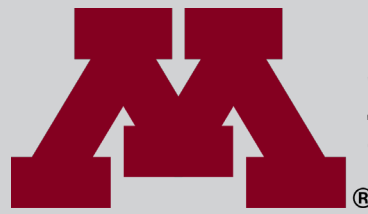DEPARTMENT OF
AEROSPACE
ENGINEERING AND MECHANICS

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Department Update - Summer 2017

From the desk of the Department Head

It's summer in Minnesota, which for faculty means an opportunity to focus on our research endeavors. Before we begin to prepare for the next academic year, I want to congratulate AEM's graduating class of 2017. These graduates have proven to be a very talented and motivated group, and we wish them the best of luck as they continue to flourish in their careers and graduate programs.

The end of the 2016-2017 academic year also marked an important transition in the Department, as Professor Bill Garrard retired after forty-nine plus years of research, teaching, and service. Bill has been extraordinarily important to the growth of the Department through his time as Associate Head and Head. He hired or helped to hire many of us, and has been mentor, colleague, and friend to all of us.

While Bill will be greatly missed, he has left the department in great shape. For example, he has been an important factor in fostering student projects. This spring, two of our senior design teams were invited to present their work at design competitions, the RASC-AL Forum and the Society of Automotive Engineers Aero Design West Competition. More, a group of freshman students began their undergraduate education with a bang by taking on the considerable task of designing, building, and flying CubeSat models. These are but two examples of the hands-on student work that is becoming increasingly common in the College and Department, and we are proud of the hard work students (and faculty) put into these projects.

A huge part of what makes these projects successful is the support of all of our alumni and friends. Gifts of money and time not only help us support student projects, but they also help us provide scholarships and fellowships to our undergraduate and graduate students, and allow us to support high quality, innovative research from our faculty and students. I personally want to thank all our donors, friends, and alumni for your commitment to the AEM Department. We are truly honored and grateful to receive your support.

Perry Leo
Department Head

What's Inside...

College of Science and Engineering
Department of Aerospace Engineering and Mechanics
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AEM UPDATE 1

From the Development Office:

The Department of Aerospace Engineering and Mechanics thanks the many generous alumni, faculty, companies, and friends for their donations and commitment to support the department and our students. This list includes gifts received FY 17 fiscal year-to-date (July 1, 2016 - June 1, 2017). These gifts help to enhance our academic program and provide opportunities for our undergraduate and graduate students. We are so grateful for your support.

Summer is a lively time on campus. Although most of our undergrads are gone until classes start in the fall, campus is still bustling with graduate students, and large groups of soon-to-be students (and their parents) preparing to launch their college careers. And of course, our hard-working faculty and staff who continue the research and work that makes the AEM Department and college great.

We are thankful to the many alumni, friends, and companies who have given so generously to the Department of Aerospace Engineering and Mechanics this fiscal year! These annual gifts are instrumental in supporting our students, faculty, and our academic programs. Your gifts help us continue to attract and admit the most talented students into our program.

With the continued decrease in state support for the University, the need for private support has never been greater. Support from our alumni, faculty, staff, and friends ensures that we will continue shaping the future in fields from aircraft and spacecraft design, research, and development, to biomedical and computer engineering, and academia, thanks to the education they receive in the Department of Aerospace Engineering and Mechanics.

Join us in training the next generation of engineers by supporting the Department of Aerospace Engineering and Mechanics. Your gift will make a difference.

Kathy Peters-Martell
Sr. Development Officer
College of Science and Engineering

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Cont. Page 3

This listing includes all donations to the AEM department received by June 1, 2017. For more information on giving or alumni involvement, please visit our web page at www.aem.umn.edu/alumni, or contact Kathy Peters-Martell at kpeters@umn.edu or 612-626-8282 in the College of Science and Engineering Dean's Office.
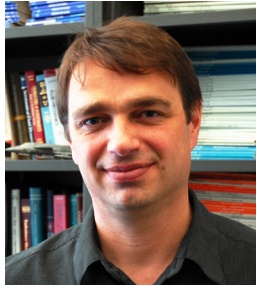
Graham Candler receives Dryden Lecture Award

This Spring, AEM Professor Graham Candler received the prestigous Dyden Lecture in Research Award from the American Institute of Aeronautics and Astronautics (AIAA). AIAA is the world's largest association for aerospace professionals. Each year, one scientist or engineer who does research for the advancement of astronautics or aeronautics is recognized at the Dryden Lecture. This year, Candler was selected for his work enabling future scramjet-powered hypersonic aircraft.

Demoz Gebre-Egziabher promoted to Professor

Faculty member Demoz Gebre-Egziabher was recently promoted from Associate Professor to Professor at the Board of Regents meeting on May 12, 2017, which will become effective the beginning of Fall Semester 2017. Gebre-Egziabher graduated with a PhD from Stanford University in 2002, and subsequently joined the AEM Department as an Assistant Professor.

Gebre-Egziabher's research is in the area of state estimation and its application to the navigation and attitude determination of aerospace vehicles.

He is the Director of Graduate Studies and since January 2017 has taken on the leadership of the Minnesota Space Grant Consortium (MnSGC) as its director. He is a member of the Institute of Navigation (ION), the Institute of Electrical and Electronics Engineers (IEEE) and the American Institute of Aeronautics and Astronautics (AIAA) where he is an associate fellow.

Bill Garrard retires after 49 years of teaching, research, and service

Professor Bill Garrard retired at the end of Spring semester 2017. Garrard earned his BS and PhD from the University of Texas at Austin, began working for the AEM department in 1967, and has remained a dedicated faculty member for 49 plus years. Garrard's career has been filled with teaching, research, and service. He has advised over 80 graduate students, and has published over 100 technical papers containing fundamental contributions in dynamics and control of aerospace vehicles, aeroelasticity, and parachute flight dynamics.

Garrard served as Associate Department Head for 8 years and Department Head for 15 years. He was the first Principal Investigator and Director of the NASA funded Minnesota Space Grant Consortium (MnSGC), and has received recognition from the American Institute of Aeronautics and Astronautics for his outstanding contributions to aerospace engineering education.

As a colleague, friend, advisor, and professor, Professor Garrard has been a leader and a consistent source of inspiration. His impact on the success of the department will be a legacy, continuing to impact many in the years to come.

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Freshman students tackle CubeSats

Students in the AEM all-freshman course, "Introduction to CubeSats," spent their spring semester designing, building, and flying devices called CubeSats. A CubeSat is a type of miniaturized satellite used for space research. Because of their small size (10cm x 10cm x 10cm), they have a much lower cost than traditional satellites, making them ideal for riskier experiments.

The course was taught by Professor James Flaten, and consisted of 10 students, who were divided into three teams. Each team designed their satellite with a different function in mind.

The teams began the design process by using the computer aided design application, Solidworks. For most groups this process took about 2-3 weeks, during which they quickly learned the importance of time management. "In our limited time frame we crammed weeks' worth of early morning hours into the project," says Modulus team member, Lukas Zumwalt.

Professor Flaten says that proper planning and time management is one of the biggest challenges students face when they take this course. "They are trying to manage a project that they don't fully understand, they benefit from the experience, and learn what needs to be done in the future," Flaten says.

After designing their CubeSats using CAD, the students began the construction process. Each team fabricated their CubeSats using different materials, depending on their overall goals for their design.

"Our CubeSat was made of wood sides with an aluminum ground plane and four metal railings to allow for the CubeSat to slide in and out of the P-POD as easily as possible," says CSI team member Billy Herdman.
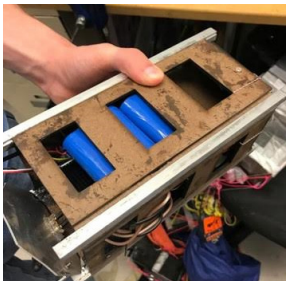
Left: Team Camera Satellite Initiative's (CSI) CubeSat designed to relay pictures taken with a camera to the ground during flight

"After the CAD was finalized, the team set about the task of printing the body, wiring the electronics, and writing the code, all of which took longer than we anticipated," says SPARTA team member Jordan Bartlett.


Left: Team SPARTA on launch day

In order to succeed in the project, the students were forced to learn many new and advanced skills as quickly as possible. Professor Flaten says, "The greatest benefit students receive from taking this course is that they quickly gain advanced skills that they otherwise wouldn't have encountered this early in their academic program. They are much more prepared for future courses because of this."

Once the construction process was finished, it was time to prepare for flight. The students placed their devices into mock P-PODs (used to carry CubeSats), which were then hung from weather balloons and carried into the stratosphere to be launched.

Right: Team Modulus inserting their CubeSat into a P-POD to prepare for launch
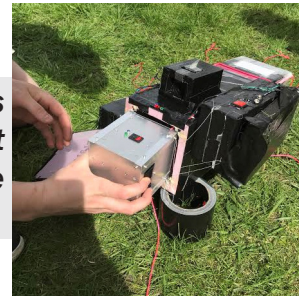
After the flight, the students recovered their CubeSats and analyzed the data they had collected. For Team SPARTA, the process of analyzing their data was limited to radio transmission records. "When the balloons landed, we discovered that our CubeSat, and the CubeSat of another group, were no longer attached to the balloon. This meant that they were lost somewhere during flight, and we were unable to find them," says Bartlett.

Professor Flaten explains that this is a general occurrence in real CubeSats – ones that actually go into space are never recovered, so only data sent down by radio actually counts. So, while it is disappointing that the students lost their CubeSat, it also gave the team valuable insight into a real industrial issue.

At the end of the semester, the students displayed their hard-work in the Gary J. Balas Atrium, and presented what they learned.

"In the end, the class and Professor Flaten provided us (the students) with very insightful experiences and lucky opportunities," says Zumwalt.

# AEM senior design team presents at NASA's RASC-AL design competition

This spring, an AEM senior design team was selected to present in the final round of NASA's RASC-AL Design Competition. The 2017 competition focused on the development of innovative capabilities that help to support NASA's goal of improving our ability to work more effectively in micro-gravity.

Team members, Austin Meuchel, Bobby Nguyen, David Deng, Josh Hagood, Keegan Clay, Michael Schmit, Seth Willing, and Vaughn Weirens began working on designing an airlock for the competition in fall 2016. The objective of the airlock design category is to design an airlock system with a minimum operational life of 15 years that can be incorporated or attached to a deep space habitat by 2021.

The group's deep space airlock, "Janus" has a simple design plan: to take what is already known to work in airlock systems and to develop innovative improvements that make it usable for deep space missions. Nguyen explains this process by saying, "Innovation does not mean to create something new, but to make something better."

Right: Internal Configuration of the Janus airlock system
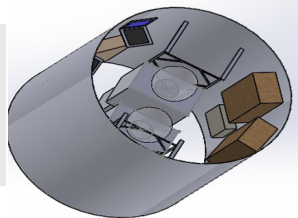
The team chose the airlock theme because it is a less common category. "Designed airlocks, which are operable in deep space are one of the key pieces of technology required to extend space exploration beyond low earth orbit. Compared to habitats or propulsion systems they are much less attractive and often overlooked, so it can be one of the more interesting and challenging problems because fewer people have already looked deeply into the design challenges," says Deng.

The group started out by looking at existing solutions in airlock designs. From there, they began to focus on new technologies in order to develop innovative solutions to meet the requirements of the project. Some of these innovations revolved around the use of the Z-2 suit (NASA's new spacesuit design), as they wanted to make sure that they were designing their airlock for future suits.

NASA's current airlock, the Quest airlock, stores suits perpendicular to the axis of the airlock to take advantage of the waist entry. However, in order for the Janus airlock to do this it would be necessary to significantly increase the diameter of the design (which would not meet the design requirements). To avoid this, the team's airlock design places spacesuits parallel to the axis of the airlock, greatly reducing the minimum airlock diameter.

Other innovations included improving the power efficiency of the airlock with the implementation of lithium ion batteries, enclosing an environmental control and life support system in the airlock as a redundancy measure, and reducing the need for stored oxygen by recycling CO_2 using a cyclonic seperator and a Bosch reactor.

The development of these innovations required extensive research in areas of aerospace design that the team members hadn't learned about in their previous classes. "This project forces students to do in-depth research in new technical subjects (e.g., chemistry and electronics). Students learn how difficult it is to read research papers in new technical areas. They do a great job of learning how to gain an in depth understanding of the subject, and then to extend and apply the knowledge gained from the research to real world concepts," says the team's faculty advisor, John Weyrauch.

One of the main challenges they faced while conducting research was finding the information they needed in order to proceed with the project. "I realized that in research, I will have to find many answers myself, and I may have to be creative in order to give useful and reliable contributions to the team," says Hagood.

Group members, Hagood, Clay, Nguyen, Willing, Weirens, and Schmit presented their work in Cocoa Beach, Florida May 31 - June 2. For more information about the event visit z.umn.edu/2rvx.

2016-2017 Fellowship Recipients

Harish Venkataraman
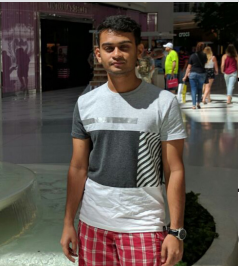
John A. & Jane Dunning Copper Fellowship. Venkataraman works with Professor Peter Seiler on investigating the prospects of incorporating the state of the art reinforcement learning to optimal control theory in order to build robust and adaptable controllers for autonomous drones. "I am very excited to work on this project as it could mean we could build highly generic controllers which can adapt to diverse applications and external conditions, and I am very fortunate to work with Professor Seiler because of his expertise in the field."

Luci Baker

National Defense Science and Engineering Graduate Fellowship and the John A & Jane Dunning Copper Fellowship. Baker works with Professor Filippo Coletti on fluid mechanics research. "I am analyzing the results of a direct numerical simulation of microparticles suspended in homogenous turbulence, which is applicable to how dust or other particles behave in the atmosphere. I am studying how they form clusters in turbulence, and what fractal properties the clusters have."

Andrew Akerson

John A. & Jane Dunning Copper Fellowship. Akerson will soon begin his research in solid mechanics with Professor Ryan Elliott. "My overall experience at AEM has been good so far. The Professors are very passionate in their work."

Raghu Venkataraman

Doctoral Dissertation Fellowship. Venkataraman works with Professor Peter Seiler on developing and implementing algorithms that detect part failures in drones and take corrective actions to bring it to a safe landing. "Such algoritms have the potential to make drones safer as they become commonplace sights in our skies over the next decade." Read more about Raghu's work on pages 8-9.

Mingjian Wen

Doctoral Dissertation Fellowship. Wen works with Professor Ellad Tadmor on developing a fitting framework for automatically generating interatomic potentials for 2D materials. "The key of molecular simulations are the interatomic potentials that describe the interactions of atoms within and between the sheet. Using state-of-the-art data analytics, machine learning, and informatics, I am developing a framework for automatically generating interatomic potentials for 2D materials."

Senior Exit Survey Results

Each year, graduating seniors complete a 30-question survey evaluating the AEM program. The survey touches on their experiences both as lower division and upper division students as well as their perceived quality of education, advising, and learning environment. Questions are ranked from 1 to 5, with 5 as the best score. The scores shown below indicate that students are learning the academic material, and that their preparation to use engineering tools has been steadily increasing in recent years. We suspect this is due to student participation in Senior Design courses, in which students often must know how to use computer aided design programs in order to succeed in their projects. Moreover, with the implementation of freshman courses like "Introduction to CubeSats" explained on page 4, our students are being exposed to these engineering tools very early in the undergraduate program.
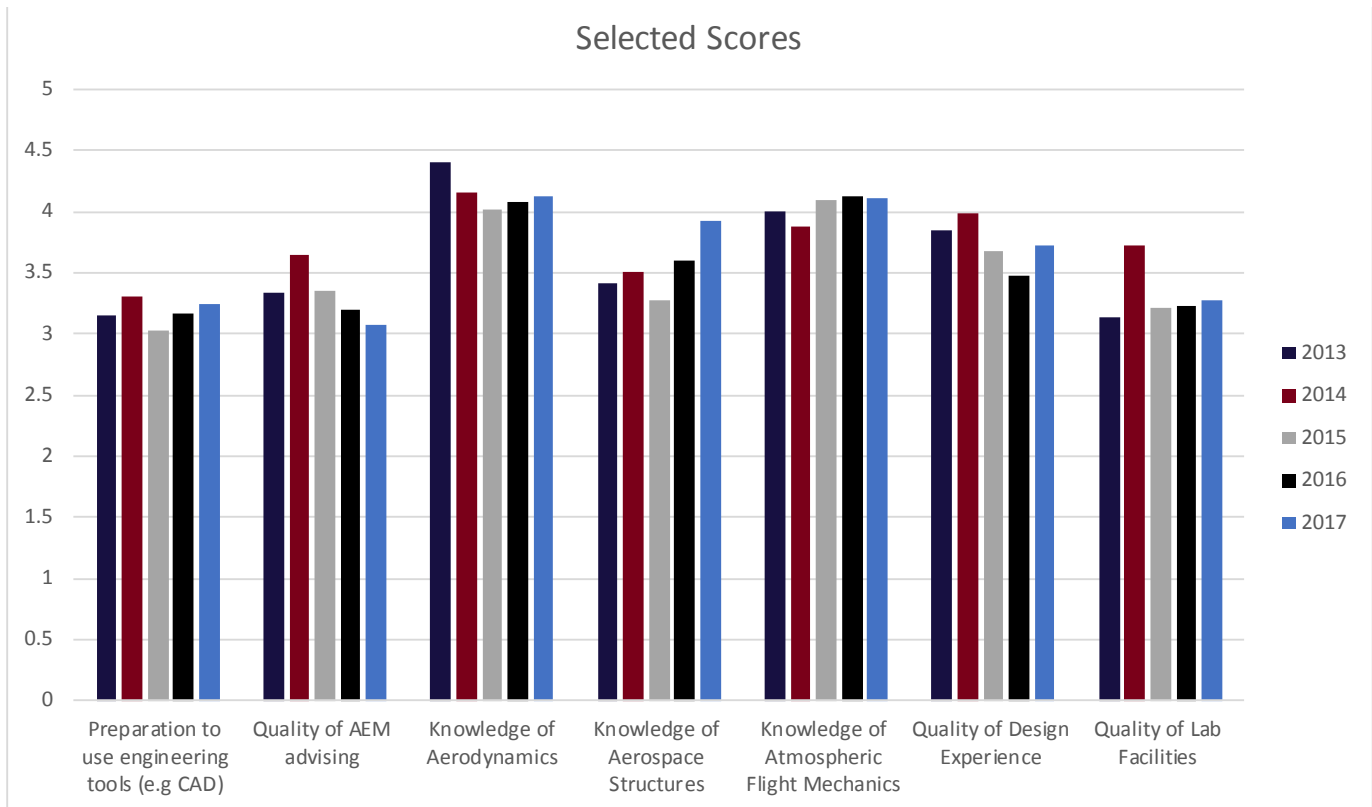
AEM Undergraduate Program Objectives

1. Consistent with the mission of the University of Minnesota, graduates of the BAEM program will be successfully employed in aerospace or other high technology industries.
2. Graduates admitted to graduate level studies in engineering and other professions will obtain an advanced degree.

Outcomes

1. A solid foundation in mathematics, science and engineering and the ability to apply this knowledge.
2. An ability to design and conduct experiments, as well as analyze and interpret data.
3. An ability to design aerospace systems and components in collaboration with others in a professional and ethical manner.
4. An ability to identify, formulate, and solve engineering problems.
5. An ability to communicate effectively.
6. A broad education necessary for the understanding of the impact of solutions of engineering problems in a global and social context as well as knowledge of contemporary issues.
7. A recognition of the need for and the ability to engage in life-long learning.
8. An ability to use techniques, skills and modern engineering tools necessary for engineering practice.
9. Knowledge of aerodynamics, aerospace materials, structures, propulsion, flight mechanics, stability and control, orbital mechanics, rocket propulsion, space structures and other space related topics.

Seiler's team develops algorithms to transform drone safety

Drones, technically referred to as Unmanned Aerial Systems (UAS), have various applications ranging from package delivery to precision agriculture. However, UAS are susceptible to part failures, which may lead to a UAS crashing with potentially fatal consequences. AEM Professor, Peter Seiler and his student Raghu Venkataraman are developing and implementing intelligent algorithms to detect these part failures and take corrective actions that allow for a safe landing. Such algorithms have the potential to make UAS safer as they become commonplace sights in our skies over the next decade.

What are UAS used for?

Drones are currently a popular consumer product. Adventure sports enthusiasts use them with GoPro cameras, businesses use them to deliver packages to consumers, and film makers use them to shoot from previously unimaginable angles. The drones typically used for these functions, called multicopters (Figure 1), are equipped with multiple rotating propellers that allow consumers to control them with ease and speed. This makes them ideal for activities that require quick maneuvering.

Fig. 1: Multicopter UAS eqipped with multiple rotating propellers

The use of drones extends far beyond recreation and package delivery. From precision agriculture to aerial mapping, drones offer a simple solution to seemingly difficult tasks. These applications typically use fixed-wing drones (Figure 2). Their wings rigidly connect to their body, much like a passenger aircraft.

Fixed-wing drones are less agile when compared to multicopters because they need to be moving in order to stay aloft. However, they are capable of traveling farther, which makes them suitable for activities that require longer flight times.

Fig. 2: A Fixed-Wing UAS equipped with two rigidly connected wings

How safe are UAS currently?

Despite their widespread use and practicality, UAS have had their share of safety issues. UAS, especially those used for industrial reasons, may weigh 20 pounds or more. Their weight, combined with their ability to travel at speeds of 20 miles-per-hour or more, may create enough energy to turn even the smallest part failure into a detrimental crash. This is especially hazardous over densely populated urban areas, as many drones contain enough kinetic energy to cause fatalities.

Estimates suggest that there will be more than 20,000 drones in the US by 2019. As these aircraft become more prevalent in our skies, increasing their safety is of prime importance.

How can algoritms be used to increase UAS safety?

UAS maneuver in the sky by deflecting flaps located on their wings, which are controlled by miniature on-board computers called autopilots. Due to limitations in present day autopilots, it is imperative that all of the flaps are functioning in order for the aircraft to operate properly. That being said, part failures are inevitable and even one malfunctioning flap is sufficient to cause a crash-landing.

The objective of Seiler and Venkataraman's work is to develop intelligent algorithms for autopilots such that fixed-wing UAS can continue flying safely even after one or more flap failures. The algorithms achieve this goal through three steps:

Flight demonstration of handicapped UAS

For the second demonstration, they mentored a team of senior undergraduate students who designed and built a UAS equipped with only two flaps. An expert human pilot safely landed the aircraft using one flap, while the other flap was immobilized.

What's the impact?

The future of UAS technology is exciting, with endless opportunities for innovation. By developing intelligent algorithms that can manage a specific class of UAS failures, Seiler and Venkataraman are paving the way for the safest UAS systems to date.

A. By detecting in a timely manner that one or more flaps have failed

B. By isolating the set of failed flaps from the set of healthy flaps

C. By controlling the aircraft using the healthy flaps

Seiler and Venkataraman have demonstrated that one flap is sufficient to both steer and land a handicapped fixed-wing aircraft. In the last two years, they have completed two demonstrations of Step C on two different UAS managed by the Uninhabited Aerial Vehicle (UAV) Laboratories. In the first demonstration, a UAS equipped with eight flaps continued to fly despite failures in seven flaps. An autopilot running robust flight control algorithms made this achievement possible.
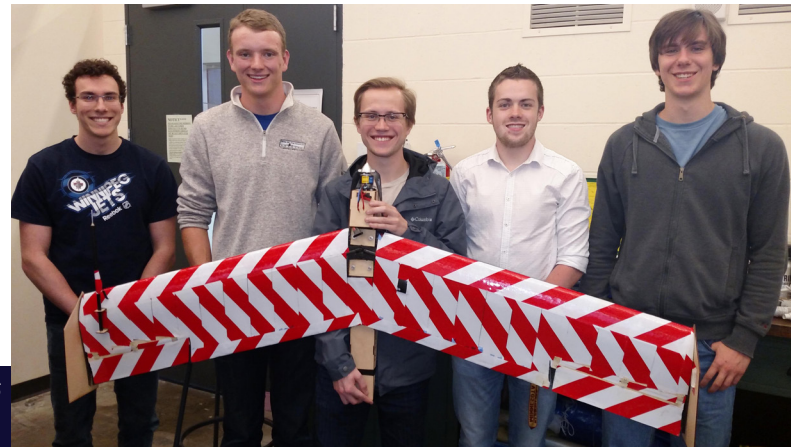
Right : Team of Senior Undergraduate students who built a two-flapped UAS

Recently Funded Research Projects

Several of our faculty members have recently received funding for their research projects. Project overviews can be seen below.

Hemati funded by U.S. Air Force to develop methods to suppress turbulent transition in shear flows

Professor Maziar Hemati has received funding from the U.S. Airforce Office of Scientific Research to pursue the project, "Shaping Modal Dynamics for Drag Reduction: A Study of Transition Supression in Shear Flows." This project comes out of the 2017 Unsteady Aerodynamics and Turbulent Flows Program, and will investigate how to reduce drag in wall-bounded shear flows by targeting the linear transient growth mechanism that is responsible for sub-critical transition to turbulence. The work will focus on formulating a new dynamic mode shaping perspective to determine if, when, and how transient growth can be eliminated.

Nichols funded to investigate the origins of hypersonic boundary layer instabilities

Professor Joseph Nichols was recently funded by the US DOD Office of Naval Research (ONR) for a project investigating "Adjoint Methods for Understanding Distributed Roughness Induced Transition in Hypersonic Boundary Layers." Nichols' research team is using adjoint methods to turn computational fluid dynamics codes "inside-out" enabling them to trace back to the physical origins of flow instabilities that lead to intense wall heat flux in hypersonic vehicles. The team is using these techniques to understand how even minute levels of roughness, when distributed over an entire vehicle's surface (such as that created by paint), can trigger instabilities.
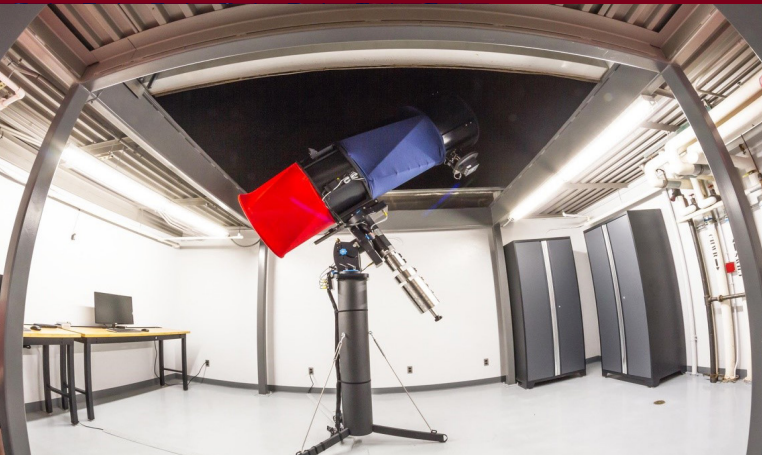
Solving the orbital debris problem - one observation at a time

Trouble in orbit

Lost on your way to an important meeting? – turn on your navigation system. Trying to decide what to wear? – check the weather. What would you do if these simple solutions were no longer possible?

Behind every navigation system or weather prediction is a satellite system or constellation of such systems continually working to provide these day-to-day services. From banking transactions to global communication to GPS mapping – we rely on satellite technology.

One threat faced by the satellite systems that provide these services is the rapidly increasing amount of space debris in near earth orbit. There are currently millions of pieces of debris, otherwise known as "space junk," orbiting earth, and their vast quantity and speed is a threat to anything crossing paths with them.

In low earth orbit, where most Space Junk resides, objects travel at 2-4 miles per second. At this speed, even an object as small as a paint fleck could render great damage to a satellite upon collision.

Saving our satellites

Working in collaboration with the University of Arizona (UofA), AEM Professor, Richard Linares, his Postdoctoral research associate, Piyush Mehta, and a team of University of Minnesota (UMN) students have set out to solve this issue. By combining Professor Linares' expertise in space debris characterization with the University of Arizona's expertise in small telescope technologies, the groups have a unique capability for solving the orbital debris problem; an optical telescope with the ability to track space debris and satellites.

"Solving the orbital debris problem requires developing a more detailed understanding of the orbital debris population," says Linares. "The goal of our telescope network is to conduct research on improving the knowledge of the orbital debris population."

The telescope, which was constructed from the ground up by a group of five students at the University of Arizona will be equipped with two software programs designed by University of Minnesota undergraduate students, Michael Schmit and Garrett Peloquin.

"Over the summer, I have been working to develop software to determine which objects are visible in the night sky, create ranking criteria to most effectively rank the objects for viewing, and to essentially output an optimized list of which objects should be viewed at any given time," says Schmit, who got involved in the project spring semester when he had Professor Linares for the course, Orbital Mechanics.

Meanwhile Peloquin has been working on the data visualization and presentation for the project. "I take the information the telescope outputs and the goal is to turn it into an animation or gif that is easy to understand," says Peloquin, who spends up to 40 hours a week learning the programming application, Python and implementing code.

While the students work on developing the software programs, Linares and Mehta are working on translating the knowledge acquired through observations into accurate orbit predictions in order to avoid future collisions.

"The state of any object, including position and velocity at any given time, can be estimated through propagation in time using dynamic models that may not be accurate," says Mehta. "Therefore, the estimated state has associated uncertainties which can be reduced with observations."

In low earth orbit (LEO), the most densely populated orbital regime, inaccurate modeling of atmospheric drag has the potential to lead to especially large uncertainties in object location. This is because drag, which is a mechanical force generated by contact between an object and a fluid, liquid or gas, can significantly modify a satellite's orbit. By developing and improving models of the thermosphere and drag coefficient, Mehta is able to characterize the interaction...

between molecules in the atmosphere and objects such as space debris, which allows for a better prediction of their orbits.

A global effort

While the University of Minnesota group develops the software programs, five undergraduate seniors from the University of Arizona's College of Engineering have been busy constructing a telescope designed to track orbital debris and satellites. Led by Vishnu Reddy, an Assistant Professor of Planetary Sciences at the UofA, these students have spent the past seven months designing, building, and testing the telescope in collaboration with the University of Minnesota.

"The orbital debris problem needs to be solved on a collaborative global scale, as it is something that affects everyone," Mehta says. "The collaboration between the University of Minnesota, and the University of Arizona makes us one step closer to solving this problem."

On display for the world to see

On June 20, 2017 officials from the Air Force joined Linares and his collaborators at the University of Arizona to celebrate the completion of the telescope.

"This is an exciting moment for my research group, as we are now able to collect observational data of the space debris population, and use this data to improve our understanding," says Linares.

Right: Prof. Reddy and Prof. Linares with the telescope

Continued from page 9

Schwartzentruber funded to advance heat-shield survivability for hypersonic vehicles

Professor Tom Schwartzentruber is leading a new research project, funded by the U.S. Air Force Office of Scientific Research, entitled "Nonequilibrium Gas-Surface Interactions at High Temperature." The research group includes Prof. Graham Candler here in the AEM department, Prof. Tim Minton from Montana State University, Prof. Erica Corral from the University of Arizona, and Prof. John Perepezko from the University of Wisconsin. The project involves numerical simulations performed in the AEM department and high-temperature materials fabrication and experiments performed at the collaborating universities. Ultimately, the research will combine new experimental capabilities, new simulation techniques, and new material fabrication methods to advance the state-of-the-art in high-temperature materials for hypersonic vehicles.

Professor Mahesh funded by the Navy to develop and improve complex software

Krishnan Mahesh, Professor in the Department of Aerospace Engineering and Mechanics, has recently been funded to develop advanced fluid simulation tools for the Navy. The goal of this research project is to develop highly accurate simulation software that can simulate the complex turbulent flow around propulsors and their resulting fluid loading. The simulations will be used in propulsor designs that meet operational requirements.

Minnesota Department of Transportation funds Gebre-Egziabher's research to improve transportation safety

Professor Gebre-Egziabher, research fellow in the Department of Mechanical Engineering, Brian Davis, and Aerospace Engineering master's student, John Jackson have received funding from the Minnesota Department of Transportation to investigate, "The Evaluation of Low-Cost, Centimeter-Level Accuracy OEM GNSS Receivers." This collaborative research project will investigate centimeter level accuracy in low-cost Global Navigation Satellite System receivers, which has the potential to enable many safety enhancements in U.S. transportation systems such as lane departure warning systems, driver assist systems, and enhanced stability control systems. The work will focus on providing an independent performance assessment in realistic settings encountered in transportation systems.

Congratulations Graduates!

BAEM recipients:

Jason Adlam	Matias Gervai	Trista Juntunen	Cheng Moua	John Thome
Andrew Akerson	Scott Gleason	Kelsey Kimball	Bobby Nguyen	Lee Thompson IV
Zachary Austin	Joshua Hagood	Reid Kleinschmidt	Karl Pihlstrom	Emily Timinski
David Barwin	Alex Hayes	Michael Koenig	Patipan Pipatpinyopong	Diep Tran
Stephen Beck	Thaine Heller	Tyler Kraut	Alexander Pratt	Justin Vaniperen
Peter Bendler	Benjamin Hiltbrand	Michael Kroells	Lucas Schaper	Devon Veldhouse
Alexandar Bock	Charles Hollender	Timothy Kukowski	Lauren Schlenker	Rodd Wagner
Andrew Bollin	Alexander Hrovat	Wilson Lau	Michael Schmidt	Michael Wang
Michael Calvert	Bryan Hulse	Kasey Laurent	Chad Serba	Stephanie Wegner
Tyler Christianson	Truc Huynh	Zicheng Li	Conrad Simmering	Seth Willing
Justin Dietz	Michael Jants	Stephen Link	Jacqueline Sotraidis	Masaaki Yamaguchi
Zachary Dohmen	Joseph Jenniges	Christopher Mauer	Thomas Stegge	Jason Yazuardi
Kyle Fleming	Alexander Jirele	Austin Meuchel	Lindsay Taylor	Ilya Zubarev
Evan Florin	Matthew Johnson	Sawyer Mitchell	Riley Terhaar	

AEM Masters and PhD recipients:

Salman Alfifi (PhD)	Masanori Honda (PhD)	Narenda Singh (MS)
Joel Amert (MS)	Sahar Jalal (MS)	Parul Singh (MS)
Joseph Brock (PhD)	Sally Ann Keyes (MS)	Hannah Weiher (MS)
Douglas Carter (MS)	Aditya Kotikalpudi (PhD)	
Vivekanand Dabade (PhD)	A.S.L Subrahmanyam	
Bryce Doerr (MS)	Pattamatta (PhD)	
John Erickson (MS)	Wei Ran (MS)	
Nathaniel Hildebrand (MS)	Adria Serra Moral (MS)	

Congratulations to this years BAEM, MS, and PhD graduates on all of their accomplishments! Commencement took place on Friday, April 28 for graduate students and on Friday, May 12 for undergraduate students.

In the News...

AEM alumnus, James Winker has passed away. James received his Bachelor of Aerospace Engineering and Mechanics from the University of Minnesota in 1952.

AEM Alumna , Katherine Glasheen has received the *National Science Foundation Fellowship*. This prestigous program recognizes and supports graduate students who are pursuing masters and doctoral degrees that are based on research in science, technology, engineering, and mathematics. Read the full story at z.umn.edu/2rur.

Thomas Sontag donates John D. Akerman's Flying Wing Blueprint

This past April, Thomas Sontag, a 1982 graduate of the AEM department, made a return visit to deliver a blueprint for the tailless airplane known as the Flying Wing. The Flying Wing was built, designed and flown by John D. Akerman, Professor Emeritus and initial Head of the Department of Aeronautical Engineering.

Tailless aircraft, like the Flying Wing, are more fuel efficient than conventional aircraft, but are inherently less stable. Despite this, Akerman didn't design his aircraft for stability or safety of flight, but rather to involve aeronautical engineering students in the process of constructing aircraft.

In the early 1930's one of Professor Akerman's students, Charles Howard Swanson, was particularly involved in this process. While at the University of Minnesota, Swanson led a team of 8 other students throughout the process of constructing the aircraft. Together these students completed the design and got about half of the plane built. John Akerman then finished the construction of the plane, and flew it in 1936.

"John Akerman was a very advanced designer, and was the man who designed the first low wing airplane that is now standard," said Charles Swanson in his autobiography. Swanson, who graduated from the University of Minnesota in 1933, stored the blueprint in a box with other model aircraft items. Years later, his daughter Dianne found the box when she inherited her father's estate. She then gave it to her handyman, who passed it along to Thomas Sontag when he learned about his interest in aircraft.

"When I went through the box, I found the drawing and carefully unfolded it. The date and the signed name of J.D. Akerman caught my eye. After a quick internet search, I found an article entitled 'Early development of tailless aircraft in the United States' by E.T Woolridge. There was Akerman sitting in the very same airplane," says Sontag.

Months later Sontag read that Professor Garrard was retiring. As a former student of Garrard's, he decided to reach out to him to see if the department was interested in the blueprint. We were, and after a long chain of events, the blueprint ended up back where it started. The blueprint is set to be displayed in the heritage room of McNamara Alumni Center alongside the Flying Wing aircraft, which is currently on loan from the Smithsonian Air and Space Museum.

AEM Alumnus, John Copper passes away

John A. Copper graduated with an Aeronautical Engineering undergraduate degree from the University of Minnesota in 1957. After graduation, he moved to California to pursue a Master's degree from the University of Southern California and an Engineering degree from the California Institute of Technology, and got a job at McDonnell Douglas as an aeronautical engineer. After John's 35-year career at McDonnell Douglas, he wanted to recognize the University of Minnesota's contribution in his preparation for a career and established the John A. and Jane Dunning Copper Fellowship for AEM graduate students in 2000. This years recipients are listed on page 6.

FACULTY-AUTHORED BOOKS

AEM is proud to have seven faculty members - Ryan Elliott, Demoz Gebre-Egziabher, Graham Candler, Filippo Coletti, Ellad Tadmor, Thomas Schwartzentruber, and Roger Fosdick who have published books.

"Volumetric Velocimetry" - 2017
Author: Filippo Coletti
Description: This publication is a chapter in the book, *Experimental Aerodynamics* by Stefano Discetti and Andrea Ianiro. The book provides an up to date description of topics such as 3D techniques and data processing methods, and is ideal for undergraduate and graduate students studying aerospace engineering. The chapter authored by Coletti reviews advanced techniques such as tomographic particle image velocimetry, holography, and magnetic resonance velocimetry.

"Modeling Materials: Continuum, Atomistic and Multiscale Techniques" - 2011
Authors: Ellad Tadmor and Ronald Miller
Description: This book covers a wide variety of topics including continuum mechanics, quantum mechanics, atomistic simulations, multiscale techniques, and more. It provides students and researchers in physics, material science, chemistry, and engineering with comprehensive knowledge of materials modeling from microscopic to macroscopic scales. For more information see: http://www.modelingmaterials.org/
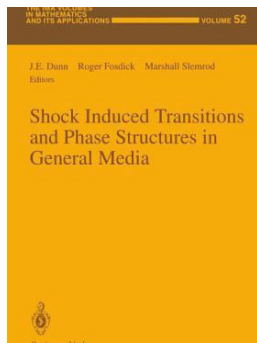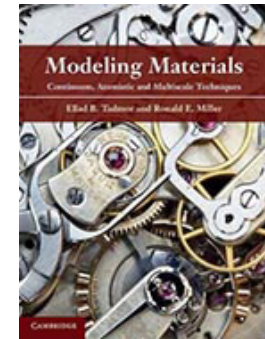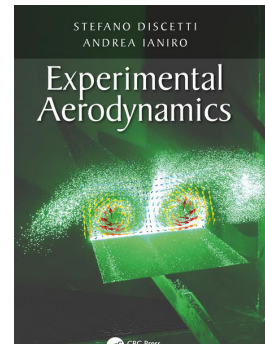
## "Shock Induced Transitions and Phase Structures in General Media" - 1993
Authors: J.E. Dunn, Roger Fosdick, and Marshall Slemrod
Description: This IMA Volume in Mathematics and its Applications is based on the proceedings of a workshop that was an integral part of the 1990-91 IMA program on "Phase Transitions and Free Boundaries." The workshop focused on the thermodynamics and mechanics of dynamic phase transitions that are mainly inertially driven and brought together physicists, metallurgists, mathematicians, engineers, and molecular dynamicists with interests in these problems.

"Continuum Mechanics and Thermodynamics: From Fundamental Concepts to Governing Equations" - 2012
Authors: Ellad Tadmor, Ronald Miller, and Ryan Elliott
Description: This book provides a self-contained, in-depth presentation of the topics of continuum mechanics and thermodynamics from a nonlinear materials modeling context. It gives the reader a fresh perspective on these important subjects, exploring their fundamentals and connecting them with micro- and nanoscopic theories. The book is ideal for graduate students as well as researchers in physics, material science, chemistry, and engineering. For more information see: http://www.modelingmaterials.org/
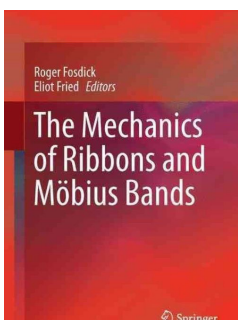
## "The Mechanics of Ribbons and Möbius Bands" - 2015
Authors: Roger Fosdick and Eliot Fried
Description: This book contains English translations of four seminal papers on the mechanics of thin, flexible ribbons and Möbius bands. The work includes 12 related research papers which expose modern developments in this field.

"Nonequlibrium Gas Dynamics and Molecular Simulation" - 2017

Authors: Iain Boyd and Thomas Schwartzentruber

Description: Starting from the behavior of individual atoms and molecules, including their quantum energy states, Boyd and Schwartzentruber develop the relationships to classical thermodynamics and gas dynamics using theory and simulation. This book is aimed at graduate students, engineers, and scientists involved in the study of nonequilibrium gas dynamics. The book also describes the direct simulation Monte Carlo (DSMC) particle method and its application to hypersonic flows.
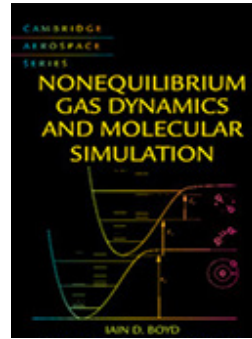
"The Rational Spirit in Modern Continuum Mechanics" - 2004

Authors: Chi-Sing Man and Roger Fosdick

Description: This book contains a collection of 42 essays and papers that are dedicated to the memory of Clifford Ambrose Truesdell III (1919 - 2000), who was the main architect for the renaissance of rational continuum mechanics since the middle of the 20th century. The work includes essays of personal reminiscences and research papers at the forefront of research in rational continuum mechanics and its applications to materials science and structural mechanics.

"GNSS Applications and Methods" - 2009

Authors: Scott Gleason and Demoz Gebre-Egziabher

Description: This book offers a practical overview of global navigation satellite systems (GNSS). With applications ranging from traditional positioning and timing to more exotic uses of GNSS (such as bistatic radars for remote sensing), the book provides readers with detailed descriptions and hands-on examples.

"Statistical Mechanics, Molecular Modeling, and the Notion of Stress" - 2014

Authors: Roger Fosdick and Eliot Fried

Description: This book examines and translates into English a paper written by Walter Noll, which gives new interpretations and provides a firm setting for ideas advanced by Irving and Kirkwood that directly relate to the basic principles of continuum mechanics. The translation exposes fundamental ideas of statistical mechanics, which are vital to modeling small scale behavior and its link to macroscopic observations. The translation is accompanied by four relevant research papers.

"Methods and Tastes in Modern Continuum Mechanics" - 2011

Authors: Roger Fosdick, Eliot Fried, and Daniel Tortorelli

Description: This book, dedicated to the memory of Donald E. Carlson (1938 - 2010), presents unique research investigations which give breadth and depth to the field of continuum mechanics and provides a vision for future advancements. The work contains one essay on the life of Carlson, and 42 research papers related to a plethora of physical phenomena on the foundations and applications of modern continuum mechanics.

"CFD Methods for Hypersonic Flows and Aerothermodynamics" - 2015

Authors: Graham Candler, Pramod Subbareddy, and Ioannis Nompelis

Description: This publication is a chapter in the book *Hypersonic Nonequilibrium Flows: Fundamentals and Recent Advances* (Progress in Astronautics and Aeronautics Series) edited by Eswar Josyula. The paper discusses recent developments in the simulation of hypersonic flows and shows that it is possible to construct a numerical flux functions for finite volume methods for these flows. It summarizes the development of a low-dissipation kinetic energy preserving flux scheme and illustrates its use for several hypersonic flows.

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AEM student team prepares to fly stratospheric balloons into total solar eclipse

On August 21, 2017, a solar eclipse will sweep across the continental United States from Oregon to South Carolina. The eclipse will touch land in Oregon at about 11:15 a.m. Central time (9:15 a.m. Pacific time), and the national livestream will begin documenting the celestial event as it travels across the United states. For more information about the NASA livestream of the 2017 total solar eclipse, visit the NASA website http://eclipse2017.nasa.gov/eclipse-live-stream.

In order to capture this video, over 40 ballooning teams from across 30 states are joining together to launch their stratospheric balloons in the event, "Learning at the Edge of Space." This includes the MN Space Grant Consortium (MnSGC) sponsored Stratospheric Ballooning Team, the "Gophernauts," at the University of Minnesota. On the day of the eclipse, the Gophernauts will launch their high-altitude balloon from Grand Island, Neb.

Team members from left to right. Back Row: Simon Peterson, Garrett Ailts, Michael Waataja, Jordan Diers, and Ryan Bowers. Front Row: Dr. James Flaten, Akshay Naik, Kathryn Kwiecinski, and Lukas Zumwalt.