# THE LONGHORN LIFTOFF

FALL 2017

## GRACE-FO

IS EARTH'S FRIEND | PAGE 14

### IN THIS ISSUE




The University of Texas at Austin
Aerospace Engineering
and Engineering Mechanics
*Cockrell School of Engineering*

## FROM THE CHAIR

**THIS FALL MARKS THE BEGINNING** of my sixth year to serve as chair for the Department of Aerospace Engineering and Engineering Mechanics at UT Austin. Over the past five years, I have worked closely with our faculty to develop strategies that reaffirm our top 10 program rankings according to U.S. News & World Report. One third of our current faculty have been recruited in this timeframe, and we continue to expand our research expertise in innovative fields such as robotics and space traffic management. In 2016, the department announced a new Bachelor of Science program in the field of computational engineering, and our project-based learning environment continued to flourish. In this Fall 2017 issue of The Longhorn Liftoff, I am pleased to share stories that celebrate these advancements. Read about our newest faculty and their cutting-edge research, learn about our latest undergraduate student projects, and find out how our alumni are changing the world. As always, please remember to keep in touch — news from engineering alumni contributes to our success. Hook 'Em!

**NOEL T. CLEMENS**

Chair, Department of Aerospace Engineering and Engineering Mechanics
Bob R. Dorsey Professor in Engineering

## LONGHORN LIFTOFF | FALL 2017

# FORGING NEW HORIZONS

*Today, as the field of aerospace engineering continues to transform, the Department of Aerospace Engineering and Engineering Mechanics at The University of Texas at Austin is evolving at an accelerated pace. To ensure that we remain leaders at the forefront, the department has been working strategically in recent years to hire faculty who specialize in the cutting-edge areas of robotics and autonomy, remote sensing, space traffic management and computational engineering. In fact, one third of the current aerospace engineering faculty has been recruited within just the past five years. Learn more about our new faculty members and the new and exciting areas of expertise they bring to the department:*

## ROBOTICS & AUTONOMY

**EFSTATHIOS BAKOLAS**
*Autonomy, systems and control theory, UAVs*

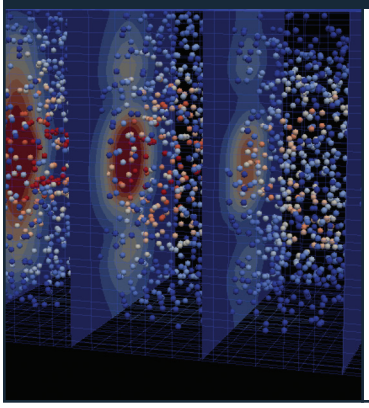
**TAKASHI TANAKA**
*Systems and control theory, autonomy, robotics*

**LUIS SENTIS**
*Humanoid robotics, exoskeletons, mobility and manipulation*

**UFUK TOPCU**
*Robotics, autonomy, verification of networked systems*


NASA image

## COMPUTATIONAL ENGINEERING



**FABRIZIO BISSETTI**
*Computational fluids, reacting flows, uncertainty quantification*

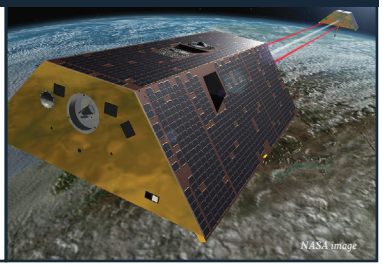
**TAN BUI-THANH**
*Computational geosciences, inverse problems, uncertainty quantification*

**MANUEL RAUSCH**
*Computational and experimental biomechanics*

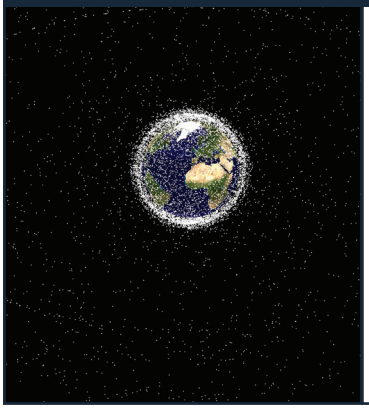
## REMOTE SENSING

**JINGYI "ANN" CHEN**
*Satellite geodesy, remote sensing, synthetic aperture radar*

**SRINIVAS BETTADPUR**
*Remote sensing, geosciences, geodesy*


NASA image

## SPACE ENGINEERING & TECHNOLOGY



**MORIBA JAH**
*Space situational awareness, space traffic management*

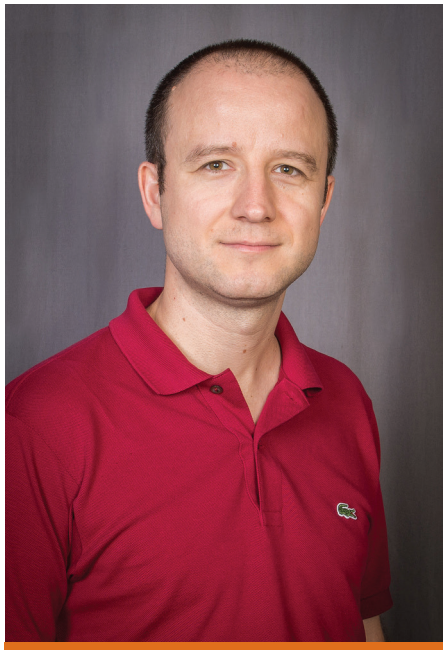
**BRANDON JONES**
*Space situational awareness, uncertainty quantification, numerical methods*

**RENATO ZANETTI**
*Space robotics, autonomy, uncertainty quantification*

### *FIRST-OF-ITS-KIND UNDERGRADUATE MAJOR*

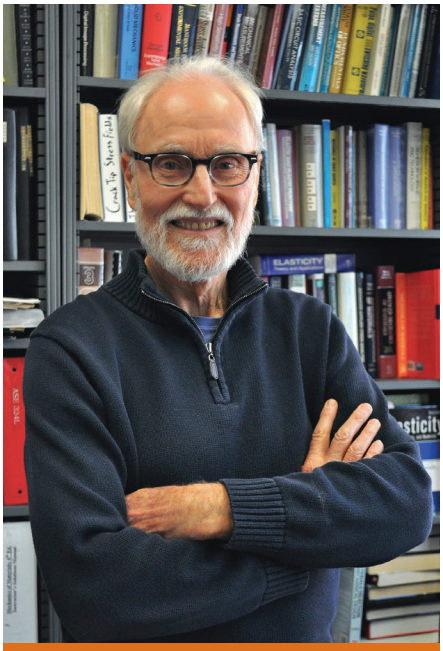
In Fall 2017, the Department of Aerospace Engineering and Engineering Mechanics at UT Austin launched the nation's first Bachelor of Science degree in computational engineering, which includes an interdisciplinary curriculum focused on opportunities for students to work on complex 21st-century engineering problems within a wide range of real-world applications.

# FACULTY AWARDS



*Ufuk Topcu, Assistant Professor*

*Thomas J.R. Hughes, Professor*



*Kenneth Liechti, Professor*

**UFUK TOPCU** is one of eight UT Austin faculty members selected by the National Science Foundation to receive a **2017 Faculty Early Career Development (CAREER) Award.** The award is the most prestigious offered by the National Science Foundation's CAREER Program.

CAREER awards provide up to five years of funding to junior faculty members who exemplify the role of teacher-scholars through outstanding research, excellent education and the integration of education and research within the context of their organizations' missions.

Topcu was awarded for his project "Provably Correct Shared Control for Human-Embedded Autonomous Systems." Establishing provable trust is one of the most pressing bottlenecks in deploying autonomous systems at scale. Topcu's project will help develop autonomous systems in which the human operator and autonomy protocols are equally essential components of the same system and reduce the so-called "automation surprises."

Topcu's team is working on technology that allows humans to control robots autonomously using brainwaves. While wearing a helmet that reads EEG waves and communicates to a computer, humans could control robotic technology with their minds. Practical uses might include flying a drone and controlling a wheelchair.

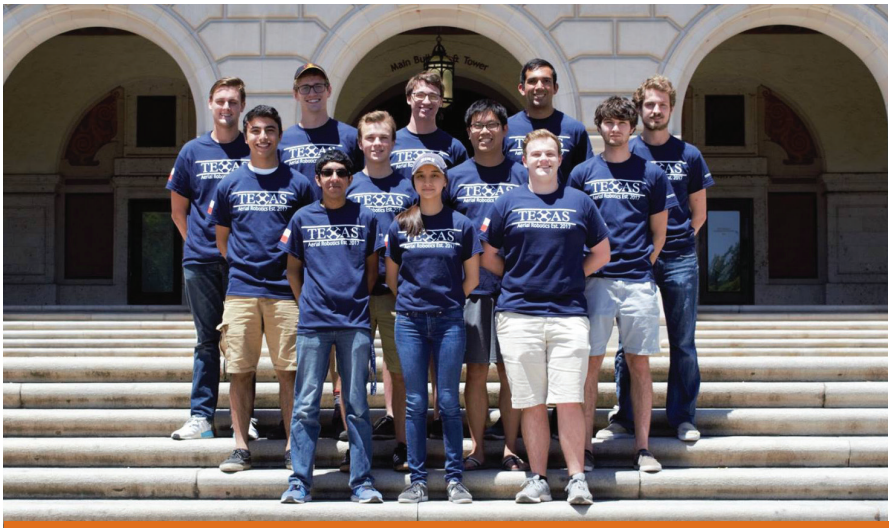
Because humans interact with autonomous systems through imperfect interfaces, there is uncertainty in a given situation. Topcu's research goal is to mathematically prove that these autonomous systems that interact with human operators satisfy safety and performance specifications and can be designed and deployed with minimal hardware testing.

**THOMAS J.R. HUGHES** was awarded the **2017 Society for Industrial and Applied Mathematics Association for Computing Machinery Prize** for his pioneering work on finite element methods for partial differential equations. Hughes was also the recipient of the **2017 Southeastern Universities Research Association (SURA) Distinguished Scientist Award**, which is given to a research scientist who has done extraordinary work according to the SURA mission to "strengthen the scientific capabilities of its members and our nation."

**KENNETH LIECHTI** was selected to receive the Society of Experimental Mechanics' (SEM) prestigious **William M. Murray Lecture award.** The lecture is presented each year in honor of Dr. William MacGregor Murray, who was the first SEM president and longtime secretary-treasurer.

# Q&A WITH TEXAS AERIAL ROBOTICS

*Formed just this year, the Texas Aerial Robotics (TAR) team was established with the purpose of competing in the International Aerial Robotics Competition (IARC), a highly sophisticated unmanned aerial vehicle competition. Following the competition, we caught up with electrical engineering student and TAR controls lead Umer Salman and aerospace engineering student and TAR president Eric Johnson to hear about their first experience at IARC.*



*Formed in Spring 2017, the Texas Aerial Robotics team came home with fourth place in their first International Aerial Robotics Competition.*

**This was the Texas Aerial Robotics team's first major international competition. What kind of "aerial robot" did your team design and how did you go about it?**

*Umer Salman:* We decided to create a straightforward, efficient robot design with interfaces for interacting with the target/ground robots and for multiple sensors to make up for the GPS-denied environment. We laser-cut wood boards for our base to allow for rapid iteration as we worked through problems with sensor types and locations and added more powerful motors after adding our onboard processing computer. One big design decision we made is to not have landing legs, which allows us to have a much larger surface area for ground robot interaction. At competition, it seemed the judges really liked our rapidly iterable, efficient design.

**What were the mission requirements for this year's competition?**

*Salman:* We competed in Mission 7a, which requires a fully autonomous drone to fly around a 20m x 20m grid and 'herd' Roombas (ground robots) out one side of the square field. The Roombas change direction randomly, and some even have poles on them to try to knock your vehicle out of the sky. The most challenging part is that the quadcopter must decide on its own which ground robots to target and autonomously fly and interact with, all without using GPS.

**Your team placed fourth overall. How many teams actually competed and how many different U.S. teams and countries around the world competed?**

*Eric Johnson:* 30 teams representing 9 countries registered; 13 teams showed up and competed in the American venue. Another 30 teams are scheduled to attend the Asian-Pacific venue.

**What was the team's biggest challenge for this project?**

*Johnson:* The team's biggest challenge was integrating all of our sub-systems which were developed by separate sub-teams.

**What is your team most proud of concerning this competition?**

*Salman:* That we were able to execute our goals for the competition exactly as we wanted, which showed the judges and other teams exactly where we stand after just a few months. Additionally, I was very proud that we exceeded the goal we set early in the year. That goal was to be competitive with the other teams, including those that have been working on this specific challenge for three or four years. By actually placing toward the top rather than the middle, like we expected, we surpassed that goal.

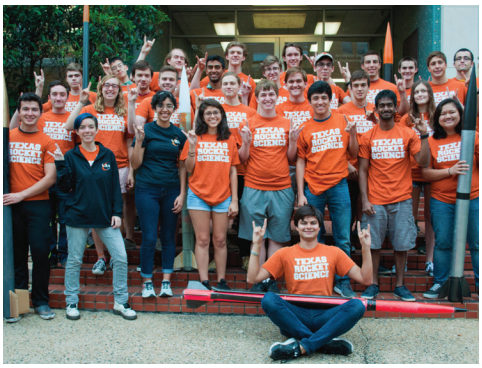
**Will the team be competing again next year? If so, what will you do to improve upon this year's design?**

*Johnson:* Each mission for IARC is played until the mission is solved. Mission 7 was not solved this year and we will be returning to Atlanta next year to solve the mission. We will be improving across the board. We will be improving our vision system, drone body and decision making, and we will be adding more sensors.

**How do you think working on a team like this has enhanced your educational experience at UT Austin?**

*Johnson:* This competition is a great way for me to take what I learn in the classroom and apply it to a real-world engineering problem. It is an opportunity to learn skills outside our majors.

# STUDENT PROJECTS

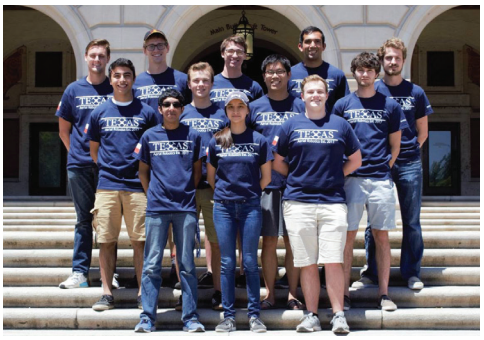


## LONGHORN ROCKETRY ASSOCIATION

The Longhorn Rocketry Association (LRA) will finish construction of a rocket engine test facility at the Pickle Research Center this fall. This facility will allow for horizontal and vertical static fire tests of rocket engines researched, designed and built by students. The club is working on several versions of a development hybrid rocket engine to compete in the student researched and designed hybrid/liquid rocket propulsion system category for the 2018 Spaceport America Cup, an international rocketry competition held in Truth or Consequences, New Mexico. The club is also continuing to build upon its knowledge gained from its hugely successful certification group by creating large serially staged rockets to reach 100,000 feet. LRA intends to combine its staged and engine development teams to launch its own liquid rocket engines to the edge of space. **Estimated Cost: $20,000**

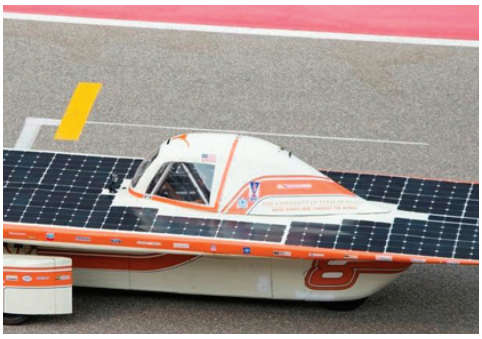
## WOMEN IN AEROSPACE FOR LEADERSHIP DEVELOPMENT

The Women in Aerospace for Leadership and Development (WIALD) is a student organization that seeks to provide a collaborative and supportive environment that will empower all students in the field of aerospace engineering and allow them to succeed at any hands-on endeavor. At the beginning of each year, the group votes on a new hands-on project. Past projects include programming a quadcopter, building a miniature rover and modifying a drone to autonomously drop a payload. **Estimated Cost: $6,000**



## TEXAS AERIAL ROBOTICS

Texas Aerial Robotics (TAR) recently competed in the International Aerial Robotics Competition (IARC). IARC is a highly sophisticated competition which pushes the limits of what is considered possible in the field of intelligent autonomous aerial vehicles. The team is researching and applying skills such as computer vision, computational simulation, parallel computing, controls, design and fabrication to create a system that autonomously interacts with moving ground targets. **Estimated Cost: $15,000**



## UT SAE DESIGN TEAMS

The UT SAE organization aims to provide students with opportunities to gain broader insight into the automotive engineering profession and to supplement their professional and intellectual growth. To do so, SAE houses four design teams: UT Solar Vehicles Team, Longhorn Racing Internal Combustion, Longhorn Racing Electric and MATE ROV. **Estimated Cost: $100,000**

## UNMANNED AERIAL VEHICLE TEAM

The Unmanned Aerial Vehicle (UAV) team is a project team that offers students the opportunity to learn technical and soft aerospace engineering skills while working in a team environment. They will compete in the AUVSI Student Unmanned Aerial Systems competition in June 2018, after placing 16th out of 54 in 2017. The UAV team is improving the plane that flew in the 2017 competition and programs involving automated obstacle avoidance to be competition-ready for 2018. They will also build a new backup plane with improved fuselage space, upgraded electronics and payload delivery capabilities. The previous year's functionality will be repeated, including real-time video surveillance, image recognition, autonomous takeoff, flight, landing and automated obstacle avoidance. The team will need to purchase components for the current and backup plane and cover travel costs to the competition. **Estimated Cost: $9,000**

## DESIGN / BUILD / FLY TEAM

The UT Design/Build/Fly (DBF) team is developing a radio-controlled aircraft for the international AIAA Design/Build/Fly competition, hosted by Cessna, a Textron Aviation company, in Wichita, Kansas, in April 2018. Every competition consists of various flight and ground missions that change from year to year based on that year's rules and theme. Last year's theme was "Tube-Launched UAVs," and required the construction of a hand-launched aircraft that could carry at least three hockey pucks. During the school year, students will learn firsthand how a team of engineers must work together to create a functioning product by a set deadline. The team will utilize composites, wood, testing and machining equipment, as well as electric motors to optimize aircraft performance while keeping manufacturing affordable. **Estimated Cost: $10,000**

# THANK YOU

Thank you to all of the donors who have supported our undergraduate student projects, which would not be possible without external support. If you are interested in supporting our students, there are several ways to do so.

*Make an immediate gift online:*
**ae.utexas.edu/supporting-student-groups**

*Make a lasting gift by donating to one of our two endowments:*
**Angelo Miele Endowment** and the **Student Project Endowment** support student projects. Donating to these funds will help ensure that these student projects are funded for the long-term.

To make a gift or for more information, please contact Bliss Angerman at **512-232-7085** or **bliss.angerman@utexas.edu**.

# PLAYING IT SAFE

## KEEPING PEDESTRIANS AND CYCLISTS SAFE ON THE STREETS WITH PRECISE TRACKING TECHNOLOGY

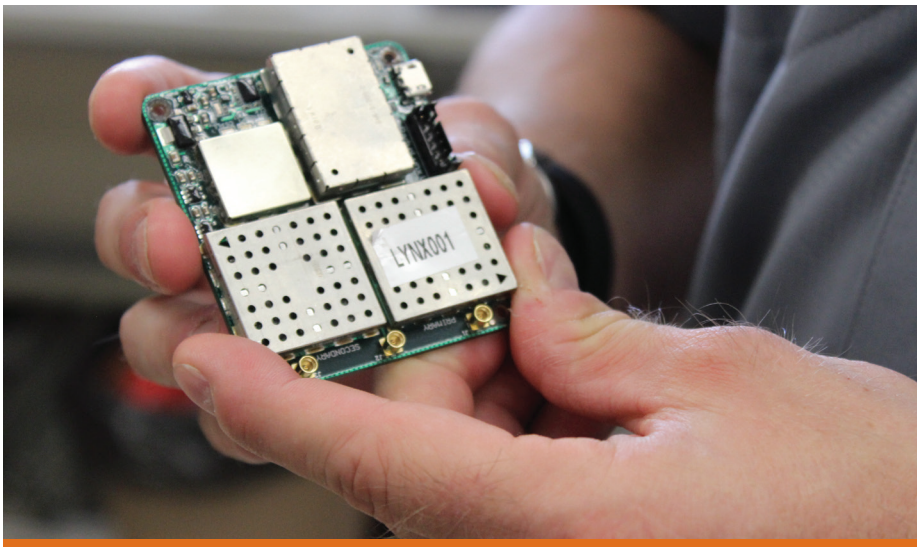
Two Ph.D. students advised by associate professor Todd Humphreys were selected to receive a Qualcomm Innovation Fellowship for 2017. The research funded by the fellowship will focus on tracking the precise location of pedestrians and cyclists and communicating these locations to traffic management systems and automated vehicles.

Aerospace engineering student Matthew Murrian and electrical engineering student Lakshay Narula will receive $100,000 from the communications company to fund their research in UT Austin's Radionavigation Lab. Qualcomm will provide one year of mentorship in addition to funding their research.

Nearly 50 percent of traffic fatalities around the world involve pedestrians or cyclists, according to the World Health Organization. There is currently a lot of work being done to develop precise localization systems for driverless vehicles, Narula says, but not much done in the way of pedestrians and cyclists. The current belief is that the quick reaction time and unwavering vigilance of self-driving cars will virtually eliminate pedestrian and cyclist fatalities.

But Narula argues that since pedestrians and cyclists move unpredictably, a self-driving car determined to avoid all accidents with these vulnerable travelers will slow to a crawl. This, Narula says, is the "crawling car conundrum."

Murrian and Narula are working on an innovative solution to this problem by developing precise location-tracking software for pedestrians and cyclists wearing smartphones with upgraded GPS and sensor technology. Their work expands upon centimeter-accurate GPS technology developed in the Radionavigation Lab. Although precise GPS is an important factor in a device's location accuracy, the duo says there is still room for improvement. In areas without a clear view of the sky, such as a city with tall buildings, GPS can become inaccurate.




*The "RadioLynx" is a dual-antenna, dual-frequency GNSS front-end developed in collaboration with the UT Austin Radionavigation Lab. It will enable robust and precise positioning for pedestrians and cyclists at very low cost.*

The team believes that a "sensor fusion" approach that combines centimeter-accurate GPS with other opto-electric sensors is the solution to accurately tracking pedestrians and cyclists. This approach combines precise GPS with an Inertial Measurement Unit (IMU) and a visible-light camera. These sensors detect the instantaneous acceleration and rotation of the cyclist/pedestrian in a way that is complementary to GPS, which provides a global location.

Murrian will focus on the GPS and IMU aspects of the project while Narula perfects the computer vision component. Their goal is to build a tracking device that will know a user's location to within half a meter and the direction the user is facing to 2-3 degrees. Narula expects their research will lead to fewer traffic fatalities because it can provide autonomous cars the precise location of pedestrians and cyclists, even if the cars' line-of-sight sensors cannot see them.

"Making cars autonomous and having better sensors will help reduce traffic fatalities, but if you can't perceive the cyclist with the sensors you have, that's where the problem is," Narula said. "Instead of the car having to see, the pedestrian or cyclist will just provide a precise location."

Though the team is concentrating on developing the software for the tracking device, Murrian said their prototype concept is an arm-mounted smartphone that contains an IMU and a camera facing outward. He said the most challenging part is making sure their final product will be cost-effective and capable for smartphone use. Another problem the team says they must overcome is hacking. For example, a pedestrian or cyclist could fabricate a location, forcing a car to stop when no one is actually at that location.

Despite the challenges, Murrian and Narula are excited to put their problem-solving skills to the test.

"This is a very challenging problem, but that's why we chose it," Murrian said. "Its difficulty is what makes it exciting."

# ON THE RISE

*The Department of Aerospace Engineering and Engineering Mechanics in the Cockrell School of Engineering at UT Austin has been rapidly growing and expanding our breadth of expertise over the past few years. In this section, we highlight our recent numbers, research areas, faculty and alumni to showcase our momentum and impact on our community and the fields associated with our department.*

## #8

AEROSPACE ENGINEERING
***GRADUATE PROGRAM***
IN THE NATION

*U.S. News and World Report*

## #8

AEROSPACE ENGINEERING
***UNDERGRADUATE PROGRAM***
IN THE NATION

*U.S. News and World Report*

## 4TH

***MOST INFLUENTIAL*** RESEARCH
INSTITUTION IN AEROSPACE

*Thomson Reuters*
*State of Innovation Report*

## #9

AEROSPACE ENGINEERING
PROGRAM ***IN THE WORLD***

*Center for World University Rankings*

# THE DEPARTMENT OF AEROSPACE ENG AND ENGINEERING MECHANICS

## FACULTY

31.5 tenure and tenure- track faculty

6 endowed chair holders

7 members of the National Academy of Engineering

7 National Science Foundation CAREER Award Winners

Our faculty work closely with students to solve important technological and scientific problems related to aviation, space engineering and science, robotics, energy, biomechanics and earth science.

## RESEARCH

$15.2 M

research expenditures

SOLIDS, STRUCTURES AND MATERIALS

CONTROLS, AUTONOMY AND ROBOTICS

ORBITAL MECHANICS

COMPUTATIONAL MECHANICS

AERODYNAMICS AND FLUID MECHANICS

# GINEERING

## STUDENTS

### UNDERGRADUATE STUDENTS

A B C D

**1440**

average SAT score of admitted students

**11**

student organizations and groups

> "The Women in Aerospace for Leadership and Development student group has made a tremendous impact on my studies. I am making friends and connections that motivate me to keep working hard. It's really nice to have a group of people to study with and who can help and support me.
>
> – JOSEPHINA SALAZAR
> *AEROSPACE ENGINEERING, CLASS OF 2019*

**$63,100**

average starting salary for B.S. aerospace engineering graduates

**53%**

of students are involved with a student organization or project

### GRADUATE STUDENTS

**ASE: 3.67**
**EM: 3.7**

average admitted GPA for 2016-17

**100%**

of ASE/EM graduate students receive fellowship support

**$155 K**

Aerospace Engineering

**$3.7 K**

Engineering Mechanics

*Total amount given in graduate fellowships in 2017*

## RESEARCH SPOTLIGHTS

Srinivas Bettadpur is leading the **GRACE Follow-On mission**, which is set to launch in early 2018, replacing the twin GRACE satellites that have been measuring Earth's water and mass movement for 15 years. The new satellites will take more accurate measurements and provide important data on the rate of melting ice, rising ocean levels and depleted aquifers.

In partnership with NASA-JSC, a **new plasma torch facility** was built at the J.J. Pickle Research Facility and is now being used by researchers to test spacecraft heatshield materials at extreme temperatures.

Kenneth Liechti and colleagues are developing methods for the **roll-to-roll transfer of graphene** that may aid in the manufacturing of the next generation of electronics.

## FEATURED ENTREPRENEURS

Todd Humphreys and his students **co-founded the startup RadioSense** and are working with Samsung to develop a snap-on accessory that will tell smartphones, tablets and virtual reality headsets their precise position and orientation based on the centimeter-accurate GPS-based positioning system that the UT Austin research team recently developed.

Nanshu Lu **co-founded the startup Rotex Technology**, a company that develops electronic tattoo technology for health care, fitness and human-computer interaction. Rotex recently raised $1 million in seed funding from Empower Investment and was named one of 10 standout technologies at the 2017 Consumer Electronics Show.

## NOTABLE ALUMNI

### ALAN STERN
### B.S. ASE '80

The principal investigator on the New Horizons mission, which has provided spectacular images of Pluto and its moons.

### ADAM HAMILTON
### M.S. ASE '87

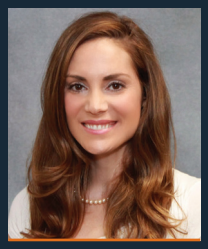
President of Southwest Research Institute, a nonprofit, multidisciplinary research entity that works to solve tough engineering and science problems.

### DENNIS MCWILLIAMS
### B.S. ASE '83

A Cockrell School Distinguished Engineering Graduate and founder of Apollo Endosurgery, a corporation that produces innovative products for endoscopic surgery.

### JEANNIE LEAVITT
### B.S. ASE '90

The first female wing commander in the U.S. Air Force and an Outstanding Young Texas Exes Award recipient.



### ANDREA CHAVEZ
### B.S. ASE '04

An aerospace engineer at Bell Helicopter and recipient of the Outstanding Young Texas Exes Award.

photo: NASA-JPL

### MICHAEL WATKINS
### PH.D. ASE '90

The director of NASA's Jet Propulsion Laboratory where he plans to "forge new directions in space exploration and earth science."

### K.C. WILLIAMS
### B.S. ASE '72

Former vice president of production for Exxon Company International and a Cockrell School Distinguished Engineering Graduate.

### DID YOU KNOW?

photo: NASA

Six of our alumni are astronauts, including Andreas Mogensen (Ph.D. ASE '07, pictured left), who co-piloted a flight to the International Space Station and Stephanie Wilson (M.S. ASE '92, pictured right) who was honored with the Texas Exes Distinguished Alumna Award.

# BUILDING FUTURE BOTS

## CREATING ROBOTS THAT COULD ASSIST ASTRONAUTS AND GIVE THE HUMAN BODY A BIONIC BOOST

*BY MONICA KORTSHA*

Science fiction has long envisioned humans getting assistance from robotic helpers. Associate professor Luis Sentis is bringing to life two of the most well-known kinds: mechanical suits that boost the wearer's physical strength and humanoid robots that can lend a hand on missions to other planets.

This summer, Sentis received research grants from the National Science Foundation and the Department of Defense to create the robotic devices. The NSF grant funds the development of humanoid robots that can prepare long-term living and work spaces on Mars or the moon ahead of human missions and then work alongside the astronauts when they arrive. The DoD grant supports research into strength- and speed-enhancing exoskeletons that feel second nature to the person strapped into the suits.

*Associate professor Luis Sentis presents the HCRL/Apptronik Draco Leg, a joint effort between UT Austin and Apptronik Systems, at the Office of Naval Research Science and Technology Expo.*

As the director of the UT Human Centered Robotics Group, Sentis' work is grounded in creating robotic devices with humans in mind. The robots created by the group are intended to directly assist people and easily communicate with them.

"Our work enhances the productivity of people," Sentis said. "Their comfort, health, security and output — there is always the human factor."

Sentis has plenty of prior experience creating robots that do just that. In 2013, he helped NASA design and test Valkyrie, an experimental humanoid robot with a superhero-like appearance built to move and maneuver around obstacles. He worked with engineering students to build Dreamer, a multi-purpose robot with blinking cartoonish eyes meant to attract and engage people. And in 2017, his team took third place in the RoboCup@Home, an international competition held in Nagoya, Japan, that tests robots' domestic skills, from stocking a kitchen pantry to recognizing and greeting team members.

The robot that Sentis is developing to prepare astronaut habitats will have to be more than a good housekeeper. By the end of the four-year grant, Sentis hopes to have a robot that can drive a rover, install solar panels, open a hatch and plug in electronics. He added that the humanoid form of the robot will endow it with more flexibility in mobility than robots with more specialized parts.

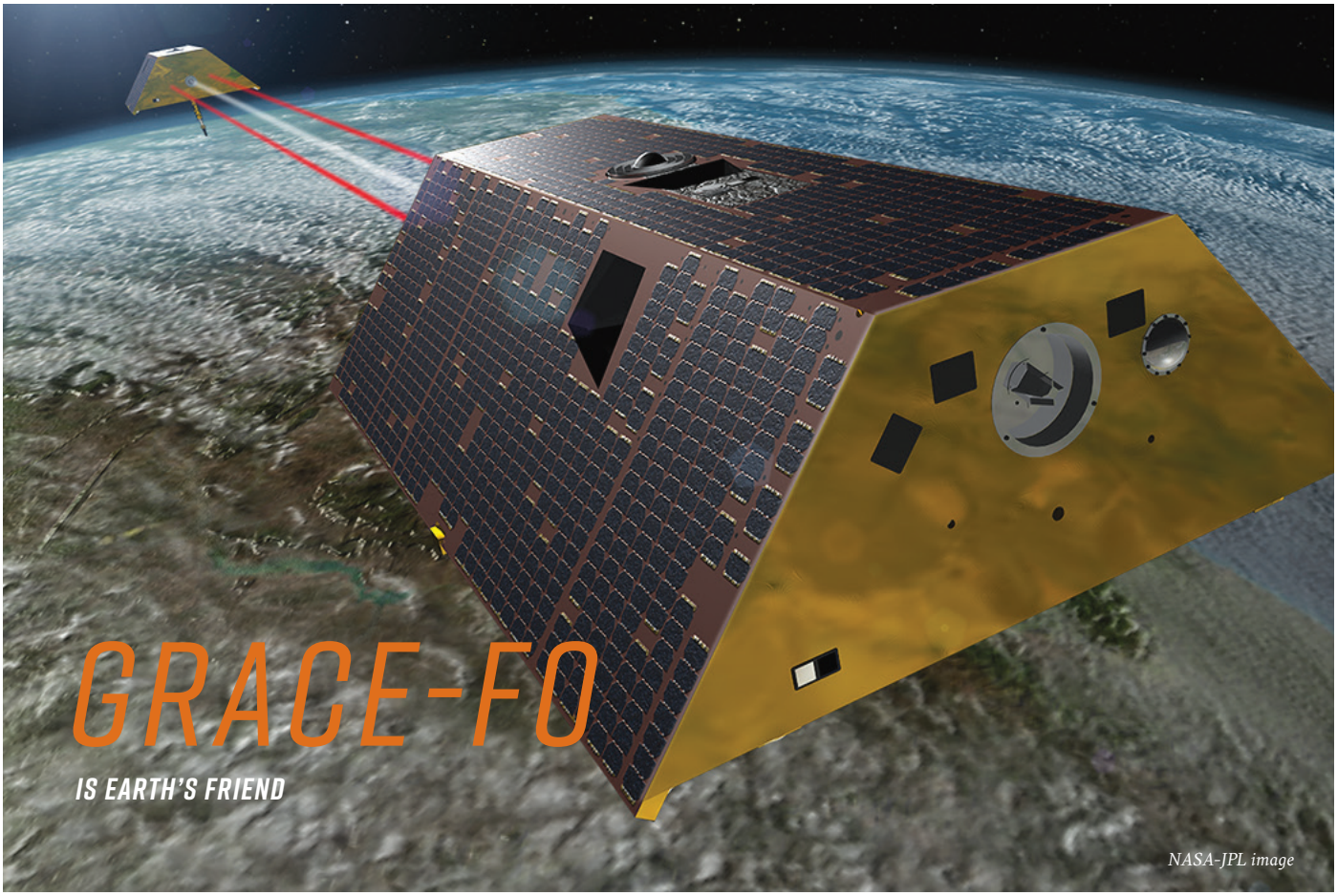
Getting the robot to move fluidly will involve making the most of its powerful actuators that physically move the machine's limbs. NASA's Valkyrie robot uses a type of series-elastic actuators developed by Sentis' research group on various parts of its limbs. Sentis said he envisions using artificial intelligence and similar actuator control systems to make space robots productive, safe and energy efficient for future exploration of extraterrestrial planets.

Advanced actuator technology is also at the heart of building an improved exoskeleton, Sentis said. A new type of actuator developed by Sentis and collaborators, called a liquid-cooled viscoelastic actuator, will help the exoskeleton be more responsive and lightweight, solving a major problem in current exoskeleton design: clunky and delayed movement.

"When people use them, they feel they're working on crutches... at the end of the day you are more tired," Sentis said. "So we're going to deliver a new iteration of this type of technology, that's focusing on what people want to wear without losing bodily dexterity or feeling uncomfortable."

Exoskeletons that feel more natural could boost the performance of people who work physical jobs, from manufacturing and health to transportation and defense. But Sentis said he thinks that the biggest group to benefit from exoskeleton technology might be people with impaired or limited mobility. He said the future of exoskeletons may look less like an advanced Iron Man and more like robot-assisted grandparents walking with their grandchildren outdoors.

"People are living to 85 and 95, so we're going to see older people who need help walking," Sentis said. "Exoskeletons will have huge applications."



# GRACE-FO

## IS EARTH'S FRIEND

NASA-JPL image

The GRACE satellites, affectionately known as Tom and Jerry, have tirelessly orbited Earth for more than 15 years, collecting valuable information about the changes in the planet's water, ice and land. Nearly 20 years ago, aerospace engineering professor Byron Tapley, director of The University of Texas at Austin Center for Space Research (UTCSR), encouraged NASA's Jet Propulsion Laboratory (NASA-JPL) to use the twin satellites to measure small changes in the earth using its gravitational pull. This March, the satellites marked their 15th year in orbit.

Since the dawn of the space age, scientists have used measurements of large variations in the orbits or the paths of Earth satellites, based on the fundamental principles presented by Isaac Newton that explain tides and the earth's structure through studying the motion of the moon around the earth. The GRACE (Gravity Recovery and Climate Experiment) mission offered a paradigm-shifting implementation with its co-orbiting twin satellites orbiting at 200 kilometers apart at 500 kilometers in altitude. This allows the continuous and highly precise measurements of the influence of never-before-seen variations in Earth's gravitational field—for instance, due to the land-water cycle or ice-sheet changes—on the orbits of the twin satellites.

It its lifetime, the GRACE mission has helped researchers understand a variety of the climate trends taking place across continents. Once the satellites beam down data to UTCSR researchers, it is converted into useful information. Measurements from the GRACE satellites are analyzed through supercomputers at the university's Texas Advanced Computing Center and have provided important data such as measuring changes in sea level and revealing when aquifer levels are at a dangerous low.

"UTCSR has delivered maps of Earth's gravitational field and mass variability that are now the established benchmark worldwide," said Srinivas Bettadpur, who is an associate professor of aerospace engineering and engineering mechanics. "Because of our analyses, we have also delivered the now de-facto standards for the time-variable and mean gravitational field models for Earth."

Additionally, Bettadpur said, geoscientists and engineers around the world have used GRACE data to show, for example, that water balance in river basins worldwide is quite variable, contrary to longstanding practices in the hydrology community, and can be indicative of the drought conditions in the past decade in places such as Texas and California. Across Greenland and Antarctica, GRACE data have also provided unprecedented measurements

of ice-sheet mass loss and helped spawn new research into the mechanics of ice-sheet evolution and the resulting societal impacts. Other GRACE outcomes include insights into the structure of the earth's crust since the last ice age, the mechanics of some of the most major earthquakes and the delineation of the ocean currents and their variability.

While the twin GRACE satellites tripled their initial life expectancy, they will be retired and replaced by new twin satellites in the GRACE Follow-On mission, or GRACE-FO, in early 2018.

Bettadpur will spearhead the work at UT Austin for GRACE-FO, with UTCSR once again playing a key role in the mission; it will be jointly implemented by NASA-JPL and the GFZ German Geosciences Research Center. GRACE-FO is not only expected to fill the role of its predecessor, but also potentially surpass its accuracy with new laser technology.

"GRACE-FO will provide continuity with GRACE, which is essential to understanding variations in the earth's system at the decadal time scales that, in turn, are critical for our understanding of societal impacts of global climate change," Bettadpur said. "At the same time, GRACE-FO will also fly a new laser interferometer demonstration system with highly precise data that will provide new insights into the earth's system processes at finer spatial scales than ever before."

GRACE-FO's end date is scheduled for 2022, but the satellites have a potential lifespan of 10 years, allowing UT Austin to continue providing crucial data on the earth's changing landmasses, ice sheets and water.

"With GRACE, scientists and engineers at UTCSR were instrumental in inventing a new remote-sensing technique and helping to establish it as the preferred technique among researchers studying globally connected climate processes," Bettadpur said. "With GRACE-FO, we are able to use our initial insights to explore further, using more capable, upgraded satellites. On the technology front, we are also looking beyond GRACE-FO, seeing how the ideas and tools that might be confined to the lab today can be put to service for society in this way in the not too distant future."

## 15 YEARS OF GRACE

*NASA Statistics*

2 SATELLITES

137 MILES APART

2.4M MILES TRAVELED

3,400 GIGATONS
*ice loss measured in Greenland*

1,500 GIGATONS
*ice loss measured in Antarctica*

1 $KM^2$ = 1 GIGATON

Charles Mallini, B.S. ASE '77, M.S. ASE '87

# CHASING THE ECLIPSE

*On Aug. 21, the total solar eclipse provided a brief opportunity for scientists to study the sun. NASA took advantage of this opportunity by observing the eclipse from two WB-57F research jets as they chased the moon's shadow across the United States. Aerospace engineering alumnus Charles Mallini (B.S. ASE '77, M.S. ASE '87), branch chief manager of NASA's WB-57F program, was at the forefront of this endeavor, and he took the time to answer some questions before and after and the eclipse.*

**What does your position entail as branch chief manager for the WB-57F program? What makes these jets unique?**

We have three WB-57 aircraft at NASA-JSC; they're the only three of their kind in the world and they are high-altitude research aircraft. We do all the maintenance here, all the operations and engineering. My job is to make sure those airplanes are ready to fly when needed. These jets have the ability to fly over 60,000 feet. If you look in the U.S., there are only a couple of other planes that can do that.

**These jets were used to chase the eclipse using twin telescopes mounted on the nose of the aircraft. What was your role in this mission?**

NASA owns the two telescopes. Our job for the solar eclipse mission was to make sure the aircraft are up and running. It's worth mentioning that we were contracted by Southwest Research Institute (SWRI), funded by a NASA grant. SWRI proposed using our two airplanes and the telescope camera systems we have. So, SWRI did the science and we flew our aircraft with the instruments.

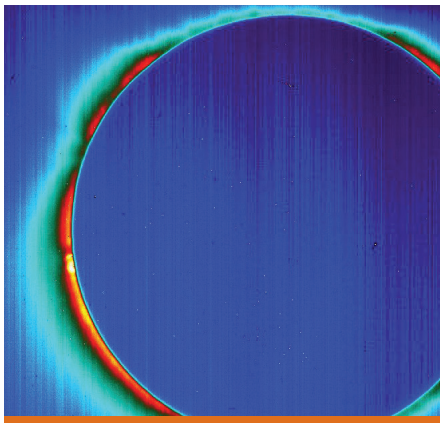
**Why is this mission important to scientists and engineers?**

The scientists and engineers will say the solar eclipse offers a unique opportunity to look at the sun. Nature is pretty close to being perfect on what it can block out on the sun, so you can then look at things like the corona, the atmosphere around the sun. Because the airplanes traveled along with the eclipse, we were able to observe it over three times longer than people watching from Earth. The pilots hit their marks perfectly and ended up with a continuous viewing of the eclipse for nearly eight minutes.

**What was the most challenging part of this mission? What are you most proud of?**

There are always small problems, and you have to work through one problem, then another. The data for the scientists went extremely well, so the principal investigator and the scientists were happy, but getting the live feed down was the hard part. We were having problems with the bandwidth for our satellite but were able to get that worked out within seconds of them queuing us up to go on to the NASA website.

The thing I'm most proud of is our team. We accomplished all of the objectives. There were a number of small issues that had to be worked out during the flight and the team worked together to solve the problems on the airplane and on the ground. The number one objective for us was the science data and we got all of the science data. We did what we set out to do and hit a home run.



*An image of the solar eclipse taken from one of the WB-57F jets with a mid-wave infrared camera.*

**How did your educational experiences at UT Austin help prepare you for this work?**

My education at UT has really taught me how to think. That's kind of strange, but there's nothing in an aerospace engineering degree that says 'you're going to be prepared to go do this.' But it has taught me how to work through problems, how to apply engineering principles, how to organize, and all of those things are critical to any job that I've done and this is just another example how of the broad experience and broad background at UT has allowed me to do these types of things.

# ALUMNI PROFILE: KRISTEN JOHN, B.S. ASE '08

POSTDOCTORAL RESEARCHER | ASTROMATERIALS RESEARCH & EXPLORATION SCIENCE GROUP | NASA-JSC

**Why did you decide to pursue an aerospace engineering degree?**
I've always been passionate about the space program, so when I was looking for a major, aerospace engineering sounded awesome! After a couple days in Dr. Hans Mark's Intro to Aerospace Engineering class, I knew I picked the right major.

**Describe your current position.**
My research at NASA Johnson Space Center involves studying the surfaces of asteroids and small planetary bodies, understanding the mechanical properties of meteorites and their parent bodies, mission/instrument concept development for robotic planetary exploration and low-cost/small-satellite development. I am the deputy project manager and project engineer for two experiments flying on the International Space Station, including the first-ever DNA sequencer in space and another that studies asteroid regolith stratification in microgravity.

**What do you like most about your job? What do you find most challenging?**
I have had the unique opportunity to design, build and fly an experiment to the ISS on a project called Strata-1. Through this project, I had the chance to see the entire design life cycle of a project in under one year, which is not typical at NASA. I really enjoyed that no two days were alike. One day I might be in the machine shop constructing a piece of equipment, another day I may be presenting in front of a safety panel on my hardware, and the next day I may be talking directly to an astronaut telling her how to operate the experiment. The biggest challenge is balancing all the tasks required to fly and support an experiment, but it is extremely rewarding and a lot of fun!

**What are your career goals?**
My career goals are to continue to contribute to the space program by advancing science, engineering and technology in my own way. I'm an engineer working in a planetary science group, which I really enjoy. I love working with scientists to find ways to fly cutting-edge experiments to space. If I can continue to work in a role that advances planetary science and exploration, I will be proud.

**Who was your most influential aerospace engineering professor and why?**
Hans Mark. I worked with him as an undergraduate research assistant. The experience I had with him in the Electromagnetic Railgun Lab gave me experience that prepared me for graduate school research. His guidance led me to work harder in my coursework so that I could increase my GPA. His role in the history of space flight has been amazing, and I'm honored to call him my mentor.

*Kristen John, B.S. ASE '08, is a NASA Postdoctoral Researcher at NASA Johnson Space Center.*

**What's your favorite memory as an aerospace engineering student?**
I always enjoyed the release of the AerOnion (a student satire newsletter). Is this still a thing? If not, some current students should make it happen! (I was not one of the writers, just an entertained reader.)

**What are three things that most people don't know about you?**
1) I lived in Dubai as a young girl. The United Arab Emirates is actually currently pursuing their own space program. 2) I have a baby, Annie, and I sometimes call her Annie the Astronaut! 3) And I have a Curious George collection. Perhaps George's adventure into space subconsciously inspired me as a kid to pursue a career in aerospace engineering.

*Payam Banazadeh, B.S. ASE '12, is working on small satellite technology to produce images of Earth.*

# START-UP CREATES SPACE-BASED RADAR SATELLITES

With the use of Synthetic Aperture Radar (SAR), satellites orbiting Earth can produce 2-D and 3-D images of the planet's landscapes, cities, ports and more, day or night and even in inclement weather. Data collected from these images could be used to analyze traffic at busy intersections, manage resources more efficiently or even save lives in search-and-rescue missions.

But SAR satellites present their own challenges. For decades, government and military agencies have used this technology, but the satellites are very large and expensive. The satellites themselves cost about half a billion dollars, with each photo costing thousands of dollars, making them an impractical option for most businesses and individuals.

Alumnus Payam Banazadeh, B.S. ASE 2012, is working on a solution to this. His company, Capella Space, is the first to combine SAR with CubeSats — small, inexpensive satellites — and plans to be the first in the U.S. to launch a commercial SAR satellite into space. Banazadeh says these satellites will have the capability to produce images at a fraction of the cost. This will allow them to put more SARs into space, making it possible to take frequent photos of more locations. Capella's goal is to create images that could develop a better understanding of the earth which could aid in disaster relief, city planning and oil and gas applications.

"Imagine if we could capture an image of Austin from space every hour of every day and every night all the time and understand how things are changing, understand the movement of cars, movement of man-made objects," he said. "There's a lot of hidden value in that type of information."

Capella Space has attracted a lot of interest for this project in the last year. Banazadeh has managed to raise millions in venture capital funding, and Capella Space already has a contract with the Department of Defense. The Capella Space team is in the process of expanding, growing to 20 people, and Forbes recently named Banazadeh and his co-founder William Woods to the Forbes 30 Under 30 list in the Technology Enterprise category for their work at Capella Space. "I never thought in a million years I would be on Forbes," Banazadeh said. "Both my co-founder Will and I are humbled and honored to be included."

> "I use everything I learned in the [Texas Spacecraft Lab] every day when I'm at work. It's essentially the reason why I'm doing it.
>
> -PAYAM BANAZADEH, *B.S. ASE '12*

Banazadeh has worked with CubeSats since his days in the Texas Spacecraft Lab at UT Austin, as an undergraduate student in aerospace engineering. He says the time he spent there with CubeSats there had a profound impact on his career.

"I would say that was the biggest program I was involved with outside of classes and probably the most influential," Banazadeh said. "I use everything that I learned in that lab every day right now when I'm at work. It's essentially the reason why I'm doing what I'm doing."

During his summers as an undergraduate student, Banazadeh interned at NASA's Jet Propulsion Lab. Working at NASA had been a dream since he first visited the Johnson Space Center as a child, so when he graduated from the university in 2012, it seemed only natural that he would end up working for NASA.

Banazadeh began his career at NASA-JPL, where he worked on various projects, such as sending CubeSats to asteroids. In 2014, he decided to pursue his management degree at Stanford, where he met his future business partner, Woods, who was working on his Ph.D. in SAR. With Woods' background in SAR and Banazadeh's background in CubeSats, the team set out to design the first American commercial SAR CubeSat.

About a year later, with secured funding, an expanding team and a bright future ahead, the duo is excited to see the difference they could make with the new satellite technology.

"We're excited about just being disruptive and doing something that hasn't happened before," Banazadeh said. "Most of our excitement comes from what we're doing, which is making this technology so accessible."

# BLAST FROM THE PAST

**ALAN STERN, B.S. ASE '80,** was elected a Fellow of The Explorers Club, an international professional society dedicated to the advancement of field research. Stern serves as the principal investigator on the New Horizons mission, which has provided spectacular images of Pluto and its moons.

**HECTOR ALVIDRES, B.S. ASE '90, M.S. ASE '94,** is a Project Engineer at L3 Communications in Greenville, Texas.

**ANDY RECTOR, B.S. ASE '08,** is Engineering Director of Intelligent Airports for GE Aviation in Austin. He writes, "I recently changed positions in order to lead the engineering effort for a startup business within GE Aviation. We are taking our industrial Internet platform, Predix, and applying our expertise into adjacent markets. I joined GE through the acquisition of a startup called Austin Digital, appropriately based here in Austin. I was chosen to lead this group based on my unique combination of engineering excellence and startup thinking within a large corporation."

**FRANK MARTIN SEBASTIANELLI, B.S. ASE '14,** is an International Space Station Robotics Systems Engineer for NASA/Jacobs Technology/MTS Inc. in Houston. He writes, "People often imagine the experiments that the crew aboard the ISS perform on a daily basis. But plenty of autonomous experiments are installed on the outside of the ISS. Usually they are installed by the three main robots located on the outside of the ISS. Since repairing the robots outside of the station isn't exactly as easy as changing a flat tire, it's part of my job to balance payload developers getting to do what they want, while making sure they do not harm or incapacitate the robots in any way."

**CRAIG ALAN PHILLIPS, B.S. ASE '81,** is Chief for Missile Integration for the U.S. Navy Civilian in Dahlgren, Virginia, where he oversees technical efforts to integrate missiles onto Navy platforms and provides technical leadership in modeling and simulation, requirements development, and end-to-end weapon system engineering.

**JONATHAN MORRELL, B.S. ASE '14,** is a Flight Data Engineer for GE Aviation in Austin. "As a flight data engineer, I handle the decoding and onboarding of recorded flight data from commercial aircraft. Flight Data Recorders (FDRs) and Quick Access Recorders (QARs) record parametric data streaming in from the aircraft's nervous system of sensors and then code that data into binary. My job is to build decoder rings that know where to look for a string of bits in a given data file and turn that into actual engineering values."

**RYAN CAMACHO, B.S. ASE '15,** is a Business Analyst for Renewal by Anderson in Austin, Texas. He writes, "I got engaged in March to my girlfriend of six years and I just purchased my first home!"

## 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! Update your contact info and send us your news at* **ae.utexas.edu/alumni-friends** *or* **longhornliftoff@fortyacres.utexas.edu**

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NASA image

## LONGHORNS IN SPACE

*The University of Texas at Austin sent its first astronaut into space in 1969, when Alan Bean became the fourth person to walk on the moon. Since then, UT Austin has graduated 12 astronauts in total, who have flown more than 533 days in space. In honor of World Space Week (Oct. 4-10), we celebrate the six astronauts who hold degrees from the Department of Aerospace Engineering and Engineering Mechanics.*

***ALAN BEAN***
B.S. Aeronautical Engineering, 1955

***ROBERT L. CRIPPEN***
B.S. Aerospace Engineering, 1960

***MICHAEL A. BAKER***
B.S. Aerospace Engineering, 1975

***PAUL S. LOCKHART*** *(pictured)*
M.S. Aerospace Engineering, 1981

***STEPHANIE D. WILSON***
M.S. Aerospace Engineering, 1992

***ANDREAS MOGENSEN***
Ph.D. Aerospace Engineering, 2008

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*For details and regisitration, visit:*
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The Longhorn Liftoff is published each fall and spring semester for alumni and friends of the Department of Aerospace Engineering and Engineering Mechanics in the Cockrell School of Engineering at The University of Texas at Austin.

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