AEM Update

Department of Aerospace Engineering and Mechanics Fall 2007

Chairman's Corner

Friends and Colleagues,

The start of school is always an exciting time for me. I look forward to the return of students, the beginning of classes and the smell of autumn in the air. It's been a great year for the Aerospace Engineering and Mechanics (AEM) department and I look forward to another great year ahead.

Some of the highlights from the past year include: Minnesat, the University's entry into a two-year, student-driven project aimed at creating nanosatellites, finished fifth overall at their national competition in the spring. We are extremely pleased with the results, especially since Minnesat was our first entry into the highly-competitive Nanosat competition. McKnight Land Grant Professor Demoz Gebre-Egziabher and several returning students are preparing for the next competition – Nanosat-5. Minnesota's entry, "Goldeneye," aims to use GPS as a type of radar to inexpensively yet accurately access target locations. Many congratulations, students and staff.

Students participating in the Reduced Gravity program elected to study a well-known but little-tested (in microgravity, at least) phenomenon: cavitation. Cavitation occurs when water quickly passes over an object (e.g., a propellor). Water vapor bubbles form, and collapse, in the wake of this machinery. The Reduced Gravity flight test is featured on page 9.

AEM and the University honored Professor Eugene E. Covert, an AEM alumnus and pioneer in aeronautical engineering who has a distinguished career in academia and service. He has been previously honored with many awards, including the prestigious Daniel Guggenheim medal. The Guggenheim medal may be the most distinguished award in aerospace, having honored the likes of Orville Wright and Charles Lindbergh in the past. More information about Mr. Covert may be found on page 12.

Several of our faculty members were recognized this year for their work. Professor Graham Candler received the 2007 AIAA Thermophysics award, one of the most prestigious in his field (see page 10). I was most honored to receive the Distinguish McKnight Professorship from the University. Professor Ellen Longmire received the Distinguished Women Scholars Award from the University. Professor Longmire was selected for the award based on her impact on her field, her international scholarly reputation, and her distinction in undergraduate and graduate education.

AEM and Akerman Hall have seen a great deal of change over the past year. In an effort to better serve our constituents, we upgraded our web site and renovated space in Akerman Hall. The updated web site is graphically more appealing, has new content offerings and is better organized than our previous web site. Remodeling of our main office and the creation of undergraduate and graduate lounges is complete. We feel it is important to provide our undergraduate and graduate students with a well-designed space to congregate, study and interact. The main office renovation improved the staff working environment, their work flow and allows us to better serve our students, faculty, alumni and visitors.

One of the goals I communicated to you last year is our intent to increase AEM's visibility on both the local and national stage. We are making progress toward that end, as our students, programs, and outreach are receiving a large amount of press at the University and beyond. Some notable articles, like a profile of AEM alumnus Steve Cook, coverage of Minnesat (in both IT magazine and the Minnesota Daily), and an article featuring seven AEM students' and their internships at NASA over the summer, are available through http://www.aem.umn.edu/spotlight.shtml. While we are making progress in increasing our visibility, we do need your assistance. Please submit news, photos, and comments to aemnews@aem.umn.edu.

We continue to strive to be one of the top Aerospace Engineering and Mechanics departments in the country. We have made excellent progress toward that goal this past academic year. With your help, we will continue to make progress and achieve our goal in the coming years.

Best Regards

Gary A Balas

What's Inside

Academics: Where are we now?

AEM Undergraduate Program

Undergraduates have a newly remodeled lounge in the space that used to house the AEM computer lab and AIAA Student Chapter. Computer usage has changed greatly over the last ten years. Over 90% of our students have their own computer and a large number of these are portable computers. The new lounge offers wireless and wired internet access with computers that are tied into the IT computer labs system for student use. Also, the nearby IT computer lab in room ME 308 provides access to large computer packages. In addition, there is a wireless network throughout Akerman Hall. This year, the IT computer fee is being used to provide students with copies of Matlab and Mathematica for their personal computers.

Our ABET accreditation visit is scheduled for November 11-13. This visit will involve a review of our program and the processes we use to act on the feedback we receive. In other sections of this issue are feedback from the Professional Advisory Board, results of our most recent Senior Exit Survey, and survey results from Alumni on achievement of our Educational Objectives. These provide valuable information that we use to identify areas where our program could be improved. Last spring, the faculty approved several changes to our BAEM degree program to address feedback related to our second design course. This course, AEM 4332W, which focused on spacecraft, has been dropped as a required course. Because the BAEM program only covers some astronautical topics, students lacked the background needed to consider all aspects of spacecraft design. AEM 4332W was also a writing intensive course so we have moved this part of the course to the junior level course, AEM 4303 – Flight Dynamics and Control. This will provide students writing instruction earlier in their program. Writing instruction is frequently mentioned in feedback as an area that could use strengthening and this move should help to address this. The first design course has been increased by one credit and will now cover both aircraft and spacecraft design and the professionalism and ethics units that were in AEM 4332W. Finally, a new technical elective, AEM 4302 – Spacecraft Attitude Dynamics and Control, has been created to maintain the number of space-related courses available to students. This course, which will be offered for the first time in the Spring of 2008, has already drawn considerable student interest.

As highlighted elsewhere in this issue, our students and faculty continue to participate in many exciting extracurricular activities. The Minnesat project has already attracted a team for the Nanosat-5 competition over the next two years. The NASA microgravity program also continues to attract students.

As highlighted elsewhere in this issue, our students and faculty continue to participate in many exciting extracurricular activities. The Minnesat project has already attracted a team for the Nanosat-5 competition over the next two years. Internships, both locally and around the country, continue to be important to our students and are a common topic of interest to prospective students. The strength of the local aerospace industry is definitely an advantage to our program and we'd like to thank those of you that support our program by offering internships.

Tom Shield
Director of Undergraduate Studies

Summer internships at NASA help students launch aerospace careers

They may not be going to the moon, but several University students are already enjoying the next best thing. As interns at NASA installations around the country, they're living the lives of space scientists and engineers as they work side-by-side with professionals.

When the chance came up, they all took a giant leap--for themselves if not for mankind.

"In Minnesota there aren't a lot of opportunities to work in the space industry," says Tom Chouinard, a freshly graduated aerospace engineering and mechanics (AEM) student from Andover, Minn., interning at Johns Hopkins University's Applied Physics Laboratory (APL).

He and 10 other students--eight from the University, two from other Minnesota higher education institutions--are spending 10 weeks this summer working on NASA projects as part of NASA's Space Grant Consortium program, a series of 52 grants that bring together colleges and universities in every state, the District of Columbia, and Puerto Rico to train the next generation of space scientists and engineers.

"It's NASA's largest higher education program," says William Garrard, University professor of aerospace engineering and mechanics and director of the Minnesota Space Grant Consortium, which receives $580,000 in NASA funding. That money is matched one-to-one by the Institute of Technology dean's office and other contributors, bringing the total budget to more than $1 million.

The program also aims to bring more women and students

More from AEM students/NASA Interns on Page 15

AEM Graduate program update

The AEM graduate program had another successful year. At the start of summer 2007, there were 70 graduate students in the department working toward their Ph.D. and M.S. degrees. Three of our graduate students, Juan Carlos Padrino Inciarte, Shankar Ghosh and Balint Vanek were honored with Graduate School Doctoral Dissertation Fellowships for 2007-2008. These awards provide full financial aid for one year for students at the completion of their Ph.D. program. This is a record number of Doctoral Dissertation Fellowships awarded to the department.

During the nine-month 2006-2007 academic year, 12 students received graduate degrees in AEM, four with a Ph.D. degree and eight with a M.S. degree These students are listed on page 15. Please join me in congratulating all of them on their achievements and wishing them the best in their future careers.

Graduate school applications for the AEM programs for the 2006-2007 academic year remained at approximately the same level as in 2005-2006. A total of 98 applications were received. Of the reviewed applicants, about half were admitted. Financial aid was offered to 25 of the admitted students in the form of teaching and/or research assistantships. Fifteen of our offers were accepted and these students enrolled in our graduate program in Fall 2007. Six additional graduate students enrolled in Fall 2007 with no financial aid from the department. We welcome all these students to AEM!

Perry Leo
Director of Graduate Studies

CSDy Graduate program update

The CSDy Interdepartmental Ph.D. Program provides an opportunity for interdisciplinary research in control science and dynamical system theory. The program coordinates scholarly and scientific activity of these areas within IT and the University and coordinates its activities with industrial firms in the Minnesota region. CSDy faculty are drawn from the Departments of Aerospace Engineering and Mechanics, Chemical Engineering, Electrical Engineering and Mechanical Engineering, as well as from the Departments of Computer Science, Mathematics and Statistics, all in IT, and from the Departments of Economics and Political Science.

The Co-Directors of the CSDy Center are Prof. Gary Balas (AEM) and Prof. Tryphon Georgiou (ECE), and Rajesh Rajamani serves as CSDy's Director of Graduate Studies. There were five students pursuing their Ph.D.s during the 2006-2007 academic year.

The Program featured a seminar series with distinguished speakers in the general area of Control Theory and Engineering and Dynamical Systems Theory. The list of speakers includes Professors Sara Susca (UCSB), Sanjay Lall (Stanford), Allen Tannenbaum (GaTech), Alex Megretski (MIT), Umesh Vaidya (Iowa State), Antonis Papachristodoulou (Oxford), Murat Arcak (RPI), Farhad Jafari (Wyoming), Mujahid Abdulrahim (Florida), Srinivasa Salapaka (Univ of Illinois), Hisaya Fujioka (Kyoto), Malcolm Smith (Cambridge), Serdar Yuksel (Yale) (http://www.csdy.umn.edu/csdy_seminars/).

Gary Balas, Tryphon T. Georgiou
Co-Directors, CSDy Program

AEM senior receives 'Innovators' scholarship from Honeywell

David Hauth, an AEM senior, is one of only eight students in the United States and one of only 18 in the world selected to participate in this prestigious program. Hauth began his paid Honeywell internship in May at Honeywell's Aerospace business located in Phoenix, AZ and in September will receive his academic scholarship.

The program seeks to assist students in two ways: by providing outstanding students with the financial and academic resources to complete their final year of undergraduate or graduate studies and, through a distinctive internship program, mentor these individuals with a paid internship at a Honeywell facility.

Hauth described the internship as a "great experience."

"I learned so much and it has opened the door to many opportunities after I graduate," he said. "As for the scholarship, what is there to say - it truly is a blessing as school becomes less and less affordable each year, and it has allowed me to focus more on both my studies and my involvement in the community - it's a privilege not many students are afforded and I feel truly honored."

David Hauth

The AEM department played a large role in preparation for the internship, he said.

"I also feel that I owe a great deal to the AEM department here at the U, as this was a specialized program which was only available to students from select universities," he said. "The fact that the University of Minnesota was one of them gives testament to the quality of education we receive here and the respect 'U' graduates garner from the industry."

AEM Advisory Board Findings from 06-07

The advisory board concurred with major AEM curricula changes

ABET Undergraduate Curriculum

- Change of Name - Orbital Mechanics (4301)

Board concurs with department decision

- New Elective Course - Spacecraft Att Dyn and Cntrl (4302)

Concur - especially in-light of Spacecraft Design change below

- Elimination of Spacecraft Design (4332W)

Concur with proposal, but given this eliminates a mandatory design course….

- See upside to encouraging students to continue into second design course (or at least declaring early who will continue)
- Keep encouraging opportunities for students who wish to pursue space opportunities - such as Nanosat, Student Launch Initiative, etc.
- Add Writing to Flight Dynamics and Control (4303-W)

Concur, but strongly encourage the department to add a verbal communications component to the curriculum as well (even if not required by the U of MN) - anywhere and as early as the AEM department can inject

AEM Compact

- Concur with aligning and leveraging with the strategy to become one of the top three research universities in the U.S without taking away from the teaching aspects of the U of M AEM Department
- Encourage aligning as much as possible with the IT three investment areas to bring in funds
- For example - composite aircraft fuselage can be a big energy and environmental savings
- Continue to leverage multi-disciplinary collaborations EE, ME, etc
- Continue to leverage multi-institutional collaborations (enlarge sphere of influence)
- Space Grant, other universities, etc

Student Advisory Board

- Students appeared to be informed and aligned with curriculum changes - shows that department leadership has been engaging their constituents
- Encourage department to continue to investigate issues raised by the students associated with courses (e.g. ME3324, AEM4501, etc)
- Strongly encourage the department to keep the board in place and meet regularly with the department leadership throughout the year

Recommended Role of the Advisory Board

- Membership Terms
- Diversity in industry, background, age, university affiliation, location, etc
- Rollover (staggered) is beneficial
- Chairman would be helpful (rotating)
- Roles and Responsibilities
- ABET accreditation issues
- Strategic direction
- Business models
- Emerging industrial needs
- Providing an opportunity for students to engage industry (lectures, seminars, AIAA, etc)
- Suggest future PAB candidates to the department

Minnesota Space Grant Consortium (MnSGC) Update for 2006-2007

The University of Minnesota remains the lead institution for the Minnesota Space Grant Consortium (MnSGC). The MnSGC is a NASA-funded group of affiliated organizations that support NASA's mission by doing teaching, research, educational outreach, and public service in Minnesota in the fields of engineering, science, and mathematics. AEM professor William Garrard is the Director of the MnSGC and professor James Flaten is the Associate Director.

Higher education affiliates of the MnSGC are Augsburg College, Bethel University, Carleton College, the College of St. Catherine (a women's college), Concordia College, Macalester College, the University of St. Thomas, Bemidji State University, Southwest Minnesota State University, Leech Lake Tribal College, Fond du Lac Tribal and Community College, the University of Minnesota – Duluth, and the University of Minnesota - Twin Cities. The MnSGC also works with the Minnesota Department of Transportation – Office of Aeronautics, Goodrich Aerospace, Inc., Boeing, Honeywell, Inc., Lockheed-Martin, AllianTech Systems, and the Science Museum of Minnesota.

The MnSGC provides scholarships and fellowships to support undergraduate and graduate students attending MnSGC higher education affiliate institutions who are pursuing careers in STEM fields (Science, Technology, Engineering, and Mathematics). During the past year 79 scholarships and

More about MnSGC on Page13

Results of Graduating Senior Exit Surveys

Each year we conduct an Exit Survey of our graduating seniors. The students are asked to respond to questions regarding their overall experiences in the BAEM program, both lower and upper division. Respondents are given a range from 1 (strongly disagree) to 3 (neutral) to 5 (strongly agree) to check off. The responses to the survey are summarized below:

Number of Surveys: 50

The percentage of students who checked either a 4 or 5 is shown in parentheses.

Preparation

A high percentage of students agreed that their education has prepared them:

- to apply knowledge of math, science and engineering fundamentals (88 percent)
- to design and conduct experiments and to analyze and interpret data (80 percent)
- to design a system, component or process to meet desired needs (72 percent)
- to identify, formulate and solve engineering problems (88 percent)
- with a good understanding of professional and ethical responsibilities: (79.6 percent)

There were some areas in which students felt not as well prepared. The percentages of 4's and 5's were much lower when students were asked if they felt that they were well prepared:

- to communicate effectively in both oral and written form: (55.1 percent)
- to use modern tools (e.g., CAD) necessary for engineering practice (28 percent), (neutral 34 percent)
- with an understanding of the impact of technology on society (58 percent)

Students had the following responses to questions about their Lower Division and Liberal Education coursework:

Advising

Of all students surveyed, 38.8 percent agreed that lower division academic advising was good, 32.7 percent remained neutral and 8.2 percent strongly disagreed to the question of whether lower division advising prepared them well for upper division. Fifty four percent of the students felt that their liberal education courses gave them an appreciation of the societal context in which engineering is practiced. Students felt that the science components (68 percent) and math components (74.5 percent) had prepared them well for their major courses.

Experience

Students were more satisfied regarding:

- whether computational facilities were available for their use (62 percent with 22 percent remaining neutral)
- whether instructors were available to discuss course related issues outside of class (80 percent); and
- whether their courses included active learning experiences, such as discussion and team work (84 percent)

Students were positive about their Upper Division experience, with 44.9 percent who thought the upper division academic advising was good, and 28.6 percent remaining neutral. The majority of the students felt that their education provided them with:

- a good understanding of engineering materials (74 percent)
- a good understanding of aerodynamics (87.8 percent)
- a good understanding of aerospace structures (67.3 percent)
- a good understanding of aerospace propulsion systems (85.7 percent)
- a good understanding of atmospheric flight mechanics (81.6 percent)
- a good understanding of orbital mechanics and space flight (73.5 percent)
- a good understanding of flight dynamics and control (75.5 percent)

And the rest...

The balance of the survey asked the students to respond to:

- whether they felt the design experiences provided throughout the BAEM curriculum were good: 66 percent responded positively while 16 percent were neutral.
- whether the internship and/or work experience enhanced their education; 44.9 percent responded positively while 42.9 percent remained neutral.
- whether the quality of facilities provided were good; 37 percent responded positively while 26 percent remained neutral.
- whether the quality of the computational facilities provided were good: 49 percent responded positively and 24 percent remained neutral.
- whether the senior design courses improved their ability to work as part of a team: 70 percent responded positively, while 19 percent remained neutral.
- whether the hands-on laboratory experiences provided them with a good understanding of how to conduct and design experiments as well as analyze and interpret data: 68 percent responded positively.

Although the majority of the graduating seniors were generally satisfied with their educational experiences in the BAEM program, there are clearly areas that need improvement. These areas will be addressed by the AEM faculty.

Details of the survey can be found at: http://www.aem.umn.edu/teaching/undergraduate/BAEM_prog_assessment.shtml

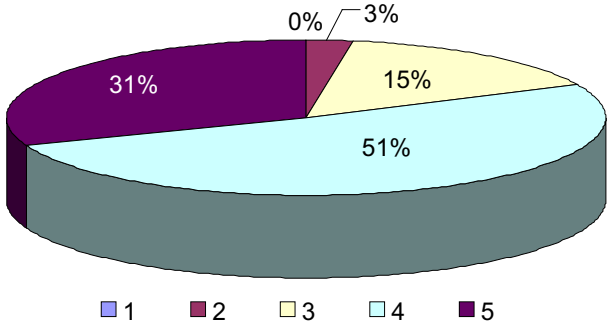
Accreditation Underway

Educational Objectives: How are we doing?

As part of the accreditation process, every engineering program must have educational objectives which are "broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve." Our objectives were formulated in 1998 in consultation with our constituents: faculty, students, employers, and alumni. Each year we evaluate how well we achieve these objectives by consulting with our Professional Advisory Board, Faculty, and Graduating Seniors. In addition, we request comments from the readers of the AEM Update and receive limited input from this source. This year we decided to conduct a formal survey of alumni to see how well they think that we are achieving our objectives, and if our current objectives are appropriate.

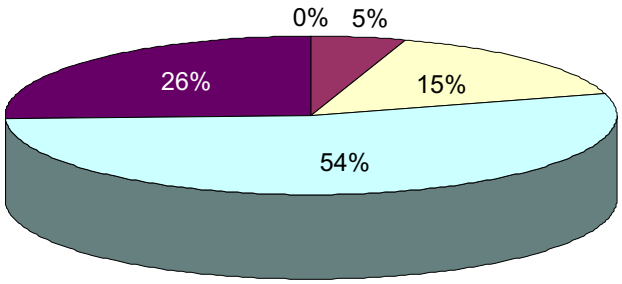
Objective 1: To produce graduates with a broad background in aerospace engineering and mechanics, including fluid mechanics, structural mechanics and aerospace systems.

My education helped me achieve this objective extremely well. (1=Strongly Disagree to 5=Strongly Agree)



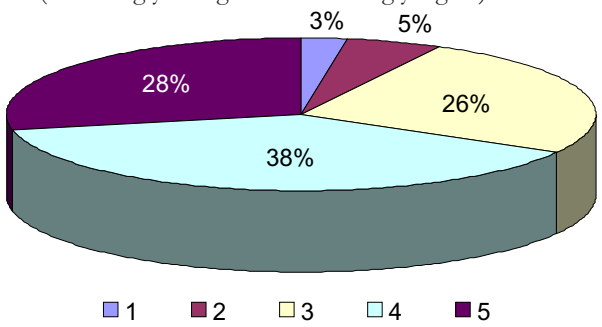
Objective 2: To produce graduates who can apply their knowledge of aerospace engineering and mechanics to achieve success in the aerospace industry, related government agencies, and other engineering industries.

My education helped me achieve this objective extremely well. (1=Strongly Disagree to 5=Strongly Agree)



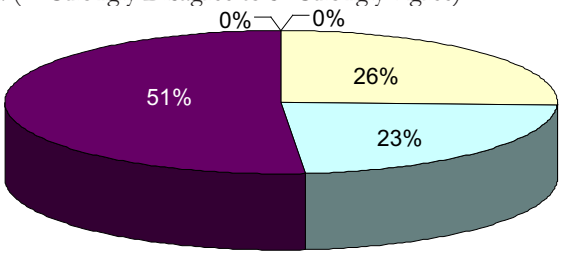
Objective 3: To produce graduates with skills in the essential tools used in aerospace and other industries. These include experimental methods, problem-solving techniques, computational methods and engineering design.

My education helped me achieve this objective extremely well. (1=Strongly Disagree to 5=Strongly Agree)



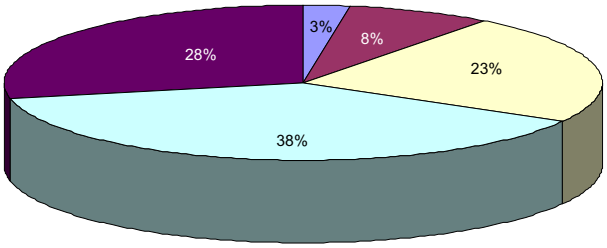
Objective 4: To produce graduates with the ability to both seek out assistance when needed and to learn new skills throughout their careers.

My education helped me achieve this objective extremely well. (1=Strongly Disagree to 5=Strongly Agree)



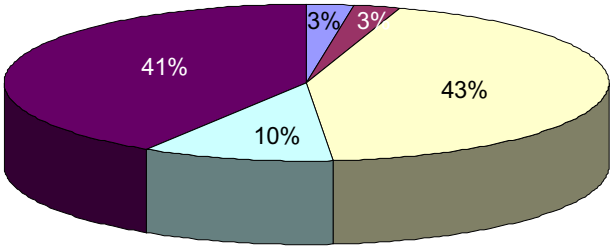
Objective 5: To produce graduates with the oral and written communication skills needed to successfully work in a modern multidisciplinary environment.

My education helped me achieve this objective extremely well. (1=Strongly Disagree to 5=Strongly Agree)



Objective 6: To produce graduates who can be successful in graduate level work in engineering, as well as in other professional schools.

My education helped me achieve this objective extremely well. (1=Strongly Disagree to 5=Strongly Agree)



Minnesat: strong showing in first competition, next round to begin

At the University, students are utilizing Global Position Systems (GPS) for more than navigating the innumerable one-ways of downtown Minneapolis.

Members of Minnesat, the University of Minnesota's entry in the student-driven Nanosatellite program, recently competed in the final stages of Nanosat-4, which marked Minnesota's first jaunt into the world of microsatellites.

The Nanosat project is a competition among colleges nationwide – the winners of which will get to launch their satellite into space thanks to the United States Air Force. This year's top honors went to Cornell's CUSat (http://cusat.cornell.edu/). A special thanks to Richard DeLeo for his financial support of this project.

Minnesat allows GPS attitude determination in space, cheaply and efficiently.

Student project director Jason Mintz said the project was exciting because students constructed a working satellite from scratch, and because industry is actually taking interest in the outcome.

"We have a very simple, scientifically-relevant and exciting experiment from a scientific standpoint that a lot of people are interested in seeing," he said.

Although Minnesat is wrapping up its two-year project, interested students can take heart – the University's proposal for the next competition was recently accepted by the Air Force.

Jason Mintz, the project's student team lead, glances at a prototype of Minnesat, the University's entry in a national nanosatellite competition.

The future project will build upon Minnesat's experience with GPS and attempt to create a new kind of radar based on GPS technology and is entitled "Goldeneye."

"The concept is called 'GPS Bistatic Radar' and the idea is to look at GPS signals reflected off other objects to determine their position and motion," said Minnesat Adviser Demoz Gebre-Egziabher.

Gebre-Egziabher, a McKnight Land-Grant professor in the Department of Aerospace Engineering and Mechanics, said both the current and future Minnesat projects could have positive implications for industry.

"The science mission we are proposing has the implication of making the ability to detect other objects near a satellite inexpensive," he said. "It will be an efficient way to equip satellites with the ability to detect objects in orbit."

Vincent Jusef is seen here working on the exterior of Minnesat

The project has also created capacity in the department for more satellite research – and teaching.

Mintz, an aerospace senior, said hands-on experience in Minnesat has helped "tremendously" with job interviews.

"This gave me a unique experience – you're not just doing the paper design on something, but you build it, troubleshoot it, and find out what went wrong and what works. It's terrific experience that a lot of students don't get a chance to have."

For more information about the Minnesat or Goldeneye projects, contact Prof. Gebre-Egziabher (gebre@aem.umn.edu). The Goldeneye website is available at: *http://www.aem.umn.edu/proj-prog/nanosat/*

Remodeling in AEM complete

After just over two months of demolition, drilling and a fair amount of dust, major construction has been completed in all three remodels taking place in Akerman Hall - the main office, the graduate student lounge and the undergraduate student lounge.

To create the undergraduate student lounge, the wall dividing Akerman 305 and 305A was removed, opening a large space for undergraduates. The new lounge features a place for students to meet, relax, and use computer facilities – either through a workstation or an available wireless connection.

Tom Shield, AEM professor and director of undergraduate studies, said the lounge will offer new functionality to undergraduates.

"The new AEM undergraduate lounge will provide students with a place to study, either alone or in groups, and there will be several computer workstations connected to the IT labs computer system, as well as wireless access so students can use their laptops," he said. "Additionally, our AIAA student chapter will have space to support their activities."

Shuffling of a few faculty offices, as well as a reduction in the size of the department head's office, has allowed for the creation of the graduate student lounge in Akerman 120. It features two areas where graduate students may meet in groups, network with their peers or members of academia and industry, or just kick back and eat some lunch. In addition to several workstations and printers, the lounge will offer students an added technological benefit – an industry-standard scanner. This allows for the quick scanning and digitizing of documents to PDF or images to JPGs. The lounge will also offer a kitchenette area for students.

Department Head Gary Balas described the lounges as a space for students to interact, meet, relax, study and connect to the internet.

"We ask a great deal of our students and therefore need to provide facilities to help them succeed; the undergraduate and graduate lounges are just one step in that direction," he said.

The remodel of the main office at 107 Akerman Hall focused on improving aesthetics and space utilization so that AEM staff might more efficiently serve students. Renovation of the main office makes better use of space, improves work flow, and provides a long-needed facelift and provides the staff with an improved work environment, according to Professor Balas.

"The architectural, curved panels hanging from the ceiling remind me of airfoils and bird wings, providing a connection between the office and the department's mission," he said. "I'm excited about our space renovation as its style and mission typifies one of the department's own objectives: building on the past to make a better future."

View more photos of the construction online at *http://www.aem.umn.edu/info/spotlight/construction520.shtml*

Reduced Gravity

Fluids Team 06-07

Faculty Supervisor
Professor Ellen Longmire
Students:
Erik Axdahl, Eric Blake, Adam Lingwall, Zane Nitzkorski and Neil Sorensen.

Microgravity Study of Cavitation

Few people will have the opportunity to experience the weightlessness an astronaut does while in space. However, several students each year get close. Annually, students are accepted by NASA's Microgravity University where they run scientific experiments in reduced-gravity environments. The feeling of weightlessness is caused by a flight trajectory flown by NASA's specially-equipped aircraft, the Weightless Wonder.

This year, students from the Department of Aerospace Engineering and Mechanics measured cavitation in a microgravity environment. Cavitation is the phenomenon in which water vapor bubbles are generated in fast-moving liquids, like the bubbles one might observe behind a propeller. Collapse of these bubbles can cause damage to the propeller. Many machines experience cavitation in surrounding liquids.

AEM's Reduced Gravity team decided to study cavitation in part because of real-world implications - the consequences of machine failure caused by cavitation could be disastrous for applications requiring the use of the machinery, like for a propeller used on a submarine or even a pump used in a spacecraft on a long-term mission, according to the team's proposal.

The team found that a vortex formed between the spinning propeller and the tunnel wall which was unstable and would dissipate at irregular intervals. The strength and size of the vortex was greater in microgravity than in normal-gravity and 2g. The team also observed that the propeller in their apparatus spun at higher rpm in microgravity than in higher gravity. They attributed this to the lack of hydrostatic head and, therefore, the fact that less work was required of the propeller.

After experiencing some problems and other technical difficulties in the time leading up to the experiment, the team pulled together and created an experimental set-up that successfully measured cavitation in microgravity.

As to the actual experience of the flight, it was "indescribably awesome," Co-team Lead Erik Axdahl said.

"It's hard to describe because experiencing weightlessness isn't what you think it's going to be," he said. "It's like skydiving without the wind being against you; you have full range to at least try and move, but you might be standing there and suddenly your feet go over your head and there's nothing you can do."

In addition to enjoying the actual weightlessness, where one can perform a "Superman" (flying across the cabin), Axdahl said he enjoyed the experience because "from an academic point and a professional development point, it's really thrilling to see a side of engineering you don't see in class."

Teamwork played a large role in the success of the mission, he said.

Erik Axdahl

"Everybody brought something different to the table," he said.

"When we were getting the experiment to run in Houston, the whole group pulled through to meet every deadline and to get the experiment off the ground - literally."

With the days of the Weightless Wonder (also lovingly known as the "Vomit Comet") behind them, the team focused on sharing their results and experience with K-12 students and the broader community.

Neil Sorensen. Photos Courtesy NASA

Ellen Longmire, an AEM professor and adviser to this year's team, said NASA's Microgravity University is a good opportunity for undergraduates.

"The program gives students great experience at working on a practical engineering project with a research orientation," she said. "It also allows students to visit and experience the environment at NASA Johnson Space Center where they can interact directly with NASA engineers and astronauts."

Student participation each year is made possible by generous financial support from AEM alumnus Dick DeLeo (1946 B.S., 1948 M.S.) and other alumni. The students also applied for and were supported by UROP grants from the University of Minnesota.

The students were assisted in design and fabrication of the facility by Dave Hultman and Mario Costello of the EECS Machine Shop.

View photos from members of the team experiencing microgravity at *http://www.aem.umn.edu/proj-prog/sfo/fluids-2007/.*

Professor Graham Candler wins Thermophysics award, involved in successful scramjet launch

Professor Graham Candler of the Department of Aerospace Engineering and Mechanics received the prestigious 2007 Thermophysics Award in June from the American Institute of Aeronautics and Astronautics (AIAA), the professional society of the aerospace engineering field. This award recognizes the foremost leaders in the field of thermophysics – the study of thermodynamics, fluid mechanics and heat transfer.

Professor Graham Candler

Candler is the principal investigator for the National Center for Hypersonics Research, which has become a focal point for U.S. academic research in hypersonic aerodynamics. Center researchers are developing simulation methods to predict the flow of air over aircraft traveling at many times the speed of sound.

Thermophysics and the properties and mechanisms involved in predicting heat transfer rates during high-speed flight – Candler's main research interest – remains one of the most important and challenging areas in aerospace sciences, according to AIAA Executive Director Robert Dickman.

"As systems become more complex, and thermal properties in gases more difficult to measure, high fidelity numerical techniques are critical to our ability to understand and predict the properties of high temperature gas dynamics flow," he said. "The techniques developed by Professor Candler will have applications across a wide range of air and space systems."

Candler's work in thermophysics is used to understand the details of the flow field around spacecraft entering the atmosphere of a planet or traveling at high speed in earth's atmosphere. For example, his methods are being used to analyze the NASA Jet Propulsion Lab Mars Science Laboratory mission that is planned for launch in 2009.

Scramjet involvement:

In late June, a joint venture between Australia's Defence Science and Technology Organisation and the United States's Defense Advanced Research Projects Agency experienced a success, as did Professor Candler, who is heavily involved in the project.

A prototype scramjet engine flew at up to ten times the speed of sound, and is near or may exceed the fastest-ever air-speed record for non-rocket-propelled flight. A scramjet utilizes air to efficiently combust fuel in a ramjet engine. Professor Candler designed the air inlet, an integral part of the experimental engine.

Specifically, Candler said, computational fluid dynamics methods were used to design the inlet, or front-end of the vehicle. The inlet takes oncoming air and compresses it efficiently, so it can be burned with fuel to produce thrust.

"It's essential to the engine," Candler said. "The efficiency of the inlet to a large extent determines the efficiency of the engine itself."

Candler said it is exciting to see something he had designed fly.

"As an engineer, it's fun that you actually design something and go fly it," he said. "This is the first work I've been involved with where what we have worked on has been flown."

Other research:

Similar to his work on optimizing flow for scramjet engines, Candler is heavily involved in designing a next-generation nozzle for the Calspan-University of Buffalo Research Center. CUBRIC is partnered with AEM in the National Hypersonics Research Center. The nozzle will serve as the backbone for CUBRIC's new wind tunnel, which will allow.

Additionally, Candler is actively involved with NASA's Jet Propulsion Laboratory on the Mars Science Laboratory project. MSL is set to launch in 2009, and will search for water and biological material on Mars. The rover will weigh four times as much as previous rovers, and should roam Mars for almost two years.

Candler is working on MSL in two different areas: control systems and parachute optimization. The former aims to help the entry vehicle steer accurately in a difficult and varying atmosphere, Candler said.

"It's a difficult endeavor in the sense that the Mars atmosphere is about one tenth the pressure and density of the Earth atmosphere," he said. "There are fewer molecules to fly through, fewer molecules to slow down – it's hard to put big things on Mars because the entry problem is a lot more difficult."

The new rover's mass will compound the already-difficult atmospheric conditions, Candler said. For that reason, NASA has elected to release a much larger parachute from a greater altitude, which presents its own set of problems.

However, Candler said, simulations shed light on the issue.

"Simulations help to understand the physics of how the parachute functions at those kind of conditions, whether it will stay inflated, and whether there will be sufficient drag to slow it down."

Department Head Gary Balas honored with Distinguished McKnight University Professorship

AEM's own Professor Gary Balas was recently honored with a Distinguished McKnight University Professorship, the highest award the University can bestow on mid-career faculty. The program was established in 1996 to recognize the University's highest-achieving faculty. Professor Balas is among six recipients from departments across the University who were selected based on:

- ♦The merit of their scholarly or creative achievements
- ♦The level of distinction and prestige that their scholarly work brings to the University of Minnesota
- ♦The dimension of national or international reputation
- ♦The extent to which their career has developed and flourished at the University and the extent to which their work and reputation are identified with the University of Minnesota
- ♦Potential for greater attainment in the field
- ♦Quality of teaching and advising
- ♦Contributions to the wider community

Professor Balas' research focuses on control engineering with application to aerospace vehicles and systems. He is an international leader in robust control, which bridges the gap between mathematical control theory and engineering applications.

Professor Perry Leo, AEM's associate department head, said Balas is one of the three top researchers in world in developing control theory and applying it to real problems. "Gary's work has been essential to national projects in aerospace engineering including the F-14 fighter jet, the International Space Station and NASA's X-38 Crew Recovery Vehicle" he said.

In addition to serving as Department Head, Balas was Director of Graduate Studies of the Control Science and Dynamical Systems (CSDy) interdisciplinary program from 1992 until 2006 and its co-Director since 1995.

Balas described the professorship, awarded by his peers at the University, as a "wonderful honor."

"My career has been able to flourish in the AEM department because of the outstanding support provided to me by the department, college and university throughout my career," he said.

The department of Aerospace Engineering and Mechanics boasts a total of three Distinguished McKnight Professors: professor Balas, professor Graham Candler and professor Richard James.

Research will continue to be a main priority, Balas said.

"I look forward to continuing research on robust and real-time control, linear parameter-varying systems and their application to real world systems."

Research:

In the vein of his main research interest, Balas has been focusing on development of analysis tools for certification of flight control laws.

Department Head Gary Balas

"Analysis techniques currently being used for current military aircraft, e.g. F/A-22 and JSF aircraft, are well-suited to certify flight control systems," Balas said. "These techniques though are complex, time-consuming and require many well trained control and simulation engineers to accomplish."

The research will focus on certification of control algorithms, allowing future UAV's the capability of highly aggressive maneuvers using nonlinear, adaptive, reconfigurable flight control systems.

"The goal is to develop a flexible, comprehensive nonlinear robustness analysis package oriented towards flight control law certification," Balas said.

Prof. Balas is also examining controlling supercavitating vehicles. Supercavitation occurs when liquids travel at very high speeds. The objects generate "cavitation," or water vapor, bubbles on the corners of sharp contours due to pressure gradients that result in flow separation.

This is often the case if a propeller spins fast enough. The surrounding liquid is vaporized due to the decrease in pressure generating cavitation bubbles, Balas said.

As pressure surrounding the liquid decreases, the bubbles collapse. Even if the body is stable inside the cavity, the vehicle may not be stable when in contact with the cavity. Collapse of these bubbles can cause damage to the propeller or other mechanical objects.

"Nonlinear interaction of the control surfaces and the body with the cavity wall is very important when calculating the fin and planing forces acting on the vehicle," Balas said. "The cavity wall exerts a large restoring force over the short period of time. The nature of this instability forces the vehicle back into the cavity, often resulting in limit-cycle behavior."

Supercavitating vehicles hold the potential to travel extremely quickly, and safely, in water.

Eugene E. Covert recognized with OAA

Dr. Eugene E. Covert, an alumnus of the Aerospace Engineering and Mechanics department, received a prestigious Outstanding Achievement Award from the University of Minnesota on May 4, 2007.

Outstanding Achievement Awards are conferred to University alumni and alumna who have attained "unusual distinction" and demonstrated "outstanding achievement and leadership" in their respective field and community. Dr. Covert certainly fits both categories.

Covert is a world-renowned aeronautical engineer who has received several prestigious awards, including the Daniel Guggenheim Medal. and is a fellow of the National Academy of Engineering. The Daniel Guggenheim Medal is arguably the most distinguished award in the aerospace field. Some of its recipients include Orville Wright, William Boeing and Charles Lindbergh.

Professor Eugene E. Covert speaks at the AEM Undergraduate reception

Dr. Covert graduated from the University of Minnesota with a BAEM in 1946 and a Masters in Aeronautical Engineering in 1948. He received a doctorate from the Massachusetts Institute of Technology in 1958.

Covert's career includes activities spanning the areas of research, teaching, and public service. His aeronautics career began in 1946 at the Naval Air Modification Unit's Pilotless Aircraft Division where he worked on projects leading to the Sparrow missile. In the 1950s he conducted tests on numerous aircraft types, including the famed F-4 Phantom, at the MIT Naval Supersonic Wind Tunnel. His interest in the problems of supporting aircraft models in wind tunnels led him to develop the world's first practical wind tunnel magnetic suspension system.

In the late 1970s, Covert served as chief scientist of the U.S. Air Force.

Robert Seamens, a former Professor and former Dean of the School of Engineering at MIT, served as Secretary of the Air Force with Covert.

"The Air Force had its share of technical issues related to its aircraft, missiles, and spacecraft during his tenure, and it was reassuring to know he was on deck at all times," Seamens said of Covert. "His participation at meetings and on travel helped me to focus on the key problems; at the same time he often broke the tension of the moment with his incisive sense of humor."

Later, Covert worked at NASA as a consultant on the Space Shuttle main engine and a member of the commission that examined the Challenger accident.

Michael Griffin, who leads NASA as its Administrator, said Covert and his expertise have "served NASA greatly" during his time on several committees, as well as during times of crisis, like the Challenger accident.

"His position on our investigation boards has ensured sound, reasonable analyses and conclusions," he said. "As a student of space history, I consider Dr. Covert to be an engineer's engineer whose legacy is unsurpassed."

William Garrard, AEM Professor, Director of the Minnesota Space Grant and former Department Head, echoed Griffin's sentiments.

"The Department and the University of Minnesota are extremely proud of Dr. Covert's many notable accomplishments. As a recipient of the Outstanding Achievement Award, he joins a very distinguished group of our alumni who have made enormous contributions to the aerospace field," he said.

Faculty News

Professor Yohannes Ketema received the "Professor of the Year" award for 2006-2007 for AEM from the Institute of Technology Student Board.

Professor Ellen Longmire was elected Secretary/Treasurer of the American Physical Society Division of Fluid Dynamics in November 2006 for a three year term.

Professor Ellen Longmire received the university-wide Distinguished Women Scholars Award in Science and Engineering for 2007.

Professor Ellen Longmire served on the Provost's Advisory Committee for the Institute for Advancement of Science and Engineering, 2006-07.

Professor William Garrard received the Leland Atwood award including a medal from the AIAA at the AIAA Atmospheric Sciences Meeting in Reno, January, 2007.

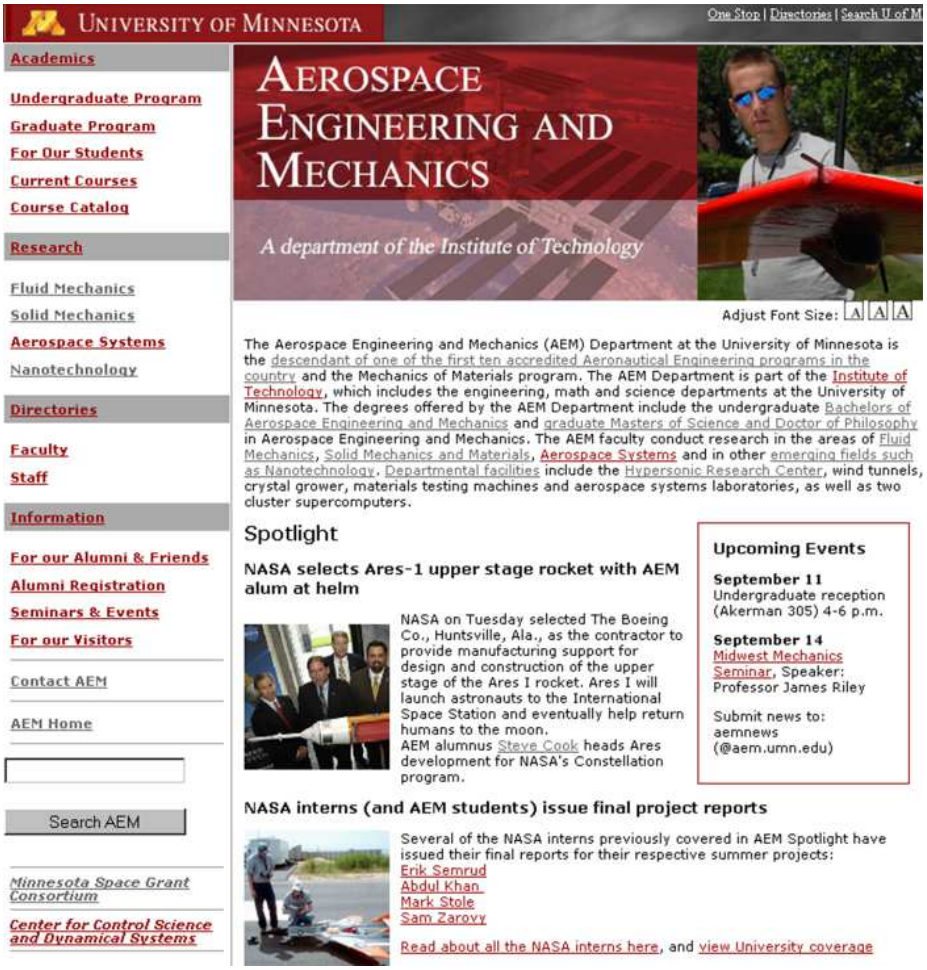
Professor Graham Candler received the 2007 Thermophysics Award from the AIAA.

Department Head Gary Balas was honored with a Distinguished McKnight Professorship from the University.

Professor Ivan Marusic left the department to take a faculty position at the University of Melbourne. He was awarded a prestigious Federation Fellowship.

Professor Ashley James left the department for a position in industry.

New AEM web site launches



After many months of planning and renovation, AEM's web site has re-launched with a new design and new content offerings. In addition to improved aesthetics, the site offers faculty more flexibility and capacity to offer information about their award-winning research. This includes a repository of interactive bibliographic information on faculty-published works. Additionally, the Research and Alumni sections, respectively, have seen a full redesign.

As part of the redesign, AEM is looking to offer more information to our constituents on the happenings of alumni and department friends. To do that, we need your help. Submit news, photos or tips, and look for it on the site.

Visit *www.aem.umn.edu* to see the changes first-hand.

MnSGC update from page 4

fellowships, valued at over $125,000, were distributed across the consortium. These included scholarships for 6 students going to NASA research centers for summer internships during the summer of 2006. An additional 11 Minnesota students received MnSGC support to do NASA internships during the summer of 2007.

Besides distributing scholarships, MnSGC affiliate institutions use Space Grant funds for Higher Education (such as development of new STEM courses), Research (like hiring student research assistants), Pre-college (for example, by offering teacher workshops), and Informal Education (sponsoring lectures or activities by which the general public can learn more about space science, NASA, research, and career opportunities in STEM areas). All 13 higher education affiliates listed above provide MnSGC programming from their campuses which are spread about the entire state of Minnesota.

At the U this past year MnSGC staff and scholarship recipients conducted numerous workshops on rocketry and other aerospace topics for local school groups and also hosted a visit by middle school teachers in an aerospace workshop put on by MNDOT. The MnSGC also supports Dr. Demoz Gebre-Egziabher's student team working on the Nanosat student-satellite competition. During the summer of 2007 Dr. Flaten mentored a ballooning team of undergraduates who design, build, and launch science payloads into "near space" (up to about 100,000 feet) using helium-filled weather balloons.

Associate Director Flaten is seen here explaining AEM's wind-tunnel capabilities to visiting teachers interested in incorporating aerospace into their curriculum.

Associate Director James Flaten

Undergraduate graduation reception

The graduation reception gave 2006-2007 graduates an opportunity to have their parents meet faculty and display their work. Congratulations, graduates, and good luck in the future!

Congratulations 2006-2007 Graduates!

Aerospace Engineering and Mechanics B.S.
- Jason Andersen
- Erik Axdahl
- Jon Braam
- Joshua Brand
- Joseph Buchholz
- Christopher Buckner
- Nicholas Buystedt
- Thomas Chouinard
- Timothy Cleaver
- Travis Cowles
- Luke Ellison
- Daniel Forster
- Andrew Geeslin
- Karen Hafner
- Raymond Haremza
- Michael Hiti
- Jacob Horky
- Jarred Huiras
- Karl Icenogle
- Kory Jenkins
- Vincent Jusuf
- Benjamin Kempen
- Nathan Leopold
- Grant Lichtsinn
- Adam Lingwall
- Brian Miller
- Matthew Mueller
- Nicholas Naschansky
- Jacob Oltman
- Alex Ordway
- Michelle Palm
- Andrew Pankewycz
- Thomas Peitzmeier
- Nicole Pierre
- Jeremy Reem
- Trent Schmittfranz
- Neil Sorensen
- Tomoyuki Sugano
- Kyle Tholen
- Adam Thoreen
- Daniel Van Lith
- Lucas Veverka
- Eric Weber
- Matthew Whitten
- Daniel Willemssen
- Aaron Fuchs
- Kurt Goedjen
- Wan Hassan
- Timothy Lau
- Charles Little
- Jason Mintz
- Umesh Rao
- Katherine Ruzicka
- Kha Tran

Aerospace Engineering and Mechanics M.S.
- Romeo Ahohe
- Rayna DeMaster
- Arnar Hjartarson
- Michael Mattson
- Gridsada Phanomchoeng
- Rajes Sau
- Tessa Stranik
- Christopher Visker
- Yiming Wu

Aerospace Engineering Ph.D.
- Martin Vysohlid

Aerospace Engineering and Mechanics Ph.D.
- Charles Campbell
- Gaio Lakin
- Ying Qi
- Suman Muppidi
- Pramod Subbareddy
- Xiaofeng Yang

Interns from page 2

from underrepresented groups into the aerospace field. With 20 to 25 percent of scholarships and fellowships going to minority applicants and 50 percent to women, the Minnesota consortium is more than meeting its goals, Garrard adds.

MESSENGER to Mercury

At this moment, NASA's MESSENGER spacecraft is speeding toward Mercury, where its mission includes photographing the poorly known planet's entire surface. Launched in August 2004, the spacecraft has completed one "flyby" of Earth and two of Venus to use the planets' gravity as slingshots to assist its flight. It will perform three flybys of Mercury before settling into orbit.

"It has a five-billion-mile [journey]," says Zane Nitzkorski, a senior from Harwood, N.D., majoring in AEM and mathematics now interning at APL along with Chouinard. "We're positioning it for its first Mercury flyby." For his part, Chouinard is dealing with the problems of keeping MESSENGER on course, with its antennas pointed correctly, even though fuel sloshing around in its tank keeps changing the spacecraft's center of gravity and momentum.

The moon is a harsh mistress

Future missions to the moon occupy interns like Erik Semrud, an AEM senior from Hugo, Minn. He's working on a project to determine if an unmanned mission to collect lunar samples can be done. The moon shows no sign of cooperating.

"The moon has a really messy gravitational field," Semrud explains. "If you put something in orbit around the moon, it will crash." That's because the moon's craters and mountains, plus other irregularities, create local highs and lows in the lunar gravity that are hard to navigate around.

But Semrud likes a challenge. He's at NASA Goddard Space Flight Center in Greenbelt, MD., researching the optimal lunar orbit for such a spacecraft and how to correct an orbit if necessary.

Nitzkorski is working on mapping the moon's profile. He uses data, dating back to the 1950s, from widely separated observers who watched the moon "graze" stars as it moved across the night sky. The observers recorded the times the stars blinked off and on behind mountains at the edge of the moon as it passed; by triangulating from two or more observations, the positions of the mountains, and thus their sizes, can be estimated.

In another project, AEM senior Jamie Wilt, from Rockford, Ill., is at Goddard, where she is calculating optimal orbits for the vehicles of a potential manned moon mission in 2012. She's looking at orbits around both Earth and the moon with an eye toward minimizing fuel consumption and travel time between the two bodies.

"I've always liked orbital dynamics and astrophysics, but this is the first chance I've had to work in the field," she says.

All the students raved about their internships.

"Just being here and talking the lingo with people who have been in the business 10 to 20 years is invaluable, something you can't learn any other way," says Chouinard.

Deane Morrison

This article was featured in August on the University of Minnesota's and UMNNews' home page.

AEM Update

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