UNIVERSITY OF FLORIDA

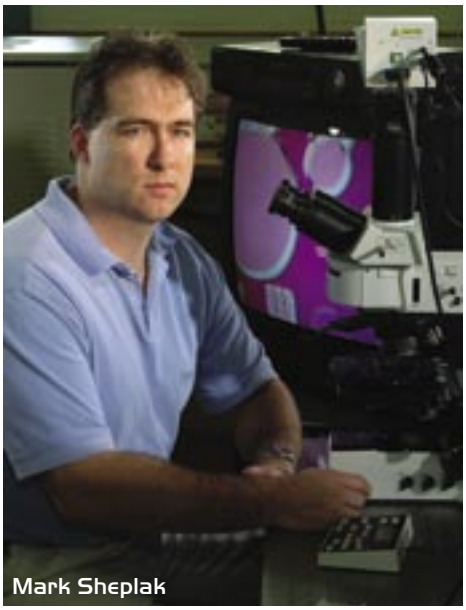
Spring 2005

MECHANICAL & AEROSPACE ENGINEERING

Synergy is Sound Science:

ROBOTICS and MEMS Lead the Way

The College of Engineering's foresightful combination of specifically related research laboratories is creating synergistic collaborations which show promise for influencing the future by developing new techniques and technologies. MAE has figured prominently in these collaborative efforts with the MEMS and the CIMAR laboratories striding boldly forward.



Mark Sheplak

Photo by Kristen Bartlett
David Armstrong (passenger)

MEMS: Probing Beyond Human Senses

Micro- and nanoscale sensors is a burgeoning field of research, in which the MAE is deeply involved. One research group which has banded together to further this area is the Interdisiplinary Microsystems Group (IMG) which focuses on the design and analysis of micro-electromechanical systems (MEMS). MEMS are an extension of microelectronics technology, which incorporates mechanical, optical, fluidic, acoustical, and biological systems using semiconductor processing technology. IMG researchers include MAE professors Mark Sheplak, Lou Cattafesta, and Hugh Fan, as well as Electrical and Computer Engineering (ECE) professors Huikai Xie and Toshikazu Nishida. These

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ROBOTICS: Futuristic Intelligent Machinery

MAE is deeply involved in intelligent machinery. Our existing laboratory, the Center for Intelligent Machinery (CIMAR) is synergistically collaborating with a number of researchers in the area of robotics.

MAE's Professor Carl Crane and Engineer David Armstrong and Nuclear and Radiological Engineering professors Dean Schoenfeld and James Tulenko are co-investigators within the University Research Program in Robotics (URPR). The URPR is an integrated consortium of universities, which when combined can provide capabilities to provide broad-based robotics and automation solutions to many difficult Department of Energy (US DOE) National Nuclear Security Administration (NNSA) problems. While each URPR participant has a major thrust area, they also work together in many areas to take advantage of particular areas of expertise, which can assist other participants in achieving high-impact products.

Conjointly with this research project, CIMAR is collaborating with the Machine Intelligence Laboratory (MIL) of the Electrical and Computer Engineering department professors Antonio Arroyo and Eric Schwartz. This collaborative effort's goal is to become the leading center for interdisciplinary basic and applied research related to the many aspects of robotics — mechanisms, autonomous vehicles, and intelligent machines. Some of the research includes development of the technologies and systems to provide 21st

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GERC to become REEF


John Rogacki

Basking in the emerald waters of the Gulf Coast, the College of Engineering (CoE)'s Graduate Engineering Research Center (GERC) hopes to change its name to "REEF" in an effort to initiate a new strategic direction and to associate itself with a beautiful location. The center is expected to be renamed the "University of Florida Emerald Coast Research and Engineering Education Facility (REEF)".

The CoE-operated graduate school adjacent to Eglin Air Force Base is near Fort Walton Beach, Florida. Located about 15 minutes from Gulf Coast beaches, the REEF occupies a 45,000 square foot facility consisting of classrooms, offices and laboratories on a 119-acre campus leased from the Air Force. The REEF has a very close working relationship with Eglin Air Force Base and related industrial and commercial aerospace partners in the area.

Dr. John ("Row") Rogacki, formerly of NASA and the Air Force Research Lab, became an MAE faculty when he assumed directorship of the REEF in August 2004. "What we offer is UF's strong university reputation in an incredible location with a small campus atmosphere, engaging with high level technical leaders at Eglin AFB," Rogacki said.

Rogacki comes to the UF with years of experience at NASA leading such programs as the Space Launch Initiative, and Integrated High Payoff Rocket Propulsion Technology, in support of the President's vision for space exploration.

Many of the GERC/REEF's graduates have risen to leadership positions in the Air Force. Ongoing research involves laboratory studies of short duration events, like impact of projectiles and shock waves using the diagnostic tools necessary to measure what goes on during those events such as lasers and high-speed imaging cameras. The REEF offers Masters, Ph.D., and Certificate level programs with an emphasis on:

- Agile autonomous flight
- Micro-air vehicles
- Computational mechanics
- Probabilistic optimization
- Microwave photonics
- Systems Engineering
- Application of electromagnetic fields

The REEF has recently benefited from nearly $2 million in grants from the Air Force Office of Scientific Research. The grants will help the University of Florida increase its research capabilities in vision-based control, rapid prototyping, aerodynamic characterization and hardware-in-the-loop simulation. Currently, the REEF has about 100 graduate students in three departments (Mechanical and Aerospace Engineering, Electrical and Computer Engineering, and Industrial and Systems Engineering). For more information visit the REEF website: http://www.gerc.eng.ufl.edu

Chairman's Corner

The merger of the former Aerospace Engineering, Mechanics and Engineering Science (AeMES) and Mechanical Engineering (ME) departments into the Mechanical and Aerospace Engineering (MAE) Department continues to thrive. One of the principal architects of this successful venture, Dr. Wei Shyy, who served as the Chair of MAE since the merger in 2002, was successfully recruited by the University of Michigan to chair its nationally prominent program in Aerospace Engineering. We are sorry to see him depart but he leaves behind a robust department of 49 current faculty, 32 visiting faculty and postdoctoral associates, and 23 staff serving nearly 1,100 undergraduate majors and 275 graduate students this year. The faculty that Wei recruited over his tenure as chair first in AeMES and later in MAE are dedicated and energetic generating over $12M in sponsored research last fiscal year and on target to modestly increase that base this year.

Since January 1, I have had the privilege of serving as Interim Chair of the department and will continue in this role while the national search for the new Chair is actively underway. As a member of the faculty since 1967, I have watched the evolution of the department into national recognition. The recently released national rankings of the doctoral programs by *US News and World Report* show our Aerospace and Mechanical programs rated as 14th and 17th respectively. Rankings of the undergraduate programs will appear later this year -- this is a department with two strong programs in which you can be very proud.

MAE is currently searching to fill two or three vacant faculty positions with several strong candidates. In the next issue of the Newsletter we will bring you up-to-date on those hires.

In other articles in this Newsletter focusing on department activities you will see the progress on planning for a new MAE building, highlights of the successes of the student groups and individual faculty recognitions. These are exciting times for the department and we are pleased to be able to share some of the stories with you.

Dr. Gene Hemp
Professor Emeritus and Vice Provost Emeritus
Interim Chair

Long Life through Nanocoatings

New nanocomposite coatings to keep space vehicle hardware working longer and better is the focus of a UF-led multi-institution research project funded by the US Dept. of Defense. The goal of the $2.5 million, five-year project is to develop solid lubricant coatings for the exposed bearing surfaces in spacecraft and satellites.

The project is the Multidisciplinary University Research Initiative (MURI) for Multifunctional Nanocomposites for Air and Space Tribology. (Tribology is the study of friction, wear, and lubrication.) Participants include engineers and scientists from UF, Rensselaer Polytechnic Institute, and the Air Force Research Laboratory.

The research team will seek multifunctional coatings that can respond and perform as they encounter the changing environments of earth, launch and orbit. The goal is to create materials that can reduce wear by 1,000 times or more over the existing coatings and retain low friction coefficient. The lubricants will combine multi-walled carbon nanotubes, polymer nanocomposites, and nanoceramics.

Sawyer's tribology team will develop polymeric nanocomposites, do extensive testing with these new materials, and try to predict coating life from the data gathered. Sawyer has an extensive tribology laboratory where his team tests materials at the macro-, micro- and nanoscale, in both inert and vacuum environments.

The collaborative group is looking for intelligent coatings that can sense their surroundings and respond to changing environmental cues to provide lubricants when needed. Smart coatings do exist, Sawyer says. They consist of mixed materials of sizes less than 100 nanometers. The lubricants are encapsulated and emerge when they are activated by the environment.

A third team, led by UF Materials Sciences and Engineering which includes MAE's John Zeigert will do simulations to predict how different environments will affect the life span of new materials, particularly in changing conditions.

But no one coating will be the ideal coating for all applications -- "the silver bullet," Sawyer points out. Different circumstances demand different lubricant systems. In some cases, coatings must provide low friction. In another, wear debris must be avoided. In yet another, the coating must be conductive. Coatings have finite lifetimes due to the wear they experience, so the ability to project their potential durability is also important.

Sawyer believes the group will successfully add a few more coatings and tribological approaches to the state-of-the-art. The coatings will be made of new materials that the researchers hope will function in both space and terrestrial environments.

The MURI was funded in Spring 2004, but Sawyer's research in the area began in 2001 when NSF granted $96,000 to look at the tribology of polymer nanocomposites. NSF followed up with another $200,000 to continue the research in 2002.

Sawyer's earlier research had significant results. Sawyer and Ph.D. student David Burris created a polymer nanocomposite solid lubricant they call "Material X" that can function in a vacuum, is biocompatible, has a low friction coefficient, and is not sensitive to the environment.

Material X is more lubricious than Teflon™, a common solid lubricant polymer that is actually soft and easily worn. Tests done in Sawyer's tribology lab have verified that a component coated with Material X could last nearly a million times longer than one coated with Teflon™. The improved wear resistance and low coefficient friction of the is nanocomposite would be especially valuable in solving the tribology problems of rotating pin points in satellites. Material X is currently being patented by the University of Florida and will be available soon for commercialization.

Writer: Martha Dobson, mwdobson@ufl.edu

Planning for the New MAE Building

This drawing shows the new MAE building with a footprint of 130,000 GSF. It is situated west of Rhines Hall, where the current MAE-C building is located.

The College of Engineering has designated the new MAE building as its only new building (thus, the "bricks and mortar") goal destined in the recently announced seven-year capital campaign, to raise approximately $1.2B (without state matching). Of that goal and challenge is $15M to be raised for the construction of the new MAE building.

Talk of the new building surfaced in 2003 with the merger of the former departments of Mechanical Engineering (ME) and Aerospace Engineering, Mechanics and Engineering Science (AeMES). At that time, it was theorized that it would the year 2007-2008 before the department could raise enough private dollars in matching funds for the project's priority to be raised so as to qualify for state Public Education Capital Outlay (PECO) funds.

The MAE and College of Engineering goal was approved by UF President Bernie Machen and the Interim Provost, Joseph Glover. Their approval will give MAE's building plans and activities major visibility and will help to raise the necessary funds. Interim MAE Chairman, Prof. Gene Hemp, described this effort as quite a challenge. "It means we have a lot of work ahead as a department. It is like preparing and selling a $15M proposal to several funding agencies," Hemp described.

Working with UF's Construction Management, Hemp is busy moving the building program on to the next stage. As part of the building planning, Hemp is gathering the name and descriptions of each lab as well as their current and projected sizes. "At this time we only have designated so many net academic square feet (NASF) for office, lab, classroom etc.," Hemp said. "Now we need to say how many offices and labs and their sizes. This exercise will also dictate the final size of the project with current estimates at 130K of gross square feet (GSF) and about 90K NASF, with a total cost of about $50 million," he explained.

MEMS: Probing Beyond Human Senses

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researchers in turn collaborate with scientists at the UF McKnight Brain Institute. Sheplak and Cattafesta's laboratory and offices have been co-located to Benton Hall adjacent to Xie and Nishida's laboratory.

Xie's research goal is developing portable inexpensive biomedical imaging instruments for real-time health monitoring and in vivo diagnosis of diseases such as cancer. Fan's work focuses on developing microfluidics and bioMEMS technologies for chemical analysis and biological applications, including genomics and poteomics. Fan is designing and fabricating a device for 2-dimensional protein separations that can search for biomarkers of traumatic brain injury. Nishida is working on the application of MEMS neural probes for facilitating brain-machine interfaces to ultimately address neurological diseases.

Sheplak's work focuses on high speed civilian aircraft noise localization and abatement by investigating electrostatic transducers and with collaborators on robust algorithms for beam-forming, digital signal processing hardware, and interface circuits. Energy harvesting technology via MEMS is an area Cattafesta is investigating. The benefits of energy harvesting technology could include self-powered sensors for structural health monitoring. Cattafesta and Sheplak and MAE Prof. Bruce Carroll are building an anechoic wind chamber to characterize, understand, and control aerodynamic flow for applications in the air as well as underwater.

Faculty Awards & Honors

Bruce Carroll received the Advising Award from the College of Engineering.

Tony Schmitz was awarded the 2005 Robert A. Dougherty Outstanding Young Manufacturing Engineer Award from the Society of Manufacturing Engineers. Schmitz was nominated by MAE Professor John Ziegert.

An **MAE team** won the 2004 Best Paper award from the American Society of Mechanical Engineers *Journal of Tribology*, for their article: "Wear Rate Uncertainty Analysis"(by T. Schmitz, J. Action, D. Burris, J. Ziegert, and W.G. Sawyer).

S.A. Banks and **W.A. Hodge** teamed up to win the Hap Paul Award from the International Society for Technology in Arthroplasty for their work "Design and Activity Dependence of Kinematics in Fixed and Mobile Bearing Knee Arthroplasties".

Mark Sheplak has been elected to Associate Fellow rank in the American Institute of Aeronautics and Astronautics (AIAA).

Bhavani Sankar and **John Ziegert** were named as MAE's Ebaugh Professors. Their five-year appointments began October 2004.

Greg Sawyer received the Burt L. Newkirk Award from the American Society of Mechanical Engineers.

U.S. President George W. Bush reappointed MAE Professor and UF Vice President **Win Phillips** to the Committee on the National Medal of Science.

UF Vice President and MAE Professor **Win Phillips** was also named to Florida Trend's "2005 CEO to Watch" list.

MAE will share in part of the **Arnold J. "Red" Morway** endowment in support of master's level and undergraduate scholarships.

Jake Stoval and Jake Bryan (L-R) of the MAE's ASME Student Chapter contemplate the ongoing and continuous research and design of the human powered vehicle.

ASME Student Chapter Competed

Jacksonville was the site of the April 7-9 American Society of Mechanical Engineers (ASME) annual Southeast Region Student Conference (which includes universities from Florida to Tennessee). UF's strong MAE undergraduate program was represented with up to 20 students competing – and brought home victories in two of the competitions.

Engineers must possess a well-developed ability to communicate, both orally and in writing. All of the competitions encompassed this essential skill. The competitions included:

- Oral Presentation–Designed to emphasize the value of an ability to deliver oral presentations. The topic was to be related to a technical, economic, or environmental aspect of engineering or any other basic engineering theme. Murray Fisher of the UF's MAE won 5th place in this competition.
- Technical Poster--Designed to emphasize the ability to deliver visual presentations. Subject matter was to be related to some area in the field of mechanical engineering. Each student member submitting a poster received his/her first year's dues, compliments of the ASME Old Guard.
- Design Problem--Students were challenged to design a small transporter that could be guided by one person and could deliver moderate amounts of granular materials up stairs or over hills and rough terrains.
- Technical Web Design--Intended to encourage the delivery of visual presentations using Web Page technology.

ASME Student Chapter Wins "Most Improved"

MAE'S student ASME chapter won the "Most Improved Society Award" on April 5 for the time period of August 2004-March 2005. The award accounts for increases in membership, society programs and officer activity. The increase in society programs includes general body meetings, tours and informational sessions.

"This year we went through a major transformation," said Ryan Jones, chairman of the student society. "Our website was completely overhauled, we added six additional officer positions, we remodeled the student lounge to include a sofa and rocking chairs, we increased our general body meetings by two times that of last year's, and we've encouraged twice as many people to attend our Regional Student Conference as last year," he explained.

Jones estimates that next year's programs will be even better. "Our goal is for ASME to not only be a society for professional improvement for mechanical engineering students, but for social improvement as well," Jones stated.

UF Hosted AIAA Student Conference

Tristan Goldbach is mounting a longeron onto a fuselage

UF's student chapter of the American Institute of Aeronautics and Astronautics (AIAA) hosted the Southeast Region II Student Conference April 4-5, at the Hilton Hotel and Conference Center in Gainesville. The conference invited some 20 student chapters and all of the at-large members from the southeastern region which includes universities from Tennessee to Florida. More than 200 students were expected to attend. The AIAA is the world's largest professional society devoted to the progress of engineering and science in aviation, space, and defense.

"The Student Conference was an opportunity for students of all levels to share their research and design projects with the entire southeastern region," said UF AIAA student chapter president Chris Rodriguez.

Rodriguez was excited about hosting the conference, interacting with professionals and representing MAE. "We've had the opportunity to experience unique leadership positions as students," he reflected.

UF MAE's Amanda Roderick won 3rd place in the Graduate Student division for her entry "Integrating Optic Flow Techniques with Waypoint Navigation for Reactive Control Purposes".

UF MAE's students made seven presentations, including:

- Integrating Optic Flow Techniques with Waypoint Navigation for Reactive Control Purposes. (Amanda Roderick)
- Analysis of a Passive Interface Platform Design for Autonomous Rendezvous and Docking (Frederick Leve)
- Camera Independent Visual Servo Tracking of Unmanned Air Vehicle/Smart-Munitions (Siddhartha Mehta)
- Design of an Unmanned Aerial Vehicle (Tristan Goldbach, Sean Bell, Jonathan Koren, Christopher Rodriguez)
- CubeSat Design: Inflate-A-Brake (Thomas Cowan, Jim VanPelt)
- On the Dynamics of Drifting - Understanding the Effect of Sideslip on Road Vehicle Performance (Mujahid Abdulrahim)
- Development of a Micro Aerial and Terrestrial Surveillance Platform (Frank Boria)

(L-R) Doug Jones and Tim Bernhard conducting a lift test, using a bag skirt

Hovercraft Aiming to Compete

MAE's air cushion vehicle (ACV) is aiming to compete in The Hover Club of America's "Hover Rally 2005" competition in Chillicothe, Ohio, June 24. Hovercraft races are run on a land/water track which typically includes a mix of tight turns and fast straight sections. This action-packed sport is brand new for MAE, as the craft is still being built. Doug Jones, president of the ACV team, said the main portion of the hull is completed, the lift engine is in place and the rear engine is running.

"We're using a 500cc air cooled motorcycle engine for thrust and a 12 1/2 hp Briggs & Stratton lawnmower engine for lift," Jones said.

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century land forces with a family of highly mobile, multi-mission, unmanned ground vehicles to achieve a "leap ahead" capability.

This collaboration provides a synergistic environment dedicated to the study and development of intelligent, autonomous robots. The faculty and students associated with the laboratories conduct research in the theory and realization of machine intelligence covering topics such as machine learning, real-time computer vision, statistical modeling, robot kinematics, autonomous vehicles, tele-operation and human interfaces, robot and nonlinear control, computational intelligence, neural networks, hidden Markov models, and general robotics. Applications of research include Micro-Air Vehicles (MAVs), direct brain-machine interfaces (BMIs), underwater unmanned vehicles, humanoid robots, autonomous land vehicles, swarm robots, and autonomous household robots.

Arroyo and Schwartz's offices and laboratory have been co-located to the MAE-B building, adjacent to Crane's CIMAR laboratory.

Staff Awards and Honors

Shirley Robinson was awarded the UF's 25-Year Continuous Service pin

Pamela Simon was awarded the UF's Five-Year Continuous Service pin.

Student Awards and Honors

MAE doctoral student **Nitin Goel** earned the American Society of Mechanical Engineer's (ASME) Solar Energy Division Graduate Student Best Paper award for "A Compact Falling Film Absorber."

Christopher Rodriguez turning an end-fairing for the aircraft payload.

MAV Team Korea Bound

In late May, the UF Micro Air Vehicle (MAV) team of at least 12 students and faculty supervisors will travel to Seoul, South Korea to compete in the 9th International MAV Competition. The UF MAV team has won the last six international competitions becoming known worldwide as a leader in MAV technology. The competition consists of four separate categories: Surveillance, Endurance, Ornithopter, and Design Report. In the surveillance mission, teams must navigate to a target located 600m from the launch site and obtain a clear image of the target with the smallest possible aircraft. UF is the record holder by completing the mission with a 5.25 inch aircraft. In the endurance mission, the objective is to maintain flight with the smallest aircraft for as long as possible. UF holds the record in this category with a 4.5 inch aircraft which flew for 14:54 minutes. The ornithoper mission is a relatively new addition to the competition, and is aimed at promoting the advancement of low Reynolds number unsteady-state aerodynamics. Ornithopters are aircraft that flap their wings to provide both lift and thrust, unlike conventional aircraft.


Jim Klausner

New Desalination Technology Taps Waste Heat from Power Plants

Desalination is one solution to the world's water woes, but current plants tend to hog energy. MAE Professor James Klausner has developed a technology that taps waste heat from electrical power plants as its main source of energy, an advance that could significantly reduce the cost of desalination in some parts of the world.

"In the future, we have to go to desalination, because the freshwater supply barely meets the demands of our growing population," Klausner said, whose $200K research was funded by the U.S. Dept. of Energy. "We think this technology could run off of excess heat from utility plants producing millions of gallons each day," he said. Klausner co-invented the technology with fellow UF MAE professor Renwei Mei.

Some 7,500 desalination plants operate worldwide, with two-thirds of them in the Middle East, where there often is no other alternative for fresh water, Klausner said. The technology is less common in North America, with plants located mostly in Florida and the Caribbean producing only about 12% of the world's total volume of desalinated water, he said.

Most commercial desalination plants now use either distillation or reverse osmosis, Klausner said. Distillation involves boiling and evaporating salt water and then condensing the vapor to produce fresh water. In reverse osmosis, high pressure pumps force salt water through fine filters that trap and remove waterborne salts and minerals.

Employing a major modification to distillation, Klausner's technology relies on a physical process known as mass diffusion to evaporate salt water. Calculations show that a 100-megawatt power plant has the potential to produce 1.5 million gallons daily. The cost is projected at $2.50 per thousand gallons, compared with $10 per thousand gallons for conventional distillation and $3 per thousand gallons for reverse osmosis.

Writer: Aaron Hoover, ahoover@ufl.edu

"Strain Sensitive" Paint Highlights Flaws on Car and Plane Parts


Paul Hubner

Using luminescent paint to highlight weaknesses and flaws in prototype drive shafts, axles and numerous other parts, MAE researchers Paul Hubner and Peter Ifju have found a technique to make car and plane parts safer, less expensive and longer-lasting.

A key step in designing parts is building and testing prototypes to discover flaws or problems before a part is mass produced. These tests determine how much stress or strain the part sustains. Stress is a measure of force intensity, or force per unit of area, while strain measures deformation, or movement.

A number of stress measurement techniques have shortcomings which raise the potential for designers to miss "hot spots" or locations on the part that appear normal to the eye and to computer-aided designs, but which experiences significant and potentially failure-level stress.

"Manufacturers don't want the part to fail two years down the road," said MAE's Paul Hubner. "The flip side is that they don't want to overdesign and put too much reinforcement into it, because if they build a million parts, it'll cost them more than it should have."

UF's "strain-sensitive" coating gives designers a way to accurately measure these stresses, that not only highlights potential flaws in a prototype, but also helps designers refine their computer models.

Resembling a glossy reddish paint, the coating is a potent mixture of light-emitting dyes and epoxies developed by UF chemistry professor Kirk Schanze and others in his lab. Once sprayed on, dried, and viewed under a blue or ultraviolet light, the light-emitting chemicals transmit polarization differences to a digital camera and computer. The result is a graphic, 3-D map of the stress levels sustained over the entire coating. The system can provide a nearly complete picture to designers in about three days, while it takes a month for other techniques, Hubner said. The result is that parts can be designed and built more quickly, translating into cost savings, Hubner explained. It may also make parts more durable, reducing the number of failures and recalls.

Writer: Aaron Hoover, ahoover@ufl.edu

MAE graduate student Donald MacArthur flies his radio-controlled helicopter for some of the 90 Alachua County elementary and middle school students who learned about aerospace engineering during a visit to the MAE department on March 24. Prof. John Schueller (with clipboard) observes with interest!

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