FY15:

(People + Ideas + Drive)$^{\infty}$

Georgia Tech | Daniel Guggenheim School of Aerospace Engineering

MAKING THE IMPOSSIBLE PRACTICAL

For many of us, there's an unstated dictum that describes the Daniel Guggenheim School of Aerospace Engineering: imagine the ***impossible***, then make it ***practical***.

For almost 100 years, those sentiments have quietly inspired generations of brilliant young thinkers to study, research, and innovate here at GT-AE.

They have also allowed GT-AE to attract the best minds — like Prof. **E. Glenn Lightsey**, who brought his unrivaled expertise in satellite launch and technology development to our faculty this past year. And energetic organizers, like **Vickie Brian**, who joined our leadership team as the assistant director for operations.

They are the spark that ignites ambition — among innovators like Regents Professor **Krishan Ahuja,** who recently agreed to head up a collaborative $8 million Air Force SMC contract to design better tools for predicting combustion stability in liquid rocket engines.

And they are the vision that continues to define our future — through the hard work of my many colleagues, like **Stephen Ruffin**, who brought in a $500,000 NASA grant this year to expand STEM outreach to community colleges and technical schools through the Georgia Space Grant Consortium.

Yes, "impossible" was a great launching pad in FY15.
I can't wait to see where it brings us in FY16.

Sincerely,

Vigor Yang
Chair of the Daniel Guggenheim School of Aerospace Engineering

Glenn Lightsey, Vickie Brian, Stephen Ruffin, Krishan Ahuja




Statistics, 2014-2015

No.3
national ranking for undergraduate program*

No.5
national ranking for graduate program*

1,456 enrolled / **20%** pursuing Ph.D.s

35% of eligible undergrads are involved in research

30% of eligible undergrads are doing internships/co-ops

**U.S. News & World Report*

GOOD ENOUGH IS NEVER ENOUGH

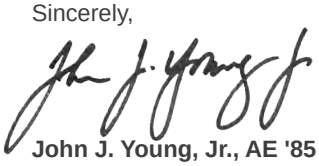
The Daniel Guggenheim School of Aerospace Engineering is one of the largest public aerospace engineering schools in the country, with a faculty whose expertise spans all aspects of this ever-expanding discipline. We have launched the careers of storied astronauts, military leaders, and industry titans. No one ***owns*** the future, but, every year, GT-AE faculty and students are ***defining*** it.

Building on this ambitious legacy is the job of every person associated with GT-AE. That's why, this year, I donated seed money to establish the first of two "maker studios" at GT-AE.

Outfitted with traditional shop equipment — lathes, routers, and mills — and with next generation machines — 3D printers, waterjet cutters, and five-axis CNCs — these new spaces will allow our students easy and convenient access to tools which can convert their own research to reality. They will be able to conceptualize, design, and manufacture the specific parts they need to put their well-honed theories and computer simulations to the test.

As an alumnus, and as the chair of the Aerospace Engineering School Advisory Council, I am glad that our leader, **Dr. Vigor Yang**, understands the strategic importance of enabling student innovation. Industry demands engineers who are systems-level thinkers and doers. His decision to forge ahead with the maker studios shows the sort of vision that will allow GT-AE to continue to define the future. I urge fellow supporters of the School to join me in supporting Vigor's forward-looking efforts.

Sincerely,



John J. Young, Jr., AE '85
Chair, Aerospace Engineering School Advisory Council

2014-2015 AESAC Members

Jennifer P. Byrne
Vice President, Aeronautics - Technical Operations
Lockheed Martin Corporation

John W. Elbon
AE '82
Vice President & General Manager, Space Exploration
The Boeing Company

Philip A. Fawcett
AE '89, '92
Principal Director, Advanced Research and Engineering
The Aerospace Corporation

Ram Janakiram
AE '76
Manager, Flight Technology
The Boeing Company

R. Steven Justice
AE '80
Director, Georgia Center of Innovation for Aerospace

Catherine Kilmain
AE '95, '98
Senior VP, Engineering & Xworx
Bell Helicopter

John E. Laughter
AE '93
Senior VP - Safety, Security and Compliance
Delta Air Lines, Inc.

Leslie Livesay
Director, Engineering and Science Directorate
Jet Propulsion Laboratory

Sandra H. Magnus
MSE '96
Executive Director
American Institute of Aeronautics & Astronautics

Jaime Peraire
Dept. Head and H.N. Slater Prof. of Aeronautics & Astronautics
MIT

Guruswami Ravichandran
John E. Goode, Jr. Prof. of Aerospace, Prof. of Mechanical Engineering, Director, Graduate Aerospace Labs, Caltech

Don W. Richardson
(Chair Emeritus)
AE '51
President and COO
Donrich Research Inc.

Jayant Sabnis
Vice President
Engineering Module Centers
Pratt & Whitney

Rajarama Shenoy
AE '76, '79
Attributes Manager
Naval Hawk Programs, Sikorsky Aircraft Corporation

Chris Singer
Director, Engineering Directorate
NASA Marshall Space Flight Center

Joseph D. Stewart
AE '64, '65, '67
Associate VP for Research,
The University of Tennessee

Robert W. Stoker
AE '89, '90, '96
Senior Manager-Product Development, Collaboration, Commercial Airlines
The Boeing Company

Gary Weissel
AE '93
Vice President and Co-managing Officer, Aviation & Aerospace, ICF SH &E

Stephanie Wojcik
AE '03
Engineering Operations
Integrated Defense Systems, The Boeing Company

Stephen M. Younger
Vice President and Chief Technologist
Northrop Grumman Technical Services

GT-AE Alumni, Like Cream, Always Rise to the Top

Admiral **James A. "Sandy" Winnefeld**, BAE '78, Dr. **Christopher T. Jones**, BAE '86, and Dr. **Ian Clark**, Ph.D. AE '09 were recognized this year by the Georgia Tech College of Engineering.

Inducted in the College of Engineering's Hall of Fame was Admiral **James A. "Sandy" Winnefeld**, whose illustrious resume has been played out on the public stage for almost three decades. After graduating from Tech with high honors, he flew the F-14 Tomcat on several deployments to the Western Pacific and Arabian Gulf and served as an instructor at the Navy Fighter Weapons School (TOPGUN). His military service has garnered many honors, including the Defense Distinguished Service Medal, Distinguished Service Medal, Defense Superior Service Medal, the Legion of Merit, the Bronze Star, the Defense Meritorious Service Medal, the Meritorious Service Medal, the Air Medal, and five Battle Efficiency awards. After a July 2015 retirement from his most recent military assignment - vice chair of the Joint Chiefs of Staff - Winnefeld will join the Sam Nunn School of International Affairs at Georgia Tech as a distinguished professor.

Northrop Grumman corporate vice president **Christopher Jones** was inducted into the prestigious College of Engineering Academy of Distinguished Engineering Alumni. In addition to earning two masters degrees and a doctorate, Jones was an active duty Air Force officer, retiring at the rank of lieutenant colonel. He was a member of the Connecticut National Guard for 14 years and participated in military deployments including Operation Noble Eagle and Operation Enduring Freedom. He serves on the boards of the National Action Council for Minorities and the Air Force Association, as well as the Georgia Tech Advisory Board. This spring, Jones was elected to the American Institute of Astronautics and Aeronautics (AIAA) as an Associate Fellow.

Dr. **Ian Clark** was selected for the Council of Outstanding Young Engineering Alumni Award. This award is given annually to alumni who have distinguished themselves through professional practice and/or service to the Institute, the engineering profession, or society at large. They are on the "fast track" to a distinguished career -- a description that accurately describes Clark, a systems specialist in Planetary Entry, Descent, and Landing (EDL) at the Jet Propulsion Lab. As the principal investigator for NASA's $200 million Low-density Supersonic Decelerator project, he is leading the way to an eventual exploration of Mars. For his work and leadership in the aerospace field, Clark has received several awards, including the Presidential Early Career Award for Scientists and Engineers, the Jet Propulsion Laboratory (JPL) Lew Allen Award for Excellence, and the JPL Explorer Award.

Loewy Lectureship Established

The establishment of a new lectureship by former school chair and beloved professor Dr. **Robert Loewy** was a high point of 2015 for the Daniel Guggenheim School of Aerospace Engineering. The **Lila S. and Robert G. Loewy Ph.D. Lectureship in Rotorcraft Technology** will allow us to expand our influence and stature in a field that GT-AE has already played a huge role in shaping. The inaugural lecture, held in March, 2015, drew dozens of rotorcraft experts to campus to hear Sikorsky Innovations vice president Chris Von Buiten give a talk entitled, "Taking on the Toughest Challenges in Vertical Flight."

"I'm proud of the leadership that the School has historically shown in this field," said Loewy. "This lectureship will give us an opportunity to reflect on new trends and pursue new opportunities to grow."

FACULTY ACHIEVEMENTS

Leading the Way

Robert Braun was chosen for Caltech's semester-long Moore Distinguished Scholar Program and also received the American Astronautical Society's (AAS) first-ever Space Technology Award.

Brian German was asked to participate in AIAA's 2015 Frontiers of Engineering Symposium.

After concluding his year-long stint as the American Helicopter Society's Nikolsky Lecturer, **Dewey Hodges** *(right)* received the American Society of Mechanical Engineers' (ASME) Spirit of St. Louis Medal.

Narayanan Komerath received the AIAA/ASEE John Leland Atwood Award.

The American Institute of Aeronautics and Astronautics (AIAA) named **Glenn Lightsey** and **Timothy Lieuwen** as Fellows. Prof. **Ben T. Zinn** was named an Honorary Fellow.

Julian Rimoli was selected for the Goizueta Foundation Junior Faculty professorship and received a highly competitive $500,000 NSF CAREER Grant.

Marilyn Smith was named a 2015 AHS Technical Fellow.

Dave Spencer was elected to join American Astronautical Society's board.

Mitchell Walker and Vigor Yang at Yang's NAE induction ceremony.

Just months after receiving the prestigious Joint Army Navy NASA Air Force (JANNAF) Lifetime Achievement Award, AE School Chair and William R. T. Oakes Professor **Vigor Yang** was elected to the National Academy of Engineering (NAE), a career-defining honor.

Rising to Meet New Challenges

Lakshmi Sankar received teaching excellence awards from the Institute, Sigma Gamma Tau, and Women in Engineering.

John-Paul Clarke was promoted to the rank for full professor.

Mark Costello, who heads up the GT-AE Center for Advanced Machine Mobility (CAMM) Lab, was confirmed as the School's new David S. Lewis Professor of Autonomy.

Dimitri Mavris's many contributions to GT-AE were recognized when he was confirmed as both a Regents Professor and as GT-AE's new Langley Distinguished Professorship in Advanced Aerospace Systems Architecture.

Brian German *(right)* was named to the Associate Langley Professor position.

J.V.R. Prasad was appointed as the new associate director of Georgia Tech's Vertical Lift Research Center of Excellence (VLRCOE).

Stephen Ruffin assumed the leadership of the National Space Grant Consortium Directors and was selected as a member of the National Resource Council's Committee on Propulsion and Energy Systems to Reduce Commercial Aviation Carbon Emissions.

Respected for Our Scholarship

Robert Braun was chosen to serve as the next editor-in-chief for AIAA's *Journal of Space and Rockets*, a seminal publication of the space industry.

"Robust Modal Filtering and Control of the X-56A Model with Simulated Fiber Optic Sensor Failures," a paper co-authored by **Dimitri Mavris**, doctoral student **Peter Suh**, and NASA's Alexander Chin, received the 2014 Best Paper Award at the AIAA Atmospheric Flight Mechanics Conference.

An article by **Joseph H. Saleh** *(right)* entitled "Flexibility: a Multi-disciplinary Literature Review and a Research Agenda for Designing Flexible Engineering Systems," was recognized by the *Journal of Engineering Design* as one of the most downloaded and most cited articles in the last five years.

Marilyn Smith joined the editorial board of *Scientific Reports.*

Elsevier also recognized two articles by **Dr. Wenting Sun** – "A Path Flux Analysis Method for the Reduction of Detailed Chemical Kinetic Mechanisms" and "Effects of Non-equilibrium Plasma Discharge on Counterflow Diffusion Flame Extinction" – as among the most cited in the last five years.

Mitchell Walker was named associate editor of the *Journal of Propulsion & Power.*

Professors Dimitri Mavris, Marilyn Smith, and Robert Braun at the Spring 2015 Commencement ceremonies.

Elsevier Publishing recognized **Dr. Vigor Yang's** paper "Dynamics and Stability of Lean-premixed Swirl-stabilized Combustion," as one of the most-popular downloads of the last decade.

STUDENT ACHIEVEMENTS

Undergraduates

Shelby Bottoms *(right, top)* – Sigma Gamma Tau's 2015 Outstanding Undergraduate of the Year for the Southeast Region

Julian Brew *(right, bottom)* – Recipient of the Lockheed Martin Foundation/President's Undergraduate Research Award

Joshua Carnes – One of 20 undergraduates nationwide to receive a 2014 NASA Aeronautics Scholarship

Sara Miller – One of just five recipients, nationwide, of the 2014 Advancing Aspirations Global Scholarship

Graduate Students

Nuno Ricardo Salgueiro Filipe, '14 and **Vrishank Raghav, '14** – These two former doctoral students of Narayanan Komerath were each 2015 recipients of the Sigma Xi Outstanding Ph.D. Awards for best dissertations

Kevin Jacobson – 2015 American Helicopter Society Robert Lichten Award for the Southern Region

Tim Murphy *(right, top)* – 2015 National Defense Science and Engineering Scholarship winner ($102,000)

Fracesco Favaro *(right, middle)* – 2015 Zonta International Amelia Earhardt Fellowship

David Blette, **Sean Chait**, **Adam Sidor** – 2014 NASA Space Technology Research Grant recipients

Imon Chakraborty *(right, bottom)* – Recipient of the AIAA Best Paper Award for his contribution to "A Requirements-driven Methodology for Integrating Subsystem Architecture Sizing and Analysis into the Conceptual Aircraft Design Phase"

Competitions

2015 Society of Automotive Engineers – ASDL team brought home first place overall in the Micro and Advance Class categories of the Aero Design competition

2015 AIAA Design-Build-Fly – BuzzKillington, the ASDL-designed remote-controlled plane took home the top honor for a design concept

2015 AHS Micro Air Vehicle Challenge – Vehicles designed and built by two GT-AE took home first place in the manually piloted and autonomous flight categories. One of them was the first vehicle to ever complete the challenge.

2014 AHS VTOL Design Competition – Under the mentorship of Prof. Daniel Schrage three GT-AE student teams took home top awards for their experimental vertical lift take-off landing vehicle designs.

Taking on the Grand Challenges

The Grand Challenges initiative of the Aerospace Systems Design Lab (ASDL) partnered more than 65 grads and undergrads with industry and government experts to tackle 18 real-world engineering problems. In addition to honing research and presentation skills, these year-long projects produced valuable practical applications for our partners—and some lasting professional relationships for our students. Here are just a few:

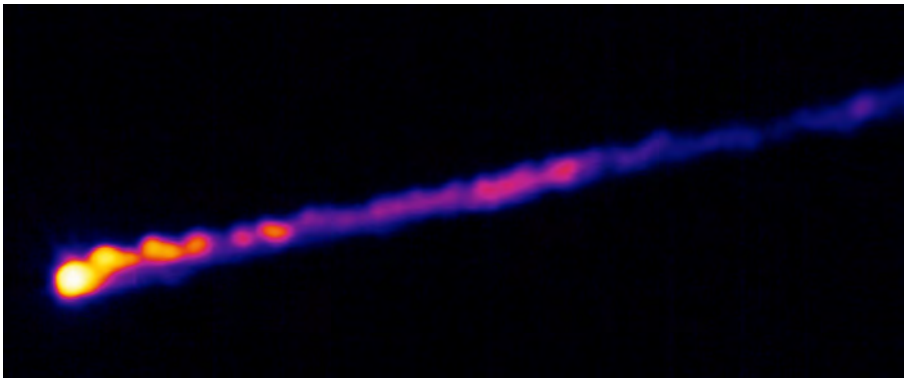
Emeals – This automated meal delivery system, designed for commercial airlines, took home the top honor in the Airbus Fly Your Ideas video competition.

SCHEMA – This development plan for establishing a 24-person colony on Mars took home the top honor in the graduate division of the NASA/NIA Revolutionary Aerospace Concepts Academic Linkage (RASCAL) competition *(pictured above)*.

NASA Marshall Space MInD – This ambitious project estimates the cost of building and deploying composite-manufactured components for NASA's space launch systems (SLS). The research that masters student **Michael Staab** poured into it earned him a $10,000 Goddard Scholarship from the National Space Club. His professional mentor, AESAC member and NASA Marshall Engineering Director **Christopher Singer**, received the Club's 2015 Aeronautics Engineer Award.

Braun: Landing on Mars

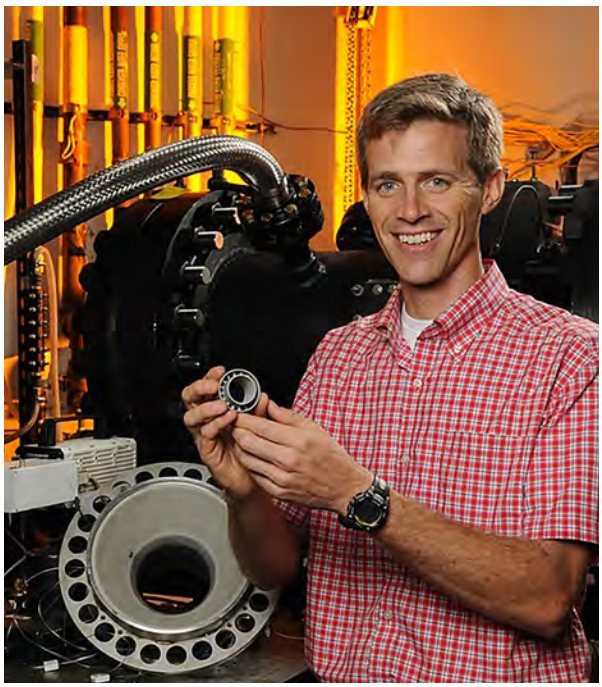
Future robotic and human missions to Mars will require landing vehicles with far more mass than has ever been tried before. To safely land these large payloads on the Mars surface, engineers must figure out how to use retropropulsion at supersonic velocities. This is hardly a simple engineering problem, and the risks associated with supersonic retropropulsion are substantial: aerothermodynamic interactions, engine startup challenges, and transitions to steady-state conditions must be addressed.



Thermal imagery of Space X Falcon 9 first stage performing supersonic retropropulsion in Mars relevant conditions in the Earth's atmosphere.

In FY'15, Prof. Robert Braun led a team of researchers from NASA, SpaceX, and Georgia Tech in quantifying the performance of this future Mars descent technology. To do this they used data obtained during first-stage recovery operations of multiple SpaceX Falcon 9 launch vehicles. Previously, the highest fidelity dataset for supersonic retropropulsion technology was only available through small-scale, air-in-air wind-tunnel testing. Analysis of the SpaceX flight dataset by Braun's team provided an accurate depiction of supersonic retropropulsion technology readiness at human exploration scales.

"Because the technologies required to land large payloads on Mars are significantly different than those used here on Earth, investment in these technologies is critical," said Braun, the principal investigator for NASA's Propulsive Descent Technologies project. "This is the first high-fidelity data set of a rocket system firing into its direction of travel while traveling at supersonic speeds in Mars-relevant conditions. Analysis of this unique data set will enable system engineers to extract important lessons for the application and infusion of supersonic retropropulsion into future large-scale robotic and human exploration missions."



Lieuwen: Cleaner, Better-performing Power Plants

Over the past year, research conducted by Prof. Timothy Lieuwen at the Ben Zinn Combustion Lab has made significant headway in improving the performance and reducing the environmental impact of combustion-powered devices. The benefits of this research will only increase, Lieuwen says, as future energy and propulsion system regulations become more stringent.

Combustion-powered devices, whether in cars, rockets, aircraft, or power plants are responsible for more than 90% of world's annual energy use. Historically, harmful instabilities have been one of the single largest risk items associated with the development of clean combustion systems used in aircraft engines or rockets. Technology developers have only known what goes in and what comes out of the combustor, with little understanding of what's really happening inside the combustor. In his work with high-fidelity simulations and advanced experiments, Lieuwen has been able to break through this barrier by visualizing the complex interactions of vortices, fuel spray, and combustion in harsh, high-pressure combustion environments, enabling technology developers and researchers a "look inside" what was formerly a black box to see what's really happening in combustion environments. The team has been able to see where the flame stabilizes and to better understand the fluid mechanic features that impact the flame.

Their findings have allowed Lieuwen's team to develop important capabilities for predicting the conditions under which harmful instabilities occur in ultra-low emissions power plants. For example, this has already enabled technology manufacturers to screen potential designs using simplified models based upon improved physical understanding or testing, reducing surprises when full scale engines are tested or fielded, reducing development cycle time, and ultimately enabling cleaner, better performing systems.

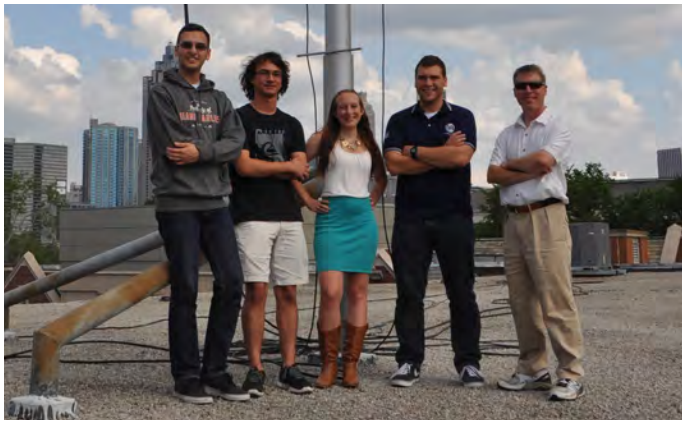
Spencer: Collaborate to Innovate

In June 2015, an intensive collaboration between GT-AE, The Planetary Society, and Cal Poly gave GT-AE professor David Spencer and his team of student researchers a chance to put their engineering skills to the test. Together, they tackled the mission design, spacecraft tracking, and mission operations for LightSail-A, a tiny satellite with its own unique payload: a 32 square-meter solar sail designed to convert sunlight into propulsive momentum for small satellites.

The LightSail mission also served as a precursor for another keenly anticipated event: the September 2016 launch of Prox-1 — the first Georgia Tech-built spacecraft to go into orbit — and LightSail-B.

The 50-kilogram Prox-1 spacecraft will be launched by a commercial vehicle, the SpaceX Falcon Heavy, and once in orbit, will deploy the LightSail-B spacecraft, which will release another solar sail. If all goes well, the Prox-1 spacecraft will use its infrared imager and visible camera to provide on-orbit inspection of the LightSail-B sail deployment.

In addition to demonstrating the solar sail technology, the Prox-1 mission will flight-qualify new technologies developed by industry partners: control moment gyros that control the rotation of the spacecraft, an uncooled infrared imager, an advanced micro-sun sensor, and a 3-D printed cold gas thruster unit.



Prof. Spencer, far right, with his ground control team.

During the four-year development of Prox-1, 140 Georgia Tech students have been involved in its research, design, and testing.

“This project is helping Georgia Tech to shape the next generation of system engineers” said Spencer. “Students engage in the full project lifecycle, from mission concept development, to design, integration, testing and mission operations. And, as a School, we benefit from the richness of the collaboration.”

Doctoral student Matthew Miller, right, and Karl von Ellenrieder preparing to dive at NASA's Extreme Environment Mission Operations trainer in the Florida Keys. Miller used this experience to better inform his research on adapting systems to deep space travel.

Feigh: Supporting Deep Space Travel

Research underway by Prof. Karen Feigh and doctoral candidate Matthew Miller of the Cognitive Engineering Center is seeking to understand how the roles of astronauts and mission control will change as missions go deeper and deeper into space.

Funded by a NASA Space Technology Research Fellowship, Feigh and Miller’s work focuses on a problem that arises when a vehicle travels into deep space: the farther it travels, the longer the radio waves take to transmit information. As NASA eyes future missions to asteroids, Mars, and beyond, the delays presented by these distances could substantially delay communications transmissions, making extra vehicular activities (EVAs) like space walks more risky than they already are.

“Currently, communications are essentially real-time,” said Feigh. “But in the future they could take 5-20 minutes just to travel the distances. That could present problems for EVA.”

Feigh’s team is utilizing cognitive engineering methods to develop automated systems that can support changes in the roles played by ground controllers, on-board astronauts, and astronauts performing EVAs. To better understand that environment, Miller has participated in three simulated EVA exercises. Thus far, they have developed several models – Information Flow, Abstraction Hierarchy, Contextual Activity and Decision Ladder – which they will use to develop a prototype support system over the next year.

Initial findings suggest that the astronaut most in need of support is not the one doing the space-walking.

“When ground control is out of direct contact, it’s that on-board astronaut who helps with things like troubleshooting and keeping the EVA astronaut’s timeline intact,” says Feigh.

Mavris: Boosting NASA Efficiency

Prof. Dimitri Mavris and 25 graduate-level researchers have worked with the NASA Environmentally Responsible Aviation Project (ERA) to evaluate technologies currently under development for aircraft in the 2025 timeframe. In two separate contracts, (totaling more than $7.7 million) the ASDL teams were tasked with evaluating both the vehicle and fleet performance impact of the technologies.

The NASA ERA technologies focus on weight reduction, drag reduction, engine thrust-specific fuel consumption reduction, and noise reduction. These technologies include arresting stitched composites, inflight trailing edge optimization, tail active flow control, ultra-high bypass ratio engines, highly loaded compressors, and landing gear design and wing flap design.

ASDL students and faculty researchers addressed a gap in NASA's procedures by performing probabilistic performance analyses for a variety of different aircraft configurations. They also helped develop a methodology that provides an unparalleled ability to track technology performance progression over the course of a development program at the vehicle level. Taken together, this foundational research by ASDL teams allowed NASA to forge ahead in the development of technologies that can achieve stated NOx emissions and fuel burn goals while also providing a longterm reduction in airport noise. The impact of ASDL's contributions were felt by NASA officials.

"This capability and analysis developed by a very dedicated Georgia Tech team has provided NASA the information necessary to provide a credible return on investment metric to our community stakeholders," said Fay Collier, project manager for NASA's Environmentally Responsible Aviation project.

Costello & Ruzzene: Taming Rugged Terrain

Research initiated by aerospace engineering professors Mark Costello and Massimo Ruzzene is tackling rotorcraft safety issues that have long prevented military, commercial, and medical flights from accomplishing critical tasks.
By replacing standard rotorcraft landing gear with new controlled robotic leg technology Costello's CAMM lab seeks to lessen the dangers faced by pilots landing in high-risk environments.

Landing on moutainous or pitching surfaces could be much safer with Rotor Buzz's flexible "legs" landing gear.

"Current rotorcraft use either skid or wheeled landing gear that is essentially fixed relative to the fuselage during landing. This is problematic on bumpy or irregular terrain and is even worse when attempting to safely interface rotorcraft with a moving ship deck," said Costello, the principal investigator.

"Pilots conducting military operations often can't predict the slope dynamics of the terrains when landing at night, or in a Degraded Visual Environment [DVE]."

Under the auspices of a two-year $1.2 million Defense Advanced Research Projects Agency (DARPA) contract, Costello, Ruzzene, research engineer Mike Ward, and a team of graduate students have been demonstrating this concept using a modified unmanned Rotor Buzz helicopter. They replaced the skid gear with a four-leg, robotic landing gear system where each leg was composed of an upper and lower leg. For each leg, the hip and knee joints were actuated with geared electric motors. The foot of each leg was outfitted with a ground contact sensor.

Using a comprehensive simulation and analysis environment, Costello also designed a robotic landing gear system for the MH-6 helicopter.

Robotic legs have the capability to conform to highly sloped ground terrain, leaving the fuselage largely level – a critical advantage for pilots landing in mountainous regions or warzones. Comprehensive analysis shows that a nominal robotic landing gear system for the MH-6 helicopter can safely land on slopes of 25 degrees – three times the limit of conventional landing gear.

By leveraging the large actuation stroke available from the robotic landing gear, hard landing loads and accelerations can also be reduced dramatically. Costello's analysis suggests that peak landing loads exerted on the fuselage-leg attachment can be reduced by a factor of 3 to 5.

"Besides predicting motion of all bodies in the system, the dynamic simulation also computes joint forces and moments between connected bodies," said Ruzzene, the co-PI.

"These loads are transferred and properly interfaced with the finite element analysis tool ABAQUS for time-dependent component stress analysis. While the system motion simulation enables landing performance assessment, the stress analysis permits design optimization of individual components for weight minimization."

Costello's research suggests that further optimization for new aircraft may substantially reduce weight of aircraft components sized by landing loads. The ability of the robotic legs to dynamically conform to uneven surfaces also enables ship landings in violent sea states with minimal loads on the helicopter and minimal workload from the pilot. Finally, simulation results show that robotic landing gear can eliminate ground resonance by using the active legs to control vibration of the rotor shaft.

FINANCES

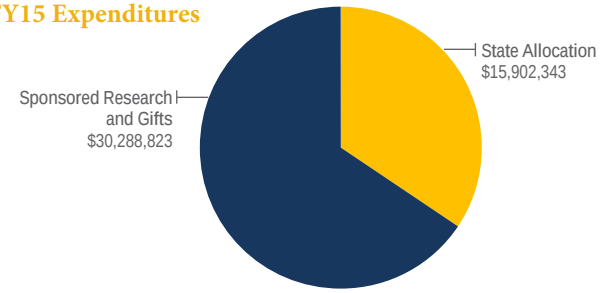
In FY'15, the School had expenditures of $46,191,166, which were funded by a combination of the School's state allocation from the Institute, sponsored research contracts, and gifts. A large percentage of the total expenditures went to support salaries of faculty, staff, research faculty, and graduate researchers.

Most of GT-AE's other expenses were for materials, supplies, travel, and equipment in support of the School's research and teaching mission.

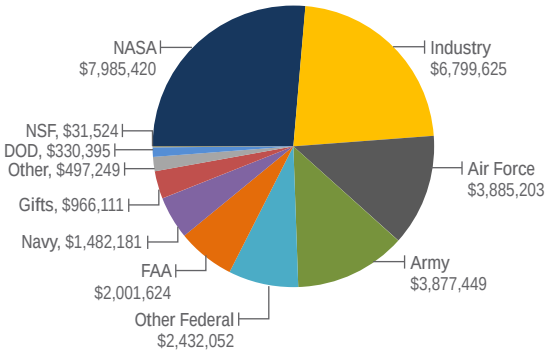
Research funding from outside sources in FY'15 totaled $30,288,833: $22,025,848 from the U.S. military and federal agencies; $6,799,625 from industry; $966,111 from gifts; and $497,249 from other sources (e.g.; local, state, and other governments).

GT-AE's state allocations were $15,902,343 for our teaching mission, general operations, and funding in support of new faculty renovation, furniture, and equipment needs.

FY15 Expenditures

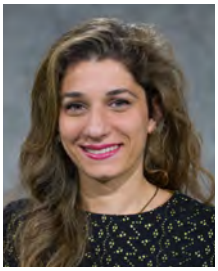


FY15 Research Funding



DEVELOPMENT

The financial support of our many friends and alumni is the bedrock on which the Daniel Guggenheim School of Aerospace Engineering has become one of the leading schools in the world. With your support, that legacy continues.



Farah A. Kashlan
Development Director
Georgia Tech School of Aerospace Engineering
farah.kashlan@ae.gatech.edu

Thank You

A warm thanks to the following individuals and corporations who have contributed to the GT-AE legacy over the past year.

American Inst. of Aeronautics & Astronautics • ARCS Foundation, Inc. • AUVSI Foundation • Bell Helicopter Textron • Boeing Company • Dassault Aviation • Dassault Systemes • Delta Air Lines, Inc. • Dr. & Mrs. James I. Craig • Drs. Jechiel & Adina Jagoda • Dr. & Mrs. Maurice M. Hallum • Dr. & Mrs. Otis H. Burnside • Dr. & Mrs. Robert Cassanova • Dr. & Mrs. Robert G. Loewy • Dr. & Mrs. Robin B. Gray • Dr. Tim C. & Mrs. Rinda Lieuwen • Dr. Ben Zinn & Ms. Adrienne Miller • Earthly Dynamics LLC • Electric Power Research Institute • Electric Rocket Propulsion Society • Epps Aviation • GE Foundation • Honeywell Aerospace • Lockheed Martin • Lockheed Martin Corporation • Lockheed Martin Space Systems • LTC Charles L. Budde • Major General & Mrs. Carl H. McNair, Jr. • Mr Robert & Dr. Marilyn J. Smith • Mr. Alan L. Weinberger • Mr. & Mrs. Andrew Ollikainen • Mr. & Mrs. C. Andrew Hardin • Mr. & Mrs. Dennis L. Berry • Mr. & Mrs. John E. Laughter • Mr. & Mrs. M. A. Smith Jr. • Mr. & Mrs. Michael Chang • Mr. & Mrs. Roger A. Krone • Mr. & Mrs. Wil E. Fowler • Mr. & Mrs. William B. Dixon III • Mr. James D. Woodruff • Mr. John & Mrs. Angela Laughter • Mr. Kenneth B. Amann • Mr. Kirk S. Thornburg • Mr. Larry M. Balkin • Mr. Patrick Epps • Mr. Reid W. Thomas • Mr. & Mrs. W. Lee Akridge • Mr. Christopher & Mrs. Elizabeth Nicholson • Mrs. Mary Jane B. Read • Mrs. Mary W. Burnett • Ms. Susan W. Jackson • Northrop Grumman Foundation • Planetary Society • Pratt & Whitney • Rolls-Royce Corporation • Saab AB • Seafarer Chapter Inc. • Sikorsky Aircraft Corporation • Society of Automotive Engineers, Inc • The Hon. & Mrs. John Young, Jr. • United Technologies Corporation • Vertical Lift Consortium, Inc.

Stay Connected

ae.gatech.edu
@GTAerospace
GT-Aerospace
GT-Aerospace

Contact Us

Georgia Institute of Technology
Daniel Guggenheim School of Aerospace Engineering
270 Ferst Drive | Atlanta GA 30332-0150

Phone: 404.894.3002 Fax: 404.894.2760

Georgia Tech Daniel Guggenheim School of Aerospace Engineering