Aerospace Engineering and Engineering Mechanics

The Longhorn Liftoff

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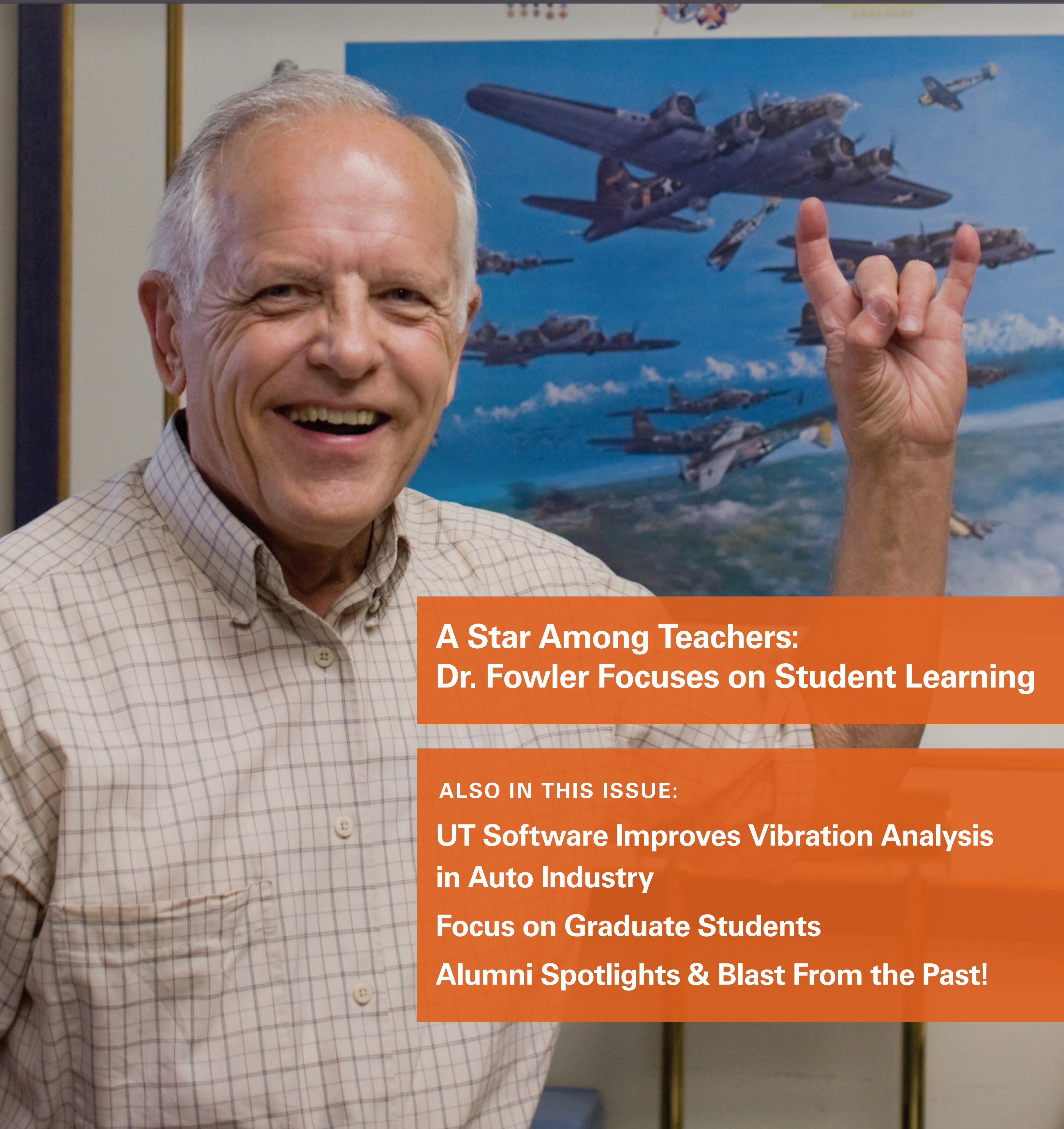


A Star Among Teachers: Dr. Fowler Focuses on Student Learning

ALSO IN THIS ISSUE:

UT Software Improves Vibration Analysis in Auto Industry

Focus on Graduate Students

Alumni Spotlights & Blast From the Past!

THE CHAIRMAN'S CORNER

by Dr. Philip L. Varghese

The new school year is now well underway, and our students are busy with classes, cutting-edge research and exciting projects. Last year we started a new organization WIALD – Women in Aerospace Leadership Development. Our students worked in collaboration with Fredericksburg High School's Aeroscience program and over the summer, WIALD members traveled to White Sands, New Mexico to watch their payload launch aboard a hybrid ballistic rocket with their instrumentation package performing exactly as designed.

Also over the summer the UT Unmanned Aerial Vehicle (UAV) Group traveled to Lexington Park, Maryland to compete at the 2010 Association for Unmanned Vehicle Systems International Student Competition. This multidisciplinary UAV team, comprising undergraduate and graduate students from ASE and ECE, won a $2,200 prize for their Phoenix II Unmanned Aircraft System. As the only team to design and build all their subsystems in-house, the UT UAV Group represents one of the best attributes of the department: continued successful collaboration between graduates and undergraduates. Our students are also beginning to take an important lesson to heart – major projects require multi-disciplinary collaboration.

Our undergraduates are constantly seeking new challenges. Just this fall, two new projects have been started: one group is working on a human-powered helicopter; another group was inspired by a presentation by MS alumnus Jon Thompson '71 to work in support of the search for Amelia Earhart's airplane.

It was gratifying to see the department once again rank in the top ten among U.S. aerospace engineering programs by the *U.S. News & World Report*. I hope you share my pride in seeing that the undergraduate program moved up to 8th place this year, while the graduate program is ranked 10th. One observation about the undergraduate rankings: there is one undergraduate program ranked above us at a school that does not have an undergraduate program in aerospace engineering. They do have an outstanding graduate program, and when people are asked to rank undergraduate programs, they automatically assume that the graduate program also has an outstanding associated undergraduate program. Possibly, one of the ways to improve our undergraduate program ranking is to further strengthen our graduate program.

We continue to have truly outstanding graduate students in our program. Fellowship recipients Annie Lum and Henri Kjellberg are developing the technology to make satellites the size of a briefcase. Colleen Kaul is studying large eddy simulation for modeling turbulent flows and Julian Hallai is investigating the stability of off-shore pipelines. I know you will enjoy reading about several of our graduate students and their innovative research on pages 7–9.

You can also read about our department's first PhD graduate, Dr. Felix Fenter, the architect of the first hit-to-kill intercept of a tactical ballistic missile. In this issue, we also spotlight one of the department's most beloved professors, Dr. Wallace Fowler, who recently received the 2010 Regents' Outstanding Teaching Award. Prof. Fowler epitomizes our faculty's mission to educate future engineering leaders, create knowledge through research with students and distribute that knowledge. Research universities play a critical role in taking innovation to the marketplace; this transfer of technology drives our nation's economy. A great example is described in the article on Professor Jeffrey Bennighof's vibration analysis software that has revolutionized the way the auto industry reduces noise and vibration in production vehicles.

Graduate students are the driving force behind our success. In order to attract the world's brightest engineering graduate students, we must remain competitive in the opportunities we offer them. Federal and state funding for graduate students has declined while other countries have made significant investments in graduate education. This jeopardizes the U.S. edge as a global economic leader. The Cockrell School has begun a bold campaign to raise $135 million for graduate fellowships, and I want the ASE/EM department to be one of the leaders both in raising funds and attracting the best students.

Our goal is to be one of the top five programs in the U.S., and to have the best aerospace engineering graduate and undergraduate programs at a public university. To achieve this ambitious goal, we will need the support of our alumni, parents and friends. I look forward to continuing to work with all of you to make this vision a reality.

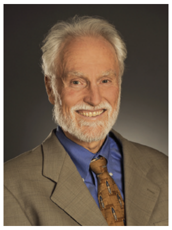
Above left: Philip L. Varghese, Distinguished Teaching Professor and Chair, Aerospace Engineeering & Engineering Mechanics Department
Photo by Beverly Barrett

FACULTY AWARDS AND UPDATES

DR. RAYNOR DUNCOMBE Professor Emeritus Raynor L. Duncombe was elected Fellow of the Institution of Navigation (ION) "for his involvement in developing the initial methods for tracking the first artificial satellites, for his leadership in the production of almanacs and the development of the new celestial reference system in the 1970s, and for his contributions in the founding of the International Association of Institutes of Navigation." Dr. Duncombe's research interests include astrometry from space, space reference frames and motions of principal planets and minor planets. He specializes in orbital mechanics and dynamical astronomy and currently teaches the graduate course "Determination of Time."

DR. WALLACE FOWLER was presented with a 2010 Regents' Outstanding Teaching award during a ceremony held on the University of Texas at Austin campus on August 11. He was among the 38 tenured faculty members to receive a $30,000 award and was also presented with a bronze medallion and a certificate of achievement. A University Distinguished Teaching Professor, Dr. Fowler has been teaching in the Cockrell School of Engineering for forty-five years. He holds the Paul D. and Betty Robertson Meek Centennial Professor in Engineering, and serves as the Director of the Texas Space Grant Consortium.

DR. THOMAS HUGHES was elected to the Foreign Associate of the Austrian Academy of Sciences. He received a diploma during the Festive Session of the Academy held in May, and in June he was presented with an honorary degree from Northwestern University at Northwestern's 152nd annual commencement exercises. This past August, Hughes gave an invited Plenary Lecture entitled "Isogeometric Analysis" at the International Congress of Mathematicians (ICM 2010) in Hyderabad, India. Professor Hughes holds the Computational and Applied Mathematics Chair III in the Institute for Computational Engineering and Sciences (ICES).



DR. KENNETH LIECHTI is among one of five co-authors to receive the Best Paper Award at the Society for Experimental Mechanics at the 2010 SEM Annual Conference and Exposition on Experimental and Applied Mechanics, held June 7-10 in Indianapolis, Indiana. The paper, titled "Fracture Between Self-Assembled Monolayers," was co-authored by S.R. Na, B. Doynov, A. Hassan, K. M. Liechti and M.J. Krische. Dr. Liechti holds the E.P. Schoch Professorship in Engineering and is affiliated with the Center for Mechanics of Solids, Structures and Materials.

DR MARY WHEELER has been elected a fellow of the American Academy of Arts and Sciences. Founded in 1780, the Academy recognizes international achievement in science, the arts, business and public leadership. The organization has brought together the nation's leading figures from universities, government, business and the creative arts to exchange ideas and promote knowledge in the public interest.

Wheeler was also recently invited to give a Sectional Lecture at the International Congress of Mathematicians (ICM 2010) in Hyderabad, India. The lecture was entitled "The Role of Computational Science in Protecting the Environment: Geological Storage of Carbon Dioxide."

Wheeler focuses on developing and refining algorithms that apply massive parallel computational power to equations that describe subsurface processes. Such processes include oil and gas recovery, the spread of groundwater contaminants and the viability of carbon sequestration. She is director of the Center for Subsurface Modeling at the University's Institute for Computational Engineering and Sciences (ICES).

Wheeler holds the Ernest and Virginia Cockrell Chair in the Department of Aerospace Engineering and Engineering Mechanics and has appointments in the departments of Mathematics and Petroleum and Geosystems Engineering.

UAV TEAM WINS COMPETITION PRIZE

by Miki Szmuk, UAV Team Lead
Faculty Advisor, Dr. Armand Chaput

Above: The UT UAV Team and its Phoenix II aircraft won a total of $2,200 in prize money at the AUVSI Competition in Lexington Park, Maryland.

This year marked the UT Unmanned Aerial Vehicle (UAV) Group's second appearance at the 2010 Association for Unmanned Vehicle Systems International (AUVSI) Student Unmanned Aircraft Systems (UAS) Competition, held in Lexington Park, Maryland. The internationally renowned competition mimics a real-world military scenario, structured around a close-proximity, autonomous reconnaissance mission. Teams are scored in three areas: a journal paper describing the UAS and the systems engineering approach taken to design it, an oral briefing resembling a Test Readiness Review (TRR), and most importantly, a 20 to 40 minute flight demonstration. Additional prize money is awarded for the completion of prize barrels.

The UT UAV Group premiered its next generation system, the Phoenix II UAS, a result of the dedicated work of an interdisciplinary group of undergraduate and graduate students from the aerospace and electrical engineering departments. The system features a new and improved airframe, a repackaged avionics system, a stabilized, dual-axis Electro-Optical (EO) sensor, and a redesigned Ground Control Station (GCS).

The Phoenix II airframe boasts a number of design improvements over her predecessor, Phoenix I. These include a larger 10ft wingspan for slower flight speeds, larger hatches for improved payload accessibility, and an external switch box that controls all of the on-board electronics.

The consolidated avionics system comprises many of the same electronics used in the Phoenix I UAS. The team placed an emphasis on minimizing wiring and increasing the reliability of connections. As part of this effort, a six-layer Printed Circuit Board (PCB) was designed and proved conducive to reducing payload volume and weight, eliminating half a pound of wiring. This endeavor served to increase the team's electrical engineering capabilities and is sure to aid in future designs.

One of the greatest improvements made to the Phoenix II UAS is a newly implemented camera-gimbal stabilization system. Utilizing a student-developed algorithm, coupled with a reformulated avionics architecture, the dual-axis gimbal is actuated by the on-board flight computer. As a result, the system is able to compensate for the aircraft's changes in attitude, and resulted in highly improved reconnaissance capabilities. Next year's system will also include a GPS target tracking capability.

Last, but not least, the re-designed GCS presented the UAS operators with improved situational awareness and functionality. Of particular importance was the Target Recognition System (TAS), which provided the UT team with a unique autonomous capability. Consequently, the UT UAV Group was the only team to win the prize barrel for Autonomous Target Recognition (ATR), an award worth $1,000.

The UT UAV Group won a total of $2,200 in prize money, placing 14th out of 26, and stood alone as the only team to design and build all of the subsystems in-house. Several competing teams commented on the Phoenix II design, stating that it was the best looking airplane at the competition. The UT team returned home in high spirits and aspires for an even higher performance at next year's competition. By utilizing the Phoenix II UAS, as well as the technical foundation established this year, the group plans to devote next year to testing, mission operations and competition readiness.

Gratitude is extended to all those who made the 2010 AUVSI experience possible. In particular, the team would like to thank Dr. Armand Chaput for his role as faculty advisor, and Chairman Dr. Philip Varghese for the department's financial support. As always, the team's efforts would have been for naught without Mark Maughmer II's invaluable technical expertise and piloting skills. The team's technical achievements were realized due to the hard work and leadership of our students: Miki Szmuk, team lead; Jonathan Tamir, TAS lead; Vishnu Joythindran, GCS lead; Akber Patel, airframe lead; Travis Weaver, avionics lead; and Hector Escobar, Jorge Alvarez, and Sergio Rodriguez (Polytechnic University of Valencia) for their work on the autopilot. Additionally, the team is indebted to Chockalingam, Ivan Davidachev, Marlan Kinsley, and Sarah Triana for their hard work throughout the year. The UT UAV Group is excited about next year's competition and is looking forward to improving its system's autonomy and mission performance.

A 'WIALD' RIDE

by Katie Lodrige, Undergraduate Student
Faculty Advisor, Dr. Armand Chaput

Above: Members of WIALD with faculty advisor Dr. Armand Chaput in White Sands, New Mexico.

Nine months ago, a group of eager women in the UT Aerospace Engineering department joined together for the purpose of collaborating on a project to encourage the enhancement of their engineering leadership skills. This newly formed group, WIALD (Women in Aerospace Leadership Development), accomplished taking on the task of creating a successful payload designed to capture real-time video aboard a hybrid ballistic rocket. Members had the opportunity to join Fredericksburg High School Aeroscience Program's dream of reaching the edge of space, a dream that may not have occurred had we not received the overwhelming support and true dedication from many people, organizations and companies.

The moment we had all been waiting for finally arrived on Friday, August 6 when the White Sands personnel began the 5 second countdown to our rocket launch. We held our breath as the rocket sat on the launch pad for 22 seconds – it was firing, but not moving. Our hearts began to sink as we believed our payload would not leave the launch pad as anticipated. Nearly ready to call it a day, the rocket suddenly launched into the air at an incredible acceleration – 20 G – reaching its maximum altitude at a couple of hundred feet before our parachute opened to bring our payload safely to the ground.

An amazing group of students at Fredericksburg High School designed and built an incredible hybrid Ballistic rocket, including the motors and propulsion system. Our payload's (an electrical component of the rocket) main mission was to capture live video feed, and it was a true success. The payload landed beautifully and virtually unharmed and provided clear video as well as on-board data – data that will help Fredericksburg High School understand their rocket's performance and help them reach their intended goal, to reach the edge of space.

Our moment of success lends most of its credit to the tremendous people who have supported the WIALD group along way. Through the help of Texas Space Grant Consortium, the Cockrell School's Women in Engineering Program, NASA, White Sands Missile Range, Fredericksburg High School's Aeroscience Program and the generous staff and students at the University of Texas, WIALD was able to have a privileged experience at the birthplace of the aerospace industry in White Sands, New Mexico.

It is our group's mission to continue to apply our college-learned skills toward challenging hands-on projects in hopes of mastering these skills. First and foremost, we plan to analyze every detail of our recent launch in order to assess the problems and triumphs we faced. It is also our goal to introduce our university to new unexplored projects that will solve relevant problems in the aerospace industry.

WIALD is a newly founded student interest group that was created during the late fall of the 2009-2010 school year. We believe our success stems from our carefree persona, consideration of all ideas and efficient communication. We emerge not only as a group of women able to launch a component of a rocket, but also as a close-knit group of friends who encourage each other to achieve our highest goals and dreams. Ultimately, WIALD seeks to provide confidence and support that will empower all women in the aerospace field of study to successes at any hands-on endeavor.

To support or learn more about our student projects and teams, please contact Amanda Brown at 512-471-4046.

FASTRAC to Launch Soon!

Since 2005 the FASTRAC (Formation Autonomy Spacecraft with Thrust, Relnav, Attitude and Crosslink) team has been waiting for the moment its satellites will launch into space, which is finally scheduled to happen this fall. The pair of nanosatellites were developed and built by students in the UT Aerospace Engineering Department. The FASTRAC project and mission, sponsored by Air Force Research Laboratory (AFRL), investigates technologies enabling space research using satellite formations. The utilization of satellite formations in space is a pivotal advancement for the future of space exploration and research.

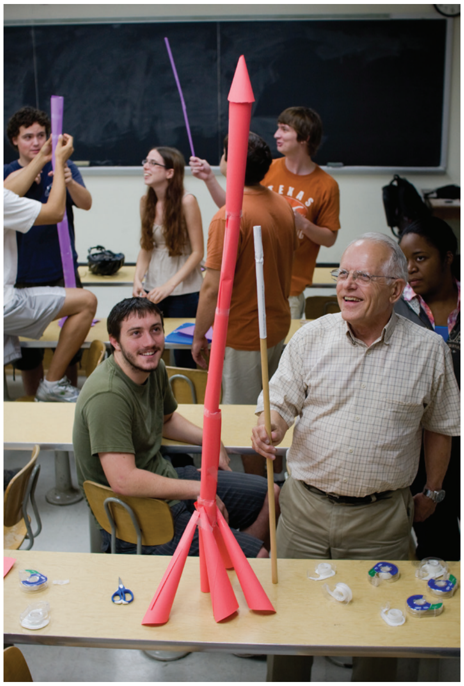
The satellites are now waiting to be integrated into the launch vehicle up in Kodiak, Alaska. From there, they will be launched into a 650 km altitude, 72° inclination circular orbit on board STP-S26, a Minotaur IV rocket provided by the Air Force Research Labs (AFRL) through the Space Test Program (STP).

In preparation for the launch, the student team has been busy putting the final touches on the operational procedures using the department's Spacecraft Control Center by tracking other amateur satellites, establishing communications with and through them to other ground stations, as well as performing "FASTRAC Mission Operations" simulations with the FASTRAC Flatsat Electrical Testbeds in the Satellite Design Lab. The team has also created a venue on the FASTRAC website for amateur radio operators where they will be able to collaborate and track the satellites once they are launched.

To stay on track with FASTRAC, visit http://fastrac.ae.utexas.edu. You can also find us on Facebook at http://www.facebook.com/fastracsats and follow us on Twitter: http://www.twitter.com/fastracsats

A STAR AMONG TEACHERS:
Professor Wallace Fowler Focuses on Student Learning

Story and Photos by Tara Haelle



Above: Dr. Fowler working with a group of students during their rocket building event.

Students and alumni alike have fond memories of their experiences with Dr. Fowler's teaching.

Raquel Galvan, BS ASE 2009 and the 2009-2010 Marsha and Wallace Fowler Scholarship recipient, said, "Dr. Fowler is a professor who genuinely wants to help his students advance, makes himself available for students and welcomes discussions and debates. He always encouraged us to be creative and push boundaries to go beyond what has already been done."

According to senior Grant Rossman who recently took Fowler's Spacecraft Mission Design course: "He tells you what you need to hear so that you can discover the right answer for yourself! And that's the most valuable thing of all. Dr. Fowler allows each student to think his way through an academic journey and make all of the groundbreaking discoveries themselves."

With his bright blue eyes sparkling, Professor Wallace Fowler shows off one of his favorite toys: a gyroscope he uses to exercise his hands. It sits on the same shelf as a triangular puzzle of golf tees and a game that requires the user to pop a small metal ball into a groove inside a clear plastic box. And these are just a handful of the knick-knacks on his bookshelves, equally packed with tomes on engineering mechanics and space mission planning, Dr. Fowler's primary area of research. In an office with nearly many toys on the shelves – from Marvin the Martian to a space cadet Smurf – as teaching awards on the walls, it's not hard to see why Dr. Fowler ranks among alumni's favorite professors in the aerospace department.

"Teaching is probably more important to me than research in a lot of ways," Dr. Fowler said. "Some people think teaching is the cross they bear to get to do the research they want, but I'm on the opposite side of that."

Fowler's success as an educator doesn't go unnoticed. Already a University Distinguished Teaching Professor, Fowler was recently honored with a 2010 Regents' Outstanding Teaching Award, reserved for faculty who demonstrate extraordinary classroom performance and innovation at the undergraduate level. One of Dr. Fowler's most popular classes is definitely innovative: his senior design course on spacecraft and mission planning requires students to plan challenging space missions in teams. Projects from this semester's students include designing a communications system to communicate from under the ice of Jupiter's moon Europa and an exploration mission that can withstand the harsh, toxic environment of Venus.

"I really enjoyed my undergraduate experience in his class," said Brent Minchew, a graduate student who earned both his Master's and Bachelor's in Aerospace at UT. "He's always this bundle of energy, always happy, smiling and encouraging. Dr. Fowler really loves this stuff and is really interested in his students, and I think that shows."

Dr. Fowler's history at UT goes way back to his undergraduate years when he earned his BA in math at UT in 1960. He continued on at the University to earn an MS in Engineering Mechanics in 1961 and a PhD in Engineering Mechanics in 1965. Arriving on campus the same year that Darrell Royal came to coach the Longhorns, Dr. Fowler witnessed the Royal era from end to end. With the endowment of the Marsha and Wallace Fowler Scholarship in 2002, his legacy will live on into the future of UT as well.

"We seeded the endowment because students need support," Dr. Fowler said. "When I was a student, I needed support every now and then too."

These days, he supports his students with more than scholarship money as he uses his gift for communication to enliven class and teach students to apply their math and design skills to real-world problems.

"If you're able to teach and communicate well, it's leverage," he said. "I can go and do it myself and be a party of one, or I can send out an army."

"I was always amazed by how he had more creative ideas about spacecraft design than most of the students! That planted the seed for not being afraid to think outside of the box."

– Ravi Prakash, BS ASE 2003

If you want to let Dr. Fowler know the impact he's made on your life, please consider making a gift to the Marsha and Wallace Fowler Scholarship. Contact Amanda Brown at 512-471-4046 or amanda.brown@austin.utexas.edu to make your gift.

Annie Lum: Launching Something into Space — Is There Anything Better?

Faculty Advisor, Professor Glenn Lightsey

This may be Annie Lum's first semester in the Aerospace program, but she has wasted no time in making the nanosatellite lab her home. Lum comes to UT from Washington, DC, where she worked at the Naval Research Laboratory's Astrodynamics and Space Navigation Group on numerical analysis for different satellite projects, including simulations and performance of systems. When she applied and was selected to participate in NRL's robust continuing education program – three semesters at any U.S. school to earn an advanced degree in her field – UT's outstanding orbital mechanics program immediately caught her attention.

"All the course offerings and classes looked interesting, and what Professor Glenn Lightsey is researching is a good fit for what I'm researching," she said. She certainly has not regretted her decision.

"I'm really enjoying the nanosatellite group," she said. "Everyone's really enthusiastic and puts in crazy hours and is totally into it. It's cool to be working with all these people who are so passionate about this work."

Lum, who earned her BS in aerospace engineering at Boston University in 2008, researches differential drag on satellites.

"Theoretically you could use different areas and different size spacecraft to maneuver them closer or farther away from each other," she explained. "If you had a way to change your projected area, you could change the way drag is affecting your spacecraft." Her research involves modifying a few equations of motion to include different perturbations – such as third body effects, solar pressure, earth gravitational effects – and then develop a controller that will use differential drag to perform maneuvers between two or more spacecraft.

"I've had a lot of hands-on learning at the [Naval] lab, which is great, but having more formal theory behind it has helped me," she said. "Taking formal classes in optimization is great for any kind of design work because you always want to get the most you can out of a system."

After she graduates in December 2011, Lum will return to NRL and hopes to play a bigger role in leadership at her employer.

"I really enjoy the work I do there, and I'm looking forward to being a more integral part of NRL's team," she said. "I think having an advanced degree will allow me to play more of a role in managing projects," said Lum.

Although she sees herself at NRL for the foreseeable future, Lum said she has always had an interest in earning her PhD and becoming a professor further down the road. She said there's no question about what makes her work in aerospace so exciting.

"To be totally nerdy, you work on something that goes up into space, something that will actually be launched up on a rocket," she said. "That's great – is there anything better?"

Henri Kjellberg: The Business of Sending CubeSats into Orbit

Faculty Advisor, Professor Glenn Lightsey

Aerospace engineering graduate student Henri Kjellberg's moment of clarity came during his undergraduate co-op experience working for United Space Alliance at NASA Johnson Space Center's (JSC) neutral buoyancy lab. He noticed something about the employees with the most exciting jobs.

"I found the people with the highest degrees had the coolest jobs at NASA," he said. "So that convinced me that I shouldn't go into the industry before getting an advanced degree."

Because he's "terribly in love with Austin," Kjellberg stayed at UT after earning his Bachelor's in Aerospace Engineering in 2008, and his National Defense Science and Engineering Graduate Fellowship gives him the freedom to work exclusively on tiny satellites called "CubeSats" in the picosatellite lab. For Kjellberg, working with Dr. Lightsey and other graduate students in the lab is about more than building cutting-edge satellites small enough to fit into a briefcase. It's also about the entrepreneurial experience of running a small business of sorts.

"We have to buy a lot of hardware and technologies from vendors and deliver them to our customer, NASA," Kjellberg explained. "We have a budget, and it's completely student-driven."

That student-driven project is a joint one between NASA-JSC, Texas A&M and the University of Texas, with teams from both universities working together on a series of four missions with NASA that will hopefully result in the autonomous rendezvous of two small satellites.

"The idea behind the mission is to take two rather small satellites, let them separate and drift apart and then let them change their orbits on their own to come back together and then dock to each other," he said. "CubeSats are becoming a viable platform for science, military and commercial missions, and the really cool thing about what we're doing is getting the attitude determination and control problem solved."

A satellite capable of changing its attitude and its velocity in space meets two technological requirements necessary for independent satellites to perform a rendezvous. The UT team delivered their first satellite, BEVO-1, to NASA last summer and watched it launch along with Texas A&M's satellite. Although the two satellites did not separate after releasing from the space shuttle, Kjellberg said the BEVO-1 mission allowed the UT team to develop the basic architecture for a satellite.

"It's very much hands-on and hardware-oriented because we're building extremely complex devices," he said. "I like these hardcore research problems and developing new technology."

In the longer term, Kjellberg hopes to find a way to use his degree and stay in Austin, the city he and his wife consider "the promised land." As she finishes her veterinary medicine degree at Texas A&M, Kjellberg commutes to Austin to spend time in the lab planning and building the next satellite.

"It's like a very complex iPhone that flies in space and can control itself," he said. "We get to build a very complicated device, but we also get to run a very complicated small business."

Julian Hallai: Protecting Our Pipelines

Faculty Advisor, Professor Stelios Kyriakides

The decision to come to The University of Texas at Austin was a natural one for Julian Hallai, an engineering mechanics PhD candidate in his fifth year. After finishing his Bachelor's and Master's degrees in marine engineering and naval architecture at the University of Sao Paulo in Brazil and working in the field with offshore pipelines for four years, he knew he wanted to work with an expert in pipelines. Our own Professor Stelios Kyriakides is among the best in the world, so Hallai packed his bags for Austin. (Dr. Kyriakides is director of the Center for Research in Mechanics of Solids, Structures and Materials.)

"It's a very high-level school and it's a small department, so we're able to have contact with all the students and professors and get to know them well," Hallai said. "We have the best researchers and professors."

Hallai's industry years were split between two years at INTECSEA (main office in Houston) and two years at PETROBRAS, where he worked on the design of high-temperature and high-pressure pipelines. His interest in the mechanical behavior of pipelines led him to his research on the behavior of pipelines bent during installation.

The pipelines are constructed from low-carbon steel in which a phenomenon called Lüders' Bands occurs: bands of plastically deformed material coexist with undeformed material. This is a material instability that can interact with other structural instabilities, especially during reel-lay installation where a pipeline is built on land, wound around a large reel and then unwound from a ship offshore.

"We're investigating what happens when we bend pipelines with certain material characteristics around the reel," he said. "We need to understand their behavior and understand our limits."

Hallai said he's fascinated with this research because he gets to investigate the relationship between the material instabilities of the steel and the structural instabilities of the pipeline itself. The minute calculations in the give-and-take of this relationship can have major consequences if companies aren't aware of a pipeline's limits.

"The bottom line is, whenever you're designing pipelines, bending is often involved, so it's important to know how much you can bend these pipelines," Hallai explained. "We're trying to determine how much we can bend them safely, which could be during their installation, normal operation or due to some unforeseen circumstances. If you don't know, you have the risk of overloading the pipeline and having it rupture."

Hallai expects to graduate within the next two years and then hopes to return to the industry and find a research position at a major oil company.

Colleen Kaul: Studying the Uncharted Territory of Large Eddy Simulation

Faculty Advisor, Assistant Professor Venkat Raman

Although she considered programs at the University of Michigan and Stanford, choosing The University of Texas was not a tough choice for Colleen Kaul, who will finish her PhD in aerospace engineering this summer. While finishing her undergraduate work in 2006 at Iowa State University, one of Kaul's professors pointed out that UT's department, in terms of her areas of interest, was on the rise. When she visited and spoke with various professors in fluids, they seemed just as interested in talking to her as she was in talking to them.

Since arriving, Kaul has intensively studied the intersection of theory and practice encountered in large eddy simulation (LES), a form of computational fluid dynamics. She focuses on the issues of LES in reacting flows, such as the flow in an aircraft engine combustor.

"Most of the time, I'm working with paper and pencil or in front of a computer, and I really feel like it is an exploration," she said. "The field I work in has a lot of unknown territory, and the way to solve the problems is not clear. It requires ingenuity and innovative thinking."

The design of aircraft engines currently involves a lot of time-consuming and expensive physical testing, she said, but virtual testing using LES could eventually significantly streamline the development process. However, further research, including Kaul's work, is necessary to establish LES as a highly reliable and accurate tool.

"A lot has been done in LES that provides good results, but why we're seeing these good results is sometimes not known," she said. "Digging deeper into what's actually going on in the simulation approach is what I work on."

As a National Science Foundation Fellow, Kaul has been able to immerse herself completely in researching LES theory. While attending various conferences during her years in graduate school, she has also published one paper in *Physics of Fluids* about analyzing numerical error in combustion models and has another paper currently under review.

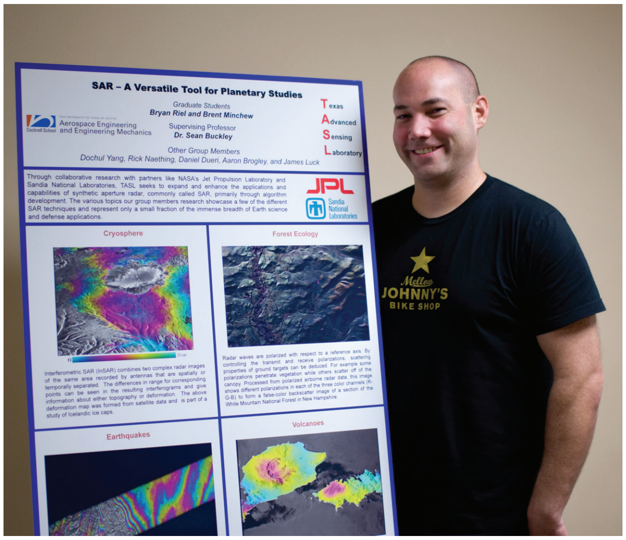
"Having the NSF fellowship allowed me to look at some fairly general, fundamental issues in large eddy simulation of combustion rather than target some specific application of the LES methodology," she said. "It also allowed me the flexibility to adjust my focus as my findings pointed me in new directions."

Though she describes her long-term plans as a "work in progress," Kaul plans to do a post-doc after earning her degree and hopes to find a faculty position. For the time being, however, she is thrilled to be able to dedicate herself to a field with so much uncharted territory.

"I have the feeling it really is an adventure," she said. "You don't know what you're going to find or what new ideas you're going to generate next."

Brent Minchew: Pushing the Limits from Serving on Marine One to Studying Glaciers

Faculty Advisor, Professor Hans Mark



Brent Minchew (MS ASE '10, BS ASE '08) has been enamored with flight ever since he was a little kid, eating lunch with astronauts and playing on the space shuttle mockup at NASA Johnson Space Center, where his mother worked. That passion, combined with a thirst for challenging experiences, led him from high school directly into the Marine Corps, where he served four years as crew chief in the Presidential Helicopter Squadron. As one of the youngest Marines ever to serve on Marine One, Minchew earned the prestigious Presidential Service Badge while supporting two presidents, transporting numerous foreign heads of state, witnessing historic peace talks, and once wrecking his bike at Camp David to avoid running over the First Dog.

By the time he left the Marines in 2004, however, he was pretty sure he didn't want anything to do with aircraft.

"I lived on my aircraft for months of my life, sleeping, eating, whatever, so as a transition, I needed to be away from it," Minchew said.

But the separation from aviation didn't last long. After enrolling at UT Dallas to be close to his family in McKinney, he soon transferred to the Department of Aerospace Engineering & Engineering Mechanics at UT Austin to complete his undergraduate studies and earn his first master's degree.

"I just love aerospace. There's something inherently appealing about defying the nature of our being in the sense that you are doing something our bodies were never meant to do," he explained. "I think space appeals to me more because it's exotic. It's still an exceptional thing, and I've always been drawn to extreme things."

That attraction to extremes pulled him into his graduate work, studying the cryosphere, and specifically Icelandic glaciers, using airborne radar systems. Working with NASA-JPL, Minchew uses their systems to analyze the data about small glaciers that can inform researchers about larger ones.

"The readings will be put into mechanical 3D models so we can model their behavior and make calculations about what they'll look like in the future," Minchew said. Predicting attributes like their approximate surface area and potential run-off is especially valuable in places like Iceland, which relies on run-off for crop irrigation and hydroelectric power.

Minchew and his colleagues can also apply the data to climate modeling, using information learned about the small glaciers at lower latitudes and elevations to extrapolate hypotheses about larger glaciers and climate trends.

"We're hoping to develop these modeling techniques now on these smaller, contained ice caps because we can study them," he said. "We start off with what appears to be the 'easy' problem first, and then we can eventually scale up to the larger, more complicated ice caps, learning as we go on these small problems to what we might see 10 to 20 years from now."

This research has led Minchew a bit further afield from aerospace into the realm of geophyiscs, as he embarks on his next adventure: earning another MS and his PhD in geophysics from Caltech's Division of Geological and Planetary Sciences. Brent is looking forward to the next chapter of his life, but no matter where he goes, he'll always be a Longhorn!

Student profile stories and photos by Tara Haelle

Inspire Engineering Change in the World

"If your actions inspire others to dream more, learn more, do more and become more, you are a leader." – John Quincy Adams

The real leaders of the Aerospace Engineering and Engineering Mechanics department are the alumni, parents, corporate partners, and friends who provide financial support to our students. Funding for graduate fellowships is critical to attracting the best and brightest students – students like Annie Lum, Henri Kjellberg, Julian Hallai, Colleen Kaul, and Brent Minchew – who are transforming our university today and the world tomorrow. Interested in becoming a leader? To learn more about supporting our students, please contact Amanda Brown at 512-471-4046 or amanda.brown@austin.utexas.edu.

A WHOLE LOTTA SHAKIN' GOING ON... OR NOT:
UT Software Improves Vibration Analysis in Auto Industry

by Professor Jeffrey Bennighof

You may have noticed that noise levels in cars have been decreasing over the years. One reason is that car manufacturers around the world have been using vibration analysis software written here in our department.

The software uses an approach that has roots in our department dating from the 1960s. Our own Professor Roy Craig, who retired in 2001, played a key role in developing the "component mode synthesis" (CMS) method. In CMS, a finite element model of an airplane, for example, is divided into several substructures (wings, fuselage, empennage, etc.) so that models of substructures can be reduced before assembling them together to form a more manageable model of the overall structure.

Our software implements "automated multilevel substructuring" (AMLS), which takes the CMS approach to an seemingly ridiculous extreme. In AMLS, a finite element model of a car with about 10 million degrees of freedom is divided into substructures, and substructures of substructures, and so on, until the model has been divided into tens of thousands of substructures on dozens of levels.

Models of individual substructures are reduced greatly to produce a model of the overall structure that has about 1/100 as many degrees of freedom as the model had originally. Then this reduced model is used to approximate about 10,000 natural frequencies and modes of the structure, so that vibration can be analyzed efficiently.

In CMS, model reduction is done manually, but in AMLS, the substructuring process is entirely automated. The trick is to do it very efficiently and without losing accuracy.

Using AMLS for vibration analysis in cars had its beginnings in a research project focused on submarines. In the 1990s, we were funded by the Navy to develop a substructuring method for predicting submarine vibrations. Submarine funding decreased after the end of the Cold War, but we began to see how a new method, which turned out to be AMLS, might work to handle very large vibration problems. At about this time the auto industry began creating fairly detailed models of entire cars so that they could be analyzed and made quieter while they were still "on the drawing board."

Fortunately the kind of extreme levels of vibration that Dr. Bennighof illustrates here are never an issue for auto drivers today, thanks in part to the software Dr. Bennighof and colleagues have developed.

Using the most efficient solver algorithm available at the time, car companies required extremely expensive liquid-cooled Cray supercomputers for vibration analysis. Ford, for example, was spending over $10 million per year on computer time to analyze vibrations. To explore future capabilities, Ford created a reasonably detailed model of a car body but found that their fastest computer took four weekends, when it was not carrying its normal workload, to get the results they wanted.

When a manager at Ford learned that we might have a faster way to solve their problem, he arranged to get us access to their supercomputers. We were able to run their 4-weekend problem in a few hours on a Tuesday afternoon when their machines were busy with their normal job queues.

That got them interested, and they began to fund us for a few years to get our "research code" ready for production use. They also encouraged us to make the code available to other car companies, because they had learned that if a code became standard across the industry it was likely to be of better quality than if Ford had exclusive rights to it.

We developed AMLS for as broad a market as possible. We and began working with a German-based firm that provides world-class consulting to the car industry, and started using them as our distribution channel. A number of auto companies in the US, Europe, and Japan quickly adopted AMLS soon after when it became commercially available in 2001. The number of licensees has numbers continued to increase, and now most carmakers worldwide have become AMLS users.

As licensing revenue began to materialize and as we also began to receive hardware and financial and technical support from computer vendors, we found that we had successfully navigated a transition from federal research funding to a healthy level of industry funding. Car companies value AMLS because it enables them to improve marketability of their products: car buyers associate low interior noise levels with higher quality. Harnessing that value has allowed funds to flow back to UT to support ongoing research and software development.

Initially, we developed our software for the Cray supercomputers used for automobile vibration analysis at the time. However, one advantage of AMLS over the previous approach is that AMLS transfers much less data from disk to memory and from memory to processor. This means the huge bandwidth capabilities of supercomputers are not required, allowing AMLS to run on much less expensive workstation-class machines.

AMLS's ability to perform vibration analysis quickly and efficiently on inexpensive computers resulted in very rapid adoption throughout the car industry. AMLS allowed car companies to switch from supercomputers that cost tens of millions of dollars to machines costing hundreds of thousands of dollars. That trend has continued as these companies have transitioned again to servers that use cheap PC-type processors. We are reaching a point where software is more valuable than the hardware on which it runs, a notion that would have seemed ridiculous in the early days of computing.

We are currently focused on making the transition from using four to eight processor cores to much larger numbers of cores. This includes both the dozens of cores that can be installed on the same motherboard with current and near-future multicore chips, and the thousands of cores that can be installed in one computer using Graphics Processing Units (GPUs) from NVidia, for example.

Over the years, a number of graduate students have contributed to the AMLS effort. Four PhD dissertations and five MS theses related to AMLS have been written in our group. Outside of UT, at least half a dozen software vendors have developed their own implementations of AMLS, and there are several finite element codes for which an interface with our software exists or is currently being developed.

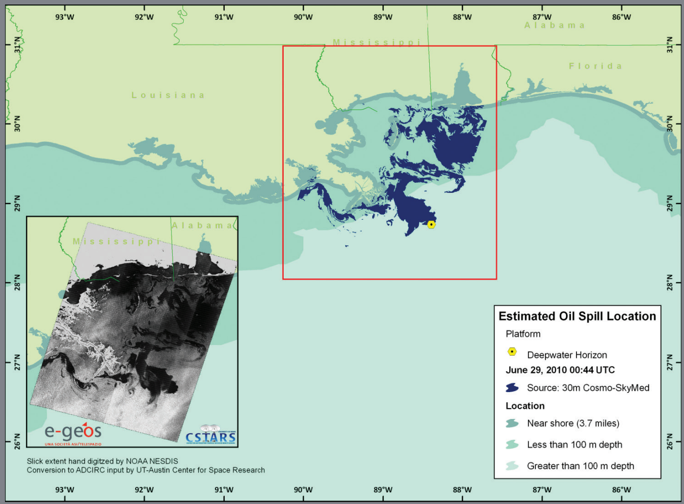
We have enjoyed our success in the car industry, but we would certainly like to see AMLS adopted in the aerospace industry to a much greater extent. (We're in an aerospace department, after all!) There are some significant differences between the needs of the auto and aerospace industries. But we hope that improvements in AMLS's capabilities in coming years, along with advances in computer hardware and a growing awareness of what is being done in the car industry, will soon profoundly change the way that structural dynamics is handled in aerospace.

Professor Clint Dawson's Team Maps Oil Spill; Alumnus Raymond Kokaly Analyzes Images

Using highly accurate models of the Gulf of Mexico's coastline that were previously used for hurricane simulations, Professor Clint Dawson's team conducted critical mapping of the Deepwater Horizon oil spill. His team used modeling to show the spread of oil into the complex maze of coastal marshes and wetlands with 10 to 20 times more detail than other models.

The modeling was based on real-time satellite imagery of the spill from UT's Center for Space Research. Using the Center's three rooftop antennas that receive regular satellite photos from the 14 American and international satellites passing over the Gulf, our faculty and researchers provided images three hours faster than NASA to 30 relief agencies.

In turn, we are deeply proud of all our alumni who worked hard to measure and resolve this enormous engineering challenge. For example, Raymond Kokaly, BS ASE '91, is a Geophysicist for the U.S. Geological Survey. As a member of the federal government's Flow Rate Technical Group, he analyzed daily satellite images and airborne imaging spectrometer data to help estimate the amount of oil and gas leaking into the Gulf of Mexico and to assess ecosystem damage to the coastal marshes.



Above: Location of surface oil prior to passage of Hurricane Alex as detected by satellite. Satellite image seen in lower left corner.

FELIX FENTER

PHD ASE 1960

by Kathleen Mabley

In the complicated world of military strategy, there is a doctrine in which two opposing countries each have enough nuclear weaponry that if either initiated an attack, it would result in the complete destruction of both sides. The strategy, known as MAD, or Mutually Assured Destruction, was the only credible strategy available during the Cold War. Sole strategic reliance on MAD was unacceptable for our long-term future, according to Felix Fenter and many others in the defense industry in the early 1980s.

"We were dedicated to finding ways to re-introduce true strategic warfare. If you had to be prepared for a war, with MAD, we were in effect denying ourselves the ability to conduct strategic warfare. The key is to have other means to not only neutralize a nuclear threat but to also achieve your strategic goals."

As Vice President of LTV Aerospace Missiles Division, Fenter successfully guided his company's efforts to win a contract with the United States Army to create a technology that would offer a credible defense against intercontinental ballistic and cruise missiles.

It was, in Fenter's words, "mutually assured protection for ourselves. It was one small step in the process of making a better world."

However, the technology that needed to be developed required not only unprecedented missile accuracy, but also the ability to apply enough lethality to negate the possibility of it still having an explosion. Therefore, they had to hit a precise location on the target where, as Fenter described it, "all the bad stuff is."

Using a simulated warhead (without the "bad stuff") of a Soviet ballistic missile, Fenter's team tested their intercept technology at White Sands Missile Range in New Mexico. When the test was complete, all that remained of the test target missile was a chunk of metal the size of a sheet of ruled paper. It now hangs on the wall in Fenter's office.

And, while the technology was extremely successful, Fenter says, "MAD precluded it from ever being used. So what good is that technology other than affecting the strategic balance? Well, there is the problem of tactical missiles – many nations have tactical missiles with conventional warheads on them, and a few probably have chemical and/or biological warheads. So the useful thing is to use this technology to protect ourselves and our allies from the real world threat of tactical missiles (such as SCUDS, for example)."

Fenter (by then, President of his company) continued to guide the team that developed the first hit-to-kill intercept of a tactical ballistic missile. And today, the Patriot Advanced Capability (PAC-3) missile developed by Fenter's company (now Lockheed Martin Missiles and Fire Control) is one of the largest missile programs in the United States Defense Department.

Photo above: Dr. Felix Fenter in his home office. Dr. Fenter began a lifelong love of aeronautics while building model airplanes as a young boy. He went on to earn three aerospace engineering degrees from UT, including the very first aerospace PhD ever awarded in 1960. While earning his PhD, he worked as a research specialist at the University's Defense Research Laboratory (which is now the Applied Research Laboratories) on various Navy missile and space programs.

Fenter left the university for employment at Chance Vought Aircraft prior to the completion of his dissertation (he would spend his entire career at Chance Vought and its successor companies – LTV, Loral, Lockheed Martin). Dean Harry Ransom created a policy of "in absentia" registration for Fenter that remains in effect 50 years later.

This article will appear in the book, ***Changing the World – Stories Celebrating 100 Years of Graduate Education at The University of Texas at Austin****, available Nov. 12 through the University Co-op.*

LAURA O'DONNELL
BS ASE, 1990

Story and Photo by Tara Haelle

Above: Laura O'Donnell, BS ASE 1990, says that her aerospace engineering senior design classes and group projects were critical in shaping her ability to be effective in business.

Even Laura O'Donnell did not expect her aerospace engineering degree would lead to becoming a top executive for the fastest growing personal HD camera company in the world. As Executive Vice President of Consumer Products at Contour, Inc., she has discovered that the versatility of her degree and the value of her engineering education have eased her path to the top in ways that now feel as natural as choosing to go to UT in the first place.

Growing up in Temple, O'Donnell took an aptitude test that recommended psychiatry or astrophysics. When she chose astrophysics, aerospace was the closest she could find in a nearby school, so UT was the obvious choice. It was after she visited NASA in her introduction to aerospace class that the dream of becoming an astronaut really caught on, but a bad car accident the summer before her senior year made that dream impossible. Undeterred, the Friends of Alec Scholarship recipient looked at other options and branched out to take a business law class her last semester. It opened her eyes to the intersection of engineering and business.

"I found very quickly that an engineering mindset – the discipline and how you solve problems and how you get from step A to B – is the same regardless of the problem you're applying that process to," she said. "In the business world, you have to have an organized thought process: What is my problem? What are my options to solve it? How will I choose the options? How do I implement it and how do I check it?"

Those guiding principles have served her well from her first job after graduation, as an attitude controls system engineer with Hughes Space and Communications, to where she is now, pioneering hands-free recording and location based video that allow explorers to tell their stories of action, adventure, and travel.

"The world is a system, and UT's aerospace program is a system program," she said. "Everything that you do in aerospace requires a lot of complex pieces coming together. To get a rocket to launch or a satellite into orbit or get an airplane to fly, you have to look at the bigger picture. You learn that people are part of the system too, so every big challenge requires communication and creativity."

O'Donnell said she was always the communicator in her classes, the one who stood up to give presentations.

"Senior design classes and group projects were by far the most critical in shaping my ability to be effective in business. It teaches you to work with other people," O'Donnell said. "You have to learn to maximize the group output even if everyone isn't necessarily as committed or contributing at the same level."

Although Laura enjoyed leading a team of 50 engineers in the development of three new satellite designs at Hughes, she reached a point where she was ready for a new challenge. An opening in Hughes' sister company at DIRECTV led her away from satellites into consumer products, and she has never looked back. As DIRECTTV's vice president of product development she led the deployment of innovative services like DVR, HD, and Interactive.

Laura would go on to bring the magic of satellites into millions of homes and cars as the founder of Synthese, LLC, providing consumer electronics product usability and design for major clients such as Sirius Satellite Radio. Her entrepreneurial spirit then led her to Contour. She became the Seattle-based company's fourth employee, and currently helps lead a 30-person team bringing in $7M in sales last year.

Along the way, Laura has stayed involved with the ASE/EM department. She served on the External Advisory Committee from 1996-1999 and is a Life Member of Friends of Alec, endowing a scholarship for a current student in an effort to encourage their academic dreams. She hopes their dreams include exploring classes outside the standard curriculum because the experience can open their eyes to new possibilities. During a recent campus visit, Laura shared this hope with members of WIALD (Women in Aerospace Leadership Development). She also encouraged the students to say yes to new opportunities, and to find their passion.

"When you find your passion, success will follow," she said. "I am passionate about giving a customer a great product and something they didn't expect. It's essential that you deliver on the promise you made, but what really brings joy to someone is when you bring them something more, and in many cases, something they didn't know they wanted."

BLAST FROM THE PAST!

Above: In the Spring 2010 issue of the Liftoff, we printed the wrong caption to accompany alumnus Terry Hill's spotlight. The corrected caption appears below:

Terry Hill, BS ASE 1996, in the official space shuttle Advanced Crew Escape Suit (ACES suit), which is used as an analog for the launch, entry and abort functions of the new Constellation spacesuit that Terry's team is designing. Terry is seated in one of the space shuttle astronaut trainers at the NASA Johnson Space Center in Houston where he is participating in space shuttle crew escape training. Photo courtesy of NASA

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1950s

CHARLES W. BECK II, BS ASE 1954 is President of International Avionics, Inc. in Addison, TX.
charles@beck.name

1970s

JAMES LINDSEY, BS ASE 1976 writes, "I was a helicopter pilot in the Marine Corps and attended Navy Test Pilot School in 1985-86. I left active duty in 1989 and worked for a year at Boeing Helicopters prior to joining Bell. My primary project work was on the V-22 Osprey, having first flown that aircraft in Nov. 1989 and was involved in the development and production of this extremely versatile tiltroter aircraft. My last V-22 flight was in Dec. 2009 just prior to retirement. I am currently on a consulting contract with NASA and a Project/Pilot Engineer at NASA Ames Research Center in California. The project involved simulation of a Large Civil Tiltorotor (LCTR)."
jimdena@tx.rr.com

ALAN RODNEY ROCHA, BS ASE 1973 is an Aerospace Engineer for NASA Johnson Space Center in Houston, TX. He writes, "I have worked in the area of aerospace structural dynamics at NASA for over 35 years. My mentor at the UT ASE/EM Department was Dr. Roy R. Craig, who greatly influenced my interest in structural dynamics and vibrations. I have provided analytical and test support to the Space Shuttle Program, Apollo-Soyuz Test Project, International Space Station, Constellation Ares/Orion Program, key Shuttle flight experiment, and several Shuttle-Orbiter cargoes and payloads, including the Hubble Space Telescope. I was on the debris-hazard assessment team during Shuttle Columbia's last flight (mission STS-107) and part of the post-accident investigation and return-to-flight engineering effort. I am and have always been proud to help lay the foundation for continuing and expanding human spaceflight and human space exploration."
ar1rocha@yahoo.com

1990s

MARTIN LINDSEY BS ASE 1993 writes, "I have been serving as an Air Force Officer since graduating in '93 and most recently became US Pacific Command's Deputy Science and Technology Advisor in Sept. '09. Our mission is to identify and demonstrate technologies that can address our Command's mission to promote security and US interests in the Asia-Pacific region. The most important skill I learned from my UT experience was to think critically and analytically under stressful conditions. It prepared me well for all of my duties, which have included supervising maintenance of ICBMs, launching Atlas II, III and Delta IV's, and conducting/leading scramjet propulsion research. The Air Force gave me the opportunity to go on and earn MS and PhD degrees in Aerospace Engineering as well. Hook 'em Horns!"
martinpenny94@yahoo.com

2000s

RODERICK AUSTIN, MS ASE 2001 is a Managing Director for SunGard Energy in Shanghai, China. He writes, "After graduating in 2001, I moved to Houston where I met my wife and lived happily until three months ago, when we were transferred to China. My business life involves copious travel all over Asia in an effort to grow our business here and we are soaking up the different cultures. We are expecting our first child in January – who will no doubt be a future Longhorn – and my Slingbox is my new best friend as I can watch my UT

BLAST FROM THE PAST!

football team in action. Thanks for a great experience and wonderful memories. Hook 'em."
roderick.austin@sungard.com

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ANGELA BRAUN LENORT, BS ASE 2000 is an Aerospace Engineer for NASA Johnson Space Center in Houston, TX.
gold101@gmail.com

ANDY TIEN, BS ASE 2010 is currently employed as a SVC Systems Engineer for Raytheon in the D.C. metro region.
ndtien88@gmail.com

Gary W. Johnson, BS ASE 1972, MS ASE 1974

After finishing his degrees in aerospace engineering at UT-Austin, Gary Johnson went to work for Rocketdyne (later Hercules) in McGregor, Texas, where he became involved in an R&D program in "ducted rockets" from 1975-1983 and again from 1987-1994, when the plant was closed.

During both tenures at McGregor, Gary participated in engine design, engine test, and test facility design activities for ramjet connected-pipe (direct-connect) testing. This unique experience provided very quickly to Gary a deep understanding of the complex physical combustion processes going on inside the engine. Within about three years, the McGregor facility (and Gary) went from novice status to recognition as an industry leader in ramjet work. After layoff, Gary did some civilian engineering and some teaching. He finally settled on teaching and is now a professor of mathematics at Texas State Technical College, Waco, Texas. He has also taught aviation science at Baylor University, automotive/manufacturing engineering technology at Minnesota State, and high school mathematics. Along the way, he obtained a doctorate late in life in general engineering.

Recently, Gary was contacted by the director of a private space tourist rocket company which had been trying to locate engineers with ramjet experience. This past summer he met with them at the Mojave airport where they discussed the possibility of Gary's assistance with building a ramjet engine. Apparently, Gary is one of the few surviving "full-capability ramjetters" (experienced with supersonic inlets, combustors, flameholders, materials, flight dynamics, internal/external aerodynamics) – exactly what the space tourist company has been looking for.

He says "If their project goes as expected, I will be helping them with the biggest ramjet ever built, a few years from now. The results should be spectacular."

Right: International Space Station Flight Controllers Pooja Joshi and Pam Martin pause for a picture in Mission Control during the most recent shuttle mission, STS-132/ULF4. Pooja (BS ASE 2007) is an Attitude Determination and Control Officer (ADCO) while Pam (BS ASE, 2006) is an Operations Support Officer (OSO). This mission delivered a new Russian module, MRM 1, and was the final planned voyage for Space Shuttle Atlantis.

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KEEP IN TOUCH

We enjoy receiving your alumni news and need more from you to keep the "Blast From the Past" column up to date. Photos are encouraged! Please visit our alumni web page to update your email, address, and send us your news at http://www.ae.utexas.edu/alumni

Updates, news and photos may also be sent directly to:

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Thank you for your interest in the department. We look forward to hearing from you soon!

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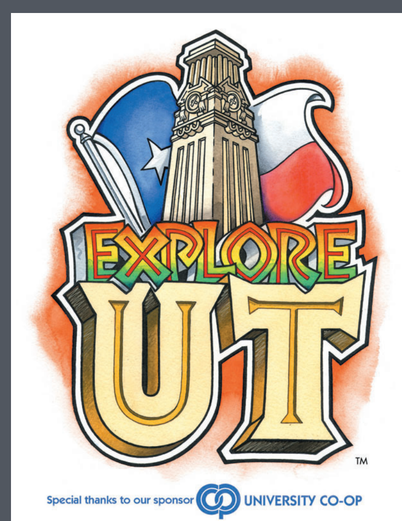

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