2018. Ari-Gur, who has conducted her post-doctoral research at the University of British Columbia, enjoys being back at this premier institution for her sabbatical and hopes to maintain the collaboration for years to come.

Dr. Judah Ari-Gur is on a sabbatical leave during the Fall semester 2017. In the early 1980s he did his post-doc at the University of British Columbia, in Vancouver, Canada. Now, for what is, in his words “my last sabbatical leave,” he chose to return to Vancouver, where he is doing research on the dynamic response of a shallow pyramidal frustum shell under external pressure pulse. Dr. Ari-Gur is using the ANSYS finite element analysis package for this study. The structure is symmetric and a quarter image of it is presented in the Figure. The thin-walled pyramid is significantly stiffer than the equivalent flat plate, but features a much more complex structural behavior due to the presence of interactions between the flat segments, the occurrence of compressive stresses, and potential buckling and snap-through. There is a vast opportunity for extended and interesting research on this type of structure. Ari-Gur will present this research work in a seminar in the Spring semester and will outline the potential for further studies.

Dr. Claudia Fajardo-Hansford will be taking a one-year sabbatical starting in January 2018. Dr. Fajardo-Hansford’s research primarily will focus on turbulence and combustion. Topics include developing strategies to enhance ignition and combustion efficiency and stability, and exploring novel techniques to more accurately characterize turbulence in bounded flows. These research topics are relevant to power generation, ground and air propulsion for both transportation and military applications. Also during her sabbatical leave, Dr. Fajardo-Hansford will seek collaborative research opportunities with the National Research Energy Laboratory and continue to oversee WMU’s Center for Advanced Vehicle Design and Simulation.
Most faculty members hold terminal degrees in mechanical engineering or closely related fields. Their areas of research include but are not limited to mechanical system, structural dynamics, system design and controls, advanced materials, experimental stress analysis, vehicle dynamics, electric propulsion, experimental and computational fluid dynamics, thermal and power systems, fuel cells, noise and vibrations, finite element analysis, and micro and nano-technology.

Koorosh Naghshineh, P.E. (Chair)
Ph.D., Mechanical Engineering, Pennsylvania State University
Areas of expertise: acoustics, structural vibrations, noise and vibration control
Phone: 269-276-3292

ME Graduate Programs Director
Muralidhar K. Ghantasala
Ph. D., Instrumentation Engineering, Indian Institute of Science, Bangalore, India.
Areas of expertise: micro/nano sensors and actuators, micro/nano fabrication technologies, high efficiency hybrid micro actuators

AE Graduate Program Director
Peter Gustafson
Ph. D., Aerospace Engineering, University of Michigan.
Areas of expertise: composite materials, finite element modeling, orthopaedic biomechanics

Other Faculty
Judah Ari-Gur
D.Sc., Aeronautical Engineering, Technion (Israel)
Areas of expertise: structural dynamics, blast response of shells, structural stability, composite material structures, finite-element modeling

Pnina Ari-Gur
D.Sc., Materials Engineering, Technion (Israel)
Areas of expertise: nano-structured materials development and characterization, smart materials, bio-materials, virtual reality laboratory, x-ray and neutron scattering and electron microscopy

Christopher Cho, P.E.
Ph.D., Mechanical Engineering, State University of New York at Stony Brook
Areas of expertise: heat transfer, two-phase flow, thermal-fluid measurement

Claudia Fajardo
Ph.D., Mechanical Engineering, University of Michigan
Areas of expertise: Experimental fluid mechanics and combustion, optical diagnostics, internal combustion engines

Jennifer Hudson
Ph. D., Aerospace Engineering, University of Michigan
Areas of expertise: space flight dynamics and control, orbital mechanics, optimal control theory

Daniel Kujawski
D.Sc., Mechanics of Solids, Warsaw University of Technology;
Ph.D., Mechanics of Solids, Polish Academy of Sciences
Areas of expertise: fatigue and fracture, life prediction, and mechanical testing

Jinseok Kim
Ph. D., Mechanical Engineering, Texas A&M University;
Areas of expertise: solid mechanics, computational mechanics, finite element method, plate and shell theories, non-local theories, functionally graded materials, and piezoelectric materials

Ho Sung Lee
Ph. D., Mechanical Engineering, University of Michigan
Areas of expertise: heat transfer, thermal design, boiling in microgravity, and engine cooling systems

Kristina Lemmer
Ph. D., Aerospace Engineering, University of Michigan
Areas of expertise: plasma diagnostic development, optical erosion spectroscopy, experimental plasma discharges and hypersonic plasma interactions

William W. Liou
Ph.D., Aerospace Engineering, Pennsylvania State University
Areas of expertise: continuum and discrete fluid flow computation, multi-physics engineering simulation, microfluid flow, transition and turbulence, aerodynamics, propulsion

Tianshu Liu
Ph.D., Aeronautics and Astronautics, Purdue University
Areas of expertise: experimental aerodynamics, applied aerodynamics, fluid mechanics, heat transfer

Parviz Merati, P.E.
Ph.D., Theoretical and Applied Mechanics, University of Illinois at Urbana-Champaign
Areas of expertise: experimental and computational fluid mechanics and heat transfer, compressible fluid flow, tribology

Richard T. Meyer, P.E.
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Kapseong Ro
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Areas of expertise: aircraft flight dynamics and control, flight simulation, unmanned aerial vehicle

Rameshwar Sharma
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Areas of expertise: system design, development, modeling, and simulation, internal combustion engines, and environmental systems

Bade Shrestha, P.E.
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Areas of expertise: alternative fuel combustion, advance internal combustion engines, fuel cells, and renewable and sustainable energy development