
Aerospace Engineering and Space Related Activities at Auburn University

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AUBURN UNIVERSITY

SAMUEL GINN
COLLEGE OF ENGINEERING

AEROSPACE

Samuel Ginn College of Engineering - Vision



Dean Chris Roberts

- The best student-centered experience in America
- Leading research that improves the quality of life and fosters economic competitiveness
- A dynamic faculty that exemplifies excellence and innovation



Auburn University

Vision

To lead and shape the future of higher education



Jan Davis ('77)

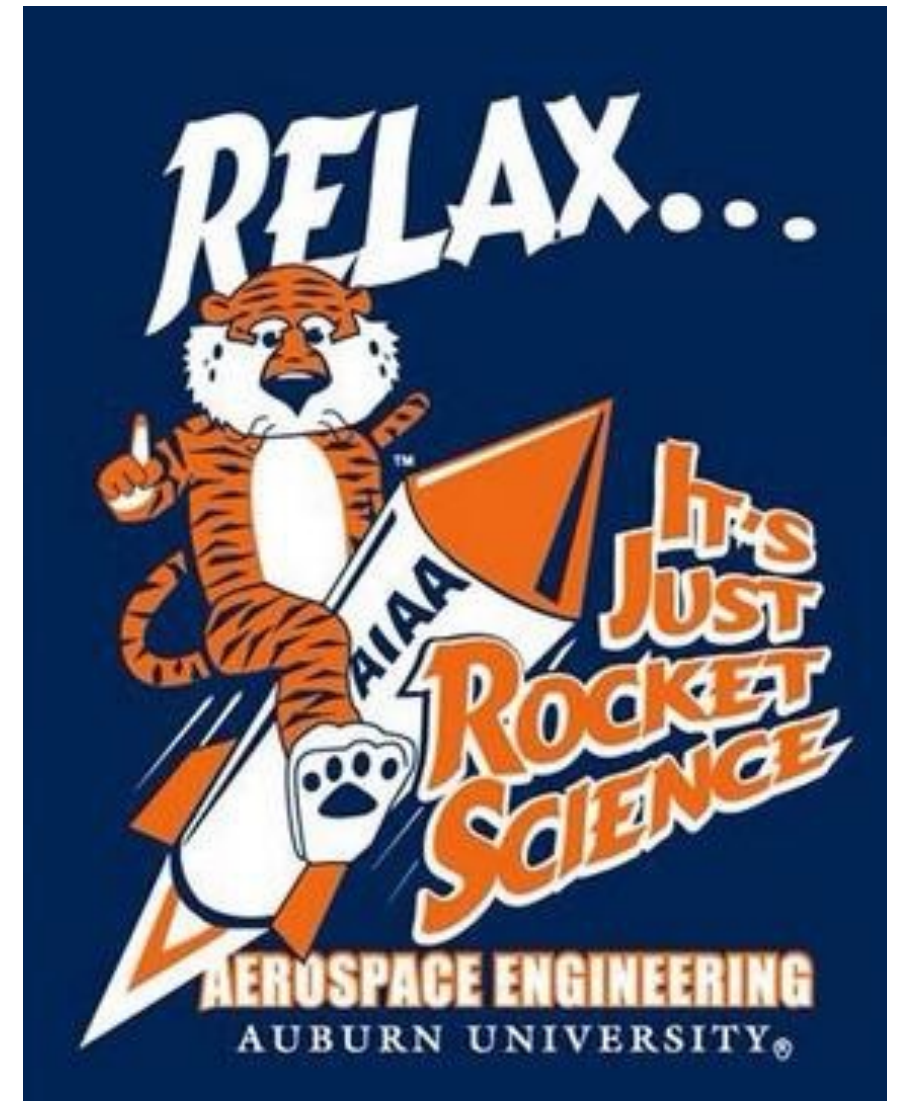


Mission

As a land-grant institution, Auburn University is dedicated to improving the lives of the people of Alabama, the nation, and the world through forward-thinking education, life-enhancing research and scholarship, and selfless service.

Academic Programs

- Auburn University – 30,737 students
- Samuel Ginn College of Engineering
6,502 students
 - Aerospace Engineering - 607 students
 - Computer Science and Software Engineering – 1,508 students
 - Electrical and Computer Engineering – 704 students
 - Mechanical Engineering – 1,426 students
- College of Science and Mathematics
2,723 students
 - Geosciences – 78 students
 - Physics – 99 students
- Aviation – 593 students
- Many other tie-ins to aerospace (Business, Forestry, Agriculture, etc.)



Motivators for Academic Program Growth and Development

- Economic development opportunities in AL related to space transportation, exploration and technologies
 - DoD
 - U.S. Space Command HQ
 - Commercial Space
 - Space Situational Awareness
 - On-Orbit Servicing, Assembly, and Manufacturing
 - Launch Vehicles
 - Quantum
 - Cybersecurity
- University mission
 - Education, Research, and Outreach
 - Workforce Development
- Align our education, research and outreach activities with state priorities and opportunities



Blue Origin – BE-4 Rocket Engines

Department of Aerospace Engineering

- Fall 2020 Enrollment
 - Undergraduate: 535 (50% increase in 5 years)
 - Graduate: 72 (30 M.S., 42 Ph.D.)
- Faculty
 - 15 Tenure-Track/Tenured
 - Will add 2 more this year
 - 2 Lecturers
- Degrees
 - B.S.
 - M.S.
 - Ph.D.
- Curriculum
 - Aerodynamics & Propulsion
 - Aerospace Structures & Materials
 - Flight Dynamics and Control
 - Orbital Mechanics
 - Aerospace Design



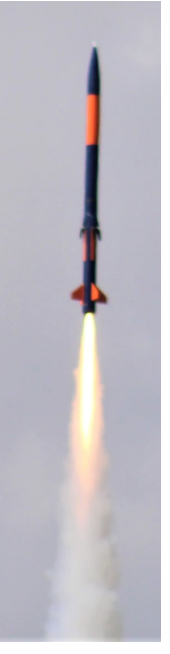
The Trajectory of Aerospace Engineering

	2015	2020	Growth
AU Undergraduate	21,786	24,505	+12.5%
Engineering Undergraduate	4,968	5,386	+8.4%
Aerospace Undergraduate	365	535	+47%
Engineering Graduate (MS/PhD)	463/387	504/593	+29%
Aerospace Graduate (MS/PhD)	31/18	30/42	+47%
Faculty (TT/NTT)	8/2	15/2	+70%
New Research Awards	\$509k	\$2.28M	+348%
Research Expenditures	\$319k	\$1.82M	+471%
# Donors to AE	59	137	+132%

The Department of Aerospace Engineering is rapidly growing and poised to make the next giant leap in space related research

Student Projects

- Auburn University Rocketry Association
- Auburn University Small Satellite Program
- Aero/Astro and Space Robotics Clubs
- Alabama CubeSat Initiative (Alabama Burst Energetics eXplorer)



Auburn University Rocketry Association

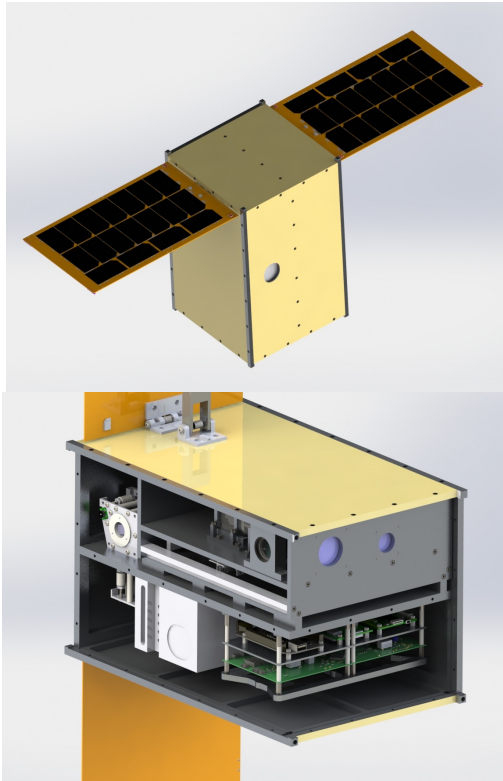


Dr. Mike Fogle, *Physics*
 Dr. Mark Adams, *Elec. Eng.*

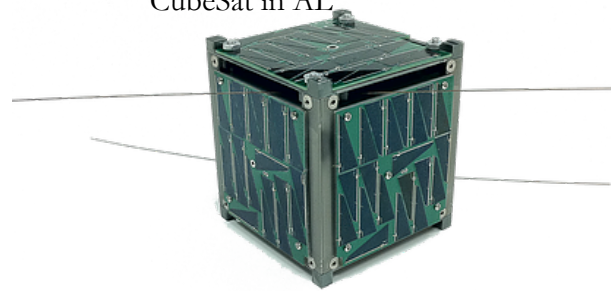
CubeSat Missions at Auburn University

QUEST

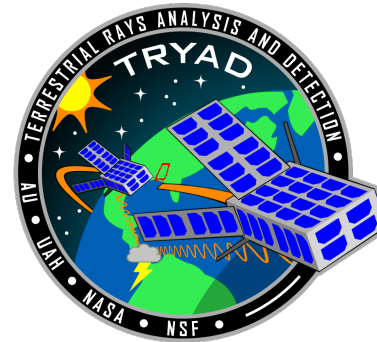
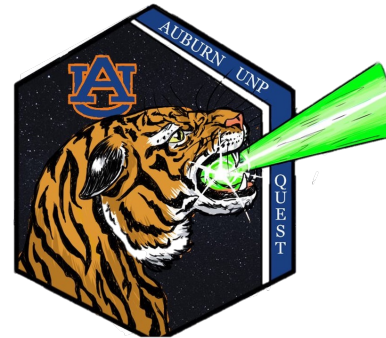
Funded by Air Force Univ.
 Nanosatellite Program - Test of
 Quantum Key Distribution (secure
 communications)



Launched in Oct 2011 – first university
 CubeSat in AL

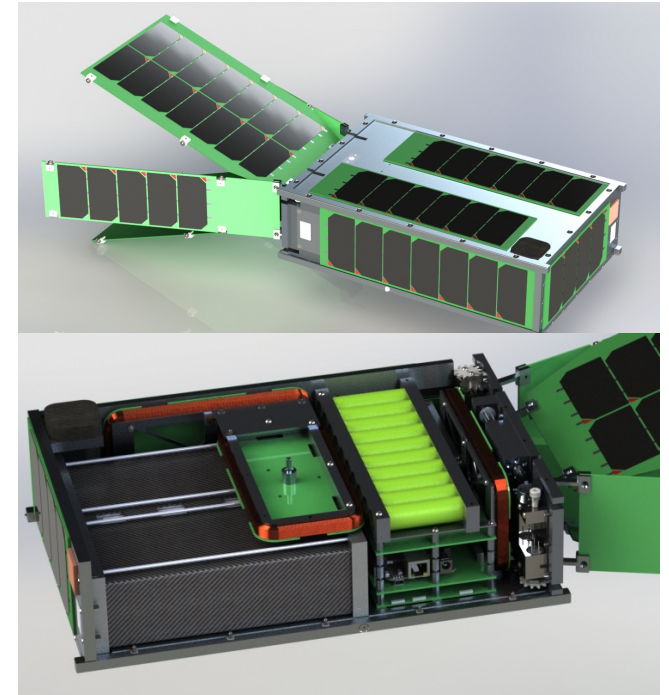


AubieSat-1



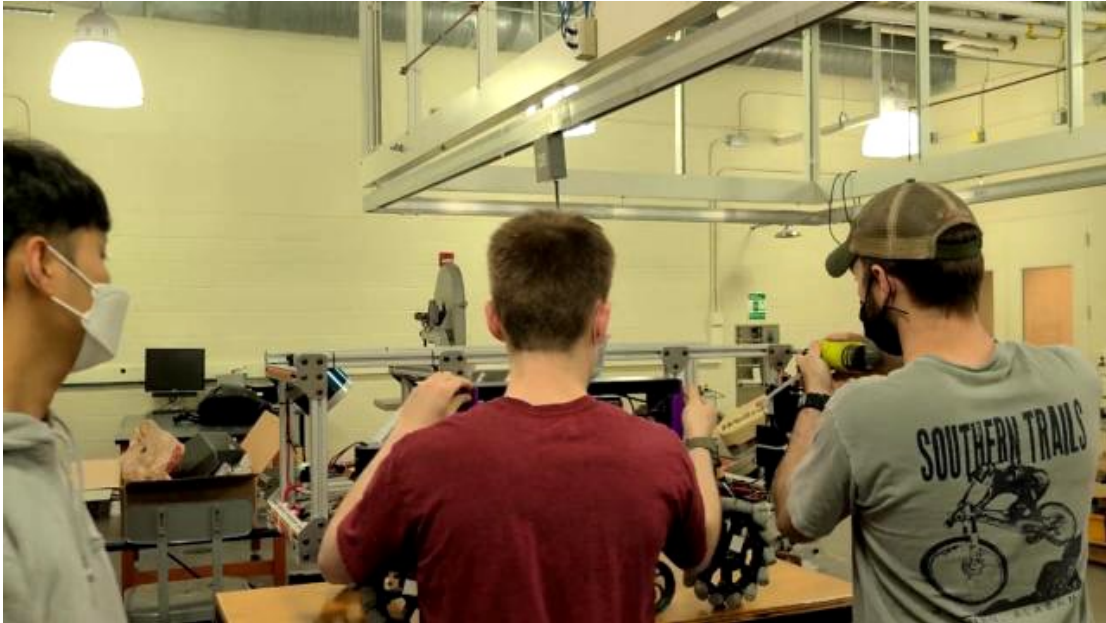
TRYAD

Funded by National Science
 Foundation joint with UAH -
 Study terrestrial gamma-ray
 flashes (space weather)



** Other satellite technology and payload development projects funded by Army (Space and Missile Defense Command) and Missile Defense Agency.*

Aero/Astro and Space Robotics Clubs



Outreach

ASTROCAMP

Women in Astrodynamics Panel
June 14th, 2021, 6pm EDT



Renee Spear is a graduate student at CU Boulder in Aerospace Engineering Sciences with a focus in Astrodynamics and Satellite Navigation. She is currently finishing her Master's degree and will be starting her PhD this coming Fall. The research she is performing for her MS is focused on transfer design within chaotic dynamical systems. Renee also has experience in Aerospace through previous work at JPL and Advanced Space. Outside of academics, she loves to be outside hiking, backpacking, or running.



Giordana Bucchioni is a researcher in the field of GNC, orbital mechanics and astrodynamics. She received her bachelor com laude in Electronic engineering at the University of Pisa and she obtained her master com laude in Robotics and Automation engineering at the same university with a thesis at the European Space Agency (ESA- ESTEC). She is working on her PhD in Information Engineering at the University of Pisa, with a thesis titled: "Guidance and Control for Phasing, Rendezvous and Docking in the Three Body Lunar Space". Currently she is researching on phasing strategies with NRHO, at the ISAE-SUPAERO, Toulouse, France. Her research interests are in the field of Guidance Navigation and Control, Trajectory propagation and orbital mechanics in presence of the third body perturbation, with a particular focus on the Earth-Moon system.



Sara Hatch started working at NASA's Jet Propulsion Laboratory in Pasadena, California after receiving her BS at Embry-Riddle Aeronautical University and MS from the Massachusetts Institute of Technology. In the last 16 years, she's worked on various mission concept studies and Flight Projects including GRAIL, SMAP, NISAR and Mars Sample Return. Currently, she is the Technical Group Supervisor of the Mission Planning group, which is responsible for strategically coordinating all activities that happen on a spacecraft to maximize science return within project constraints. Outside of work, she is married with two boys (8 and 12) and can be found doing some home improvement projects, painting, or supporting the non-profit work of the Junior League of Pasadena, Inc.



Dr. Diane Davis is the Gateway Mission Design lead at NASA Johnson Space Center. Her work focuses on multibody trajectory design for the Gateway. She currently works for AIJ solutions; previously, she worked in the inner planet navigation group at the Jet Propulsion Laboratory. Diane has a PhD in multibody dynamics from Purdue University and a Masters degree in Aerospace Engineering from the University of Texas at Austin.



Dr. Kerianne Hobbs is the Run Time Assurance Lead at the Autonomy Capability Team (ACT3) at the Air Force Research Laboratory (AFRL). There she investigates rigorous specification, analysis and bounding techniques to enable certification of autonomous and learning controllers for aircraft and spacecraft applications. Her previous experience includes work in automatic collision avoidance at AFRL from 2011 to 2014, and Autonomy Verification and Validation research from 2012 to 2020. She has a BS in Aerospace Engineering from Embry-Riddle Aeronautical University, an MS in Astronautical Engineering from the Air Force Institute of Technology, and a Ph.D. in Aerospace Engineering from Georgia Tech.



Dr. Lucia Capdevila earned her education at Purdue University in the School of Aeronautics & Astronautics. As a graduate student, Lucia taught for Purdue University's First-Year Engineering department. She conducted research abroad as part of the NSF EARL program, and worked at the NASA/Caltech JPL laboratories. Today, Lucia resides and teaches engineering at the Bay Area as an assistant professor of aerospace engineering at San Jose State University with a research focus on multibody trajectory design and inclusive teaching pedagogy.



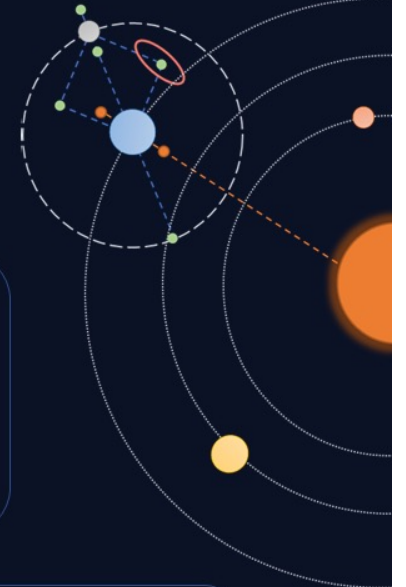
This activity is funded by NASA grant NNH20ZHA0010

- Astrocamp
- AU Summer Science Institute
- Southeastern Center of Robotics Education (SCORE)
- BEST Robotics
- Science Matters

ASTROCAMP

June 7-18, 2021

Free virtual crash course on gravitational multi-body dynamics



MISSION OBJECTIVE

Advanced astrodynamics subjects that are relevant to the NASA Artemis Program including:

- CR3BP dynamics and chaotic behavior
- Targeting of periodic orbits and principles of trajectory optimization
- Trajectories in planetary ephemerides

Prerequisites: basic orbital mechanics

CONOPS

Astrocamp is an entirely virtual experience implemented through an interactive course framework. Participants will proceed in a self-paced manner, complemented by synchronous social events.

TIME OF FLIGHT

Astrocamp is a two-week mission, divided between self-paced study (~7 hours/week), and optional synchronous social events (~3 hours/week).

REGISTER NOW!

<https://aub.ie/astrocamp>

SCAN THE QR CODE



Participation is free!

QUESTIONS?

Davide Guzzetti: guzzetti@auburn.edu
Kaela Martin: kaela.martin@erau.edu

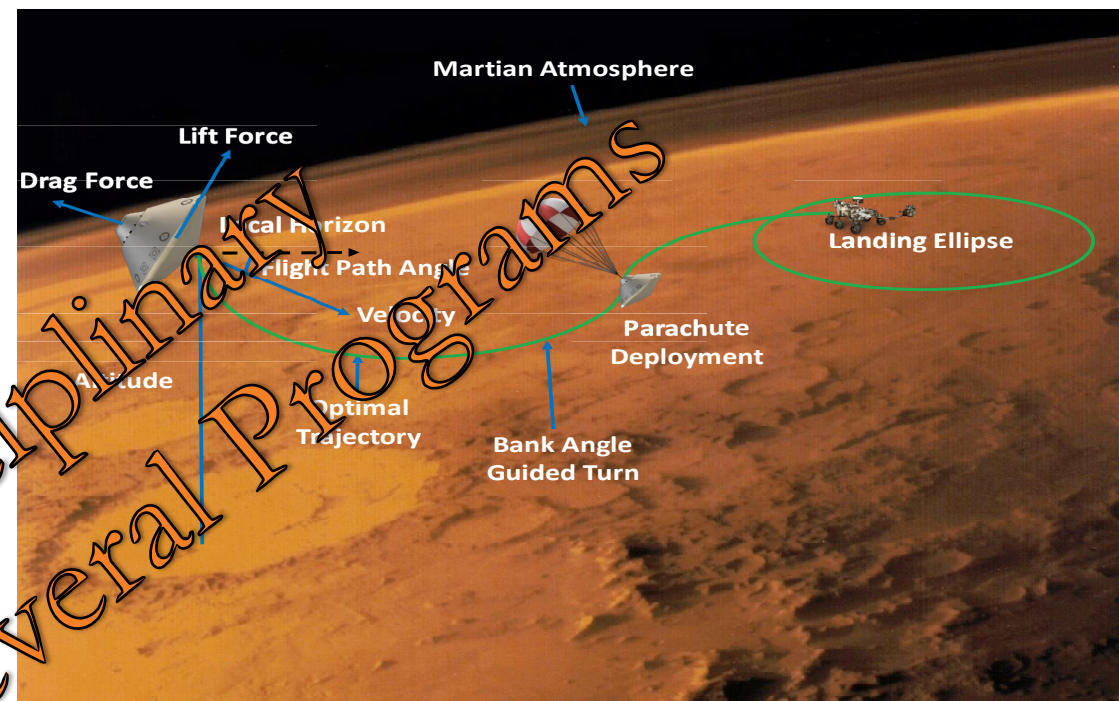


This activity is funded by NASA grant NNH20ZHA0010

Space Related Research at Auburn University

Faculty Research

- Space Mission Design
 - Astrodynamics
 - Planetary Defense
 - Planetary Entry, Descent, and Landing
 - Satellite Constellations
 - Space Systems and Exploration
- Space Science
 - Planetary Science
 - Plasma Physics
 - Space Weather
 - Space Physics
- Space Technologies
 - Communications
 - Extreme Environment Electronics
 - Planetary Protection
 - Position, Navigation and Timing
 - Propulsion
 - Remote Sensing
 - Space based autonomy
- Quantum

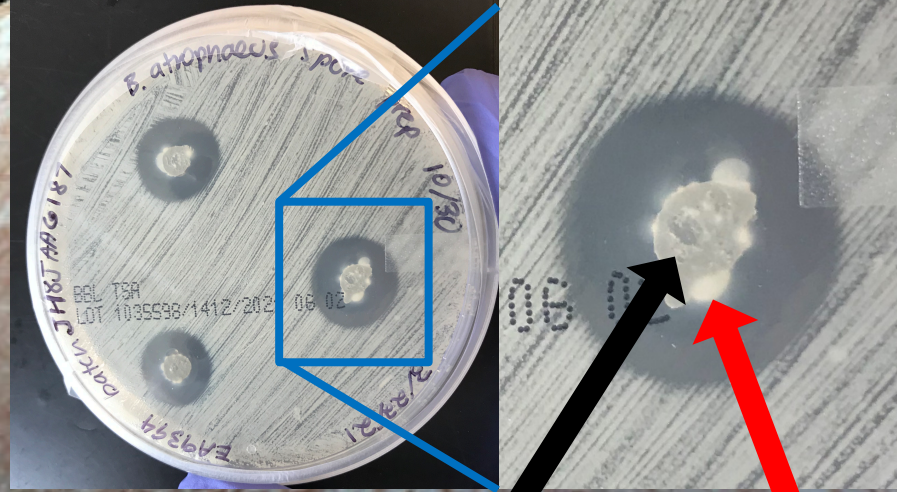


Multidisciplinary
Spanning Several Programs

Centers and Institutes

- Alabama Micro/Nano Science and Technology Center
- Auburn University Huntsville Research Center
- Center for Advanced Vehicle and Extreme Environment Electronics
- McCrary Institute for Cyber and Critical Infrastructure Security
- National Center for Additive Manufacturing Excellence

Biology in Space Liles Laboratory

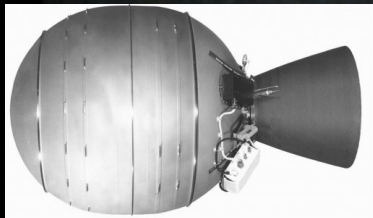


Loctite® adhesive

Bacterial contaminant



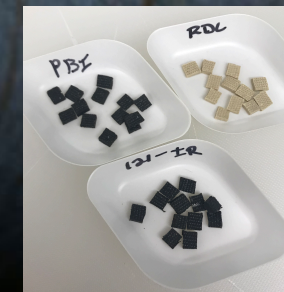
Tardigrades ("water bears") are resistant to space extremes and very hard to kill



Solid Rocket Motor



Rocket Adhesive



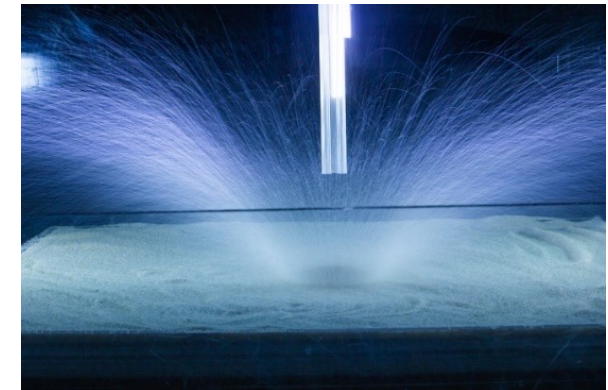
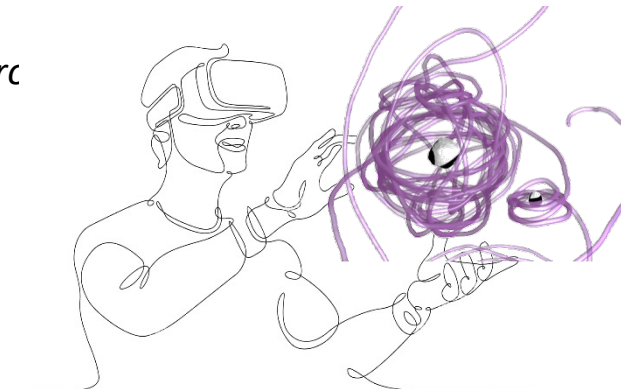
Rocket Insulation

Aerospace Engineering Current Grants and Contracts

- *Air Force/Modeling Economic Competition In The Business Of Mega-Constellations*
- *Flat Fabrication Of Progressively Self-Assembling Space Systems*
- *Teaching The Moonshot: Getting There & Back With Multi-Body Dynamics*
- *Geophysical Approach for Quantifying the Relationship between the YORP Effect Evolution and Small Asteroid Deformation Processes*
- *Planetary Forensics For The Case Of Ceres: Where Are The Missing Small Craters*
- *Non-Intrusive Approaches To Full-Domain Scaling-Law Based Experimental Investigation Of Crater Formation & Plume Surface Interaction Dynamics*
- *Miniature Imaging Systems for Embedded Internal Flow Field Measurements in High-Speed Ground Test Facilities*
- *Development Of Intensified KHz Rate Plenoptic Camera System For 3D Flow Diagnostics*
- *Concurrent Multiscale Moving-Window Scheme For Shock Wave Propagation & Microstructural Interaction*
- *Integrating Engineering Theory & Biological Measures To Model Stress Resilience, Damage and Fitness-Related Consequences*
- *Modular Generalized Framework for Assessing Aircraft Aero-Propulsive, Stability, and Control Characteristics*
- *UAM E-VTOL Aircraft-Design, Analysis & Testing Capabilities*
- *Improvement Of Rotary-Wing Unmanned Aerial Vehicles Performance Using Reduced-Order Aero-Mechanical Models*
- *Study Of Flow Separation On A Rotating Wing Using Volumetric Velocimetry In The Rotating Frame Of Reference*
- *Quantification of Confidence Level of Missile Models*
- *Enabling Aeroelastic & Aeroservoelastic Analysis In Conceptual Design*
- *Analytical & Computational Studies Of The Flow Evolution & Stability Of Vortex Liquid Rocket Engines*
- *Ignition and Performance Testing Of A P3 Technologies Developed Gas Generator*
- *Deep Learning & Fluid Dynamics Based Phenotyping Of Expiratory Central Airway Collapse*
- *Effect Of Pulsatility On Expiratory Droplet-Laden Flows*

Aerospace Research Laboratories

- **Space Sciences**
 - Aero-Astro Computational and Experimental Lab (ACE) – *Ehsan Taheri*
 - Immersive, Interactive, Intelligent Space Dynamics – *Davide Guzzetti*
 - Space Technology and Applications Research (STAR) – *Toshi Hirabayashi*
- **Vehicle Systems, Dynamics and Design**
 - Extended Reality Flight Simulation and Control Lab – *Umberto Saetti*
 - Vehicle Systems, Dynamics and Design Lab – *Imon Chakraborty*
- **Structures and Materials**
 - Advanced Materials and Processing Laboratory – *Suhasini Gururaja*
 - Mechanics of Materials – *Vinamra Agrawal*
 - Polymer Mechanics Research Laboratory – *Russell Mailen*
- **Propulsion**
 - Aero-propulsion related systems modeling, simulation and optimization – *Roy Hartfield*
 - Advanced Propulsion Research Laboratory – *Joe Majdalani*
 - Combustion Physics Laboratory – *David Scarborough*
- **Fluid Dynamics and Aerodynamics**
 - Advanced Flow Diagnostics Laboratory (AFDL) – *Brian Thurgood*
 - Applied Fluids Research Group (AFRG) – *Vrishank Raghav*
 - Computational Fluids Group – *Nek Sharan*
 - Vortex Dynamics Laboratory – *Anwar Ahmed*
- **Biomedical Engineering**
 - Applied Fluids Research Group – *Vrishank Raghav*



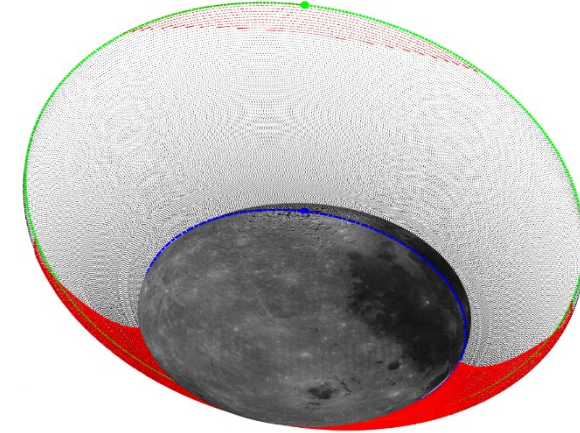
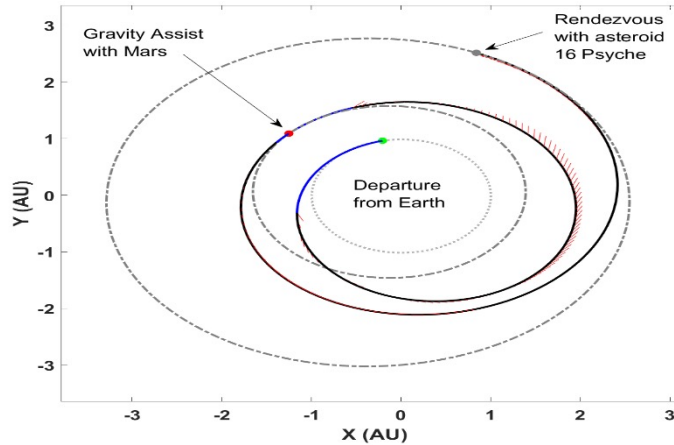
Aero-Astro Computational and Experimental (ACE) Lab

Dr. Ehsan Taheri



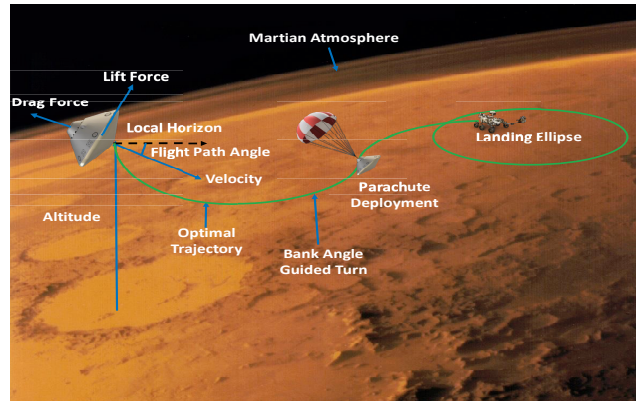
Astrodynamics

Fuel- and time-optimal trajectory design for cis-lunar and interplanetary missions using electric and chemical propulsion.



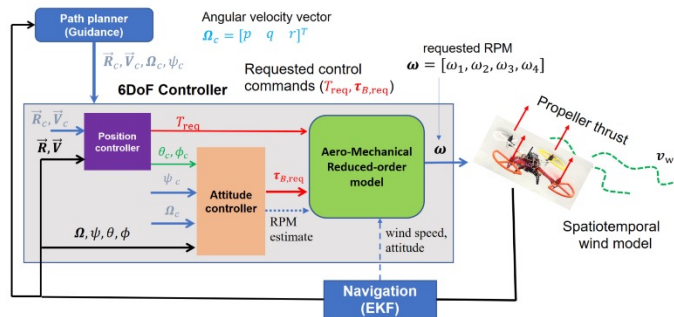
Atmospheric Flight

Robust trajectory design for entry, decent and landing (EDL) and hypersonic class of missions. Convex optimization for on-board guidance.



Embedded Systems & Robotics

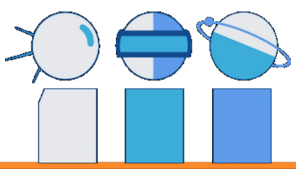
Guidance, Navigation and Control (GN&C) of custom-built multi-rotor vehicles and implementation using embedded systems.



Theory

Simulation

Experiment



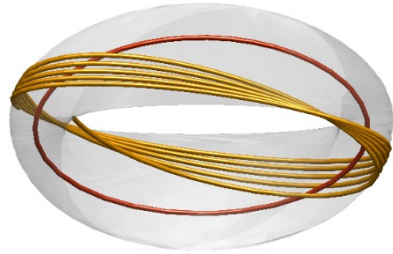
Immersive, Interactive, Intelligent Space Dynamics

Dr. Davide Guzzetti

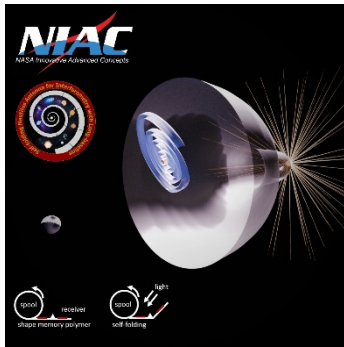


ASTRODYNAMICS

Advanced astrodynamics and 6DOF motion in space

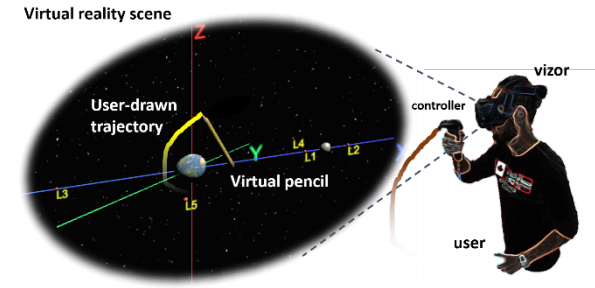


Concept and feasibility studies for space missions



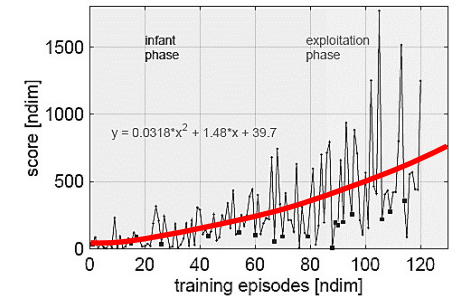
IMMERSIVE AND INTERACTIVE COMPUTING

Immersive computing and virtual reality for trajectory design



Autonomous spacecraft path-planning from demonstrations and environment interactions

Security of proliferated low Earth orbit constellations



SPACE SYSTEMS ENGINEERING

ARTIFICIAL INTELLIGENCE



The Space Technology Application Research (STAR) Lab

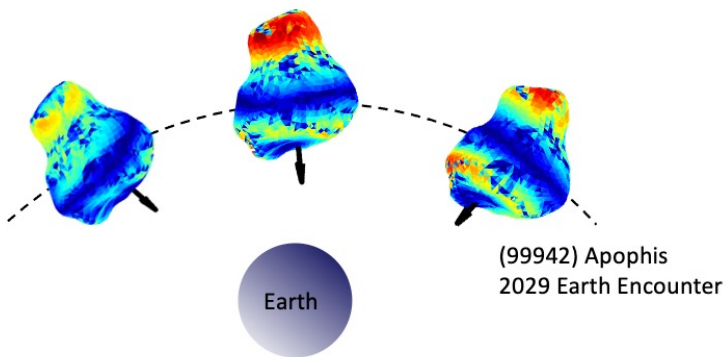
Dr. Toshi Hirabayashi



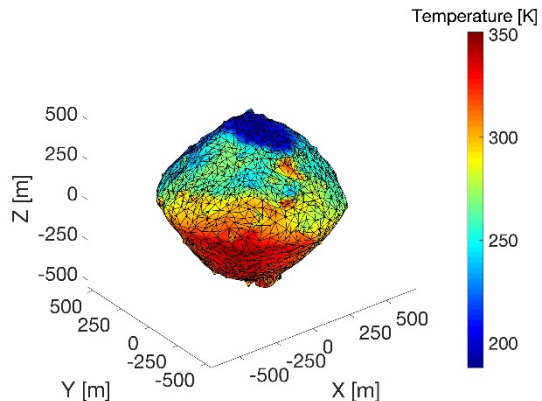
Development of unique capabilities to analyze space dynamics and planetary surface processes using multiscale modeling applications and data analysis techniques.

Space dynamics/systems

Asteroid encounter to a planet

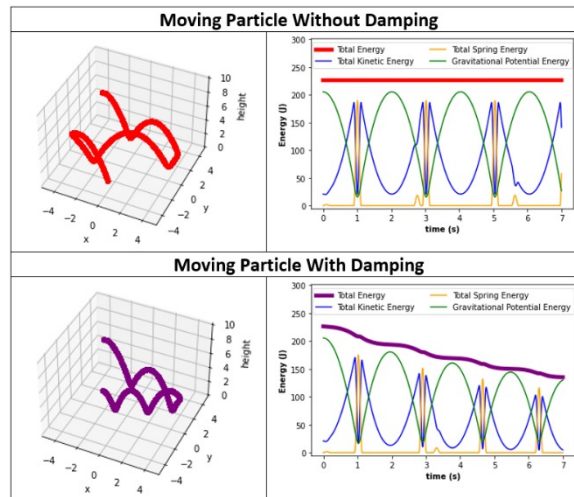


Asteroid's thermal environment

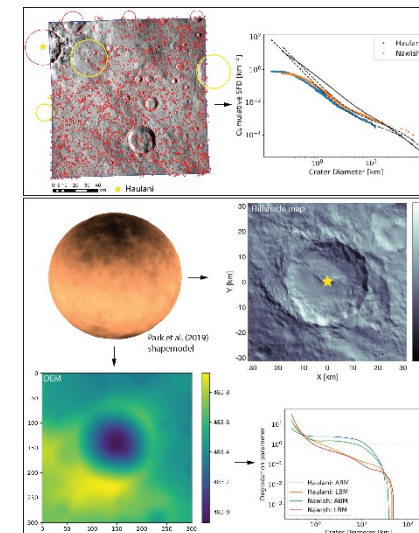


Mercury's dust environment

Granular dynamics

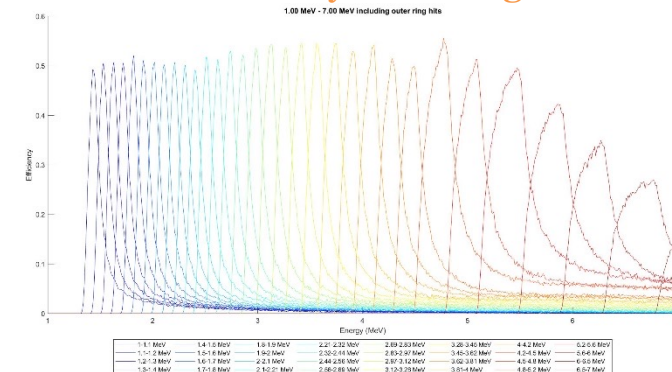


Planetary science/data processing

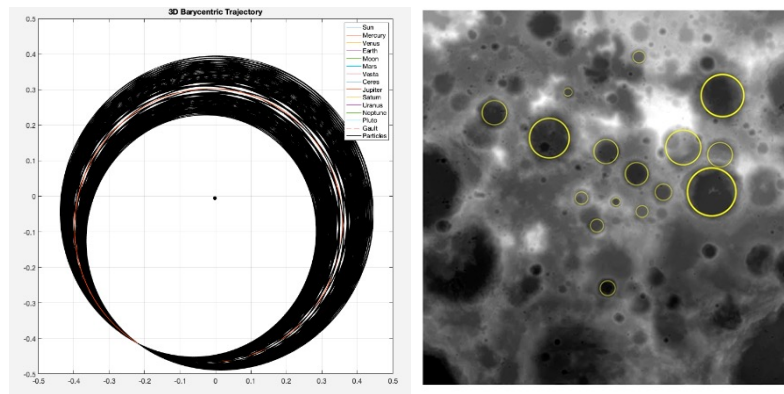


Planetary surface
on Ceres

Collaborations with Physics.
Below is work by Dr. Hong Zhao



Lunar polar region

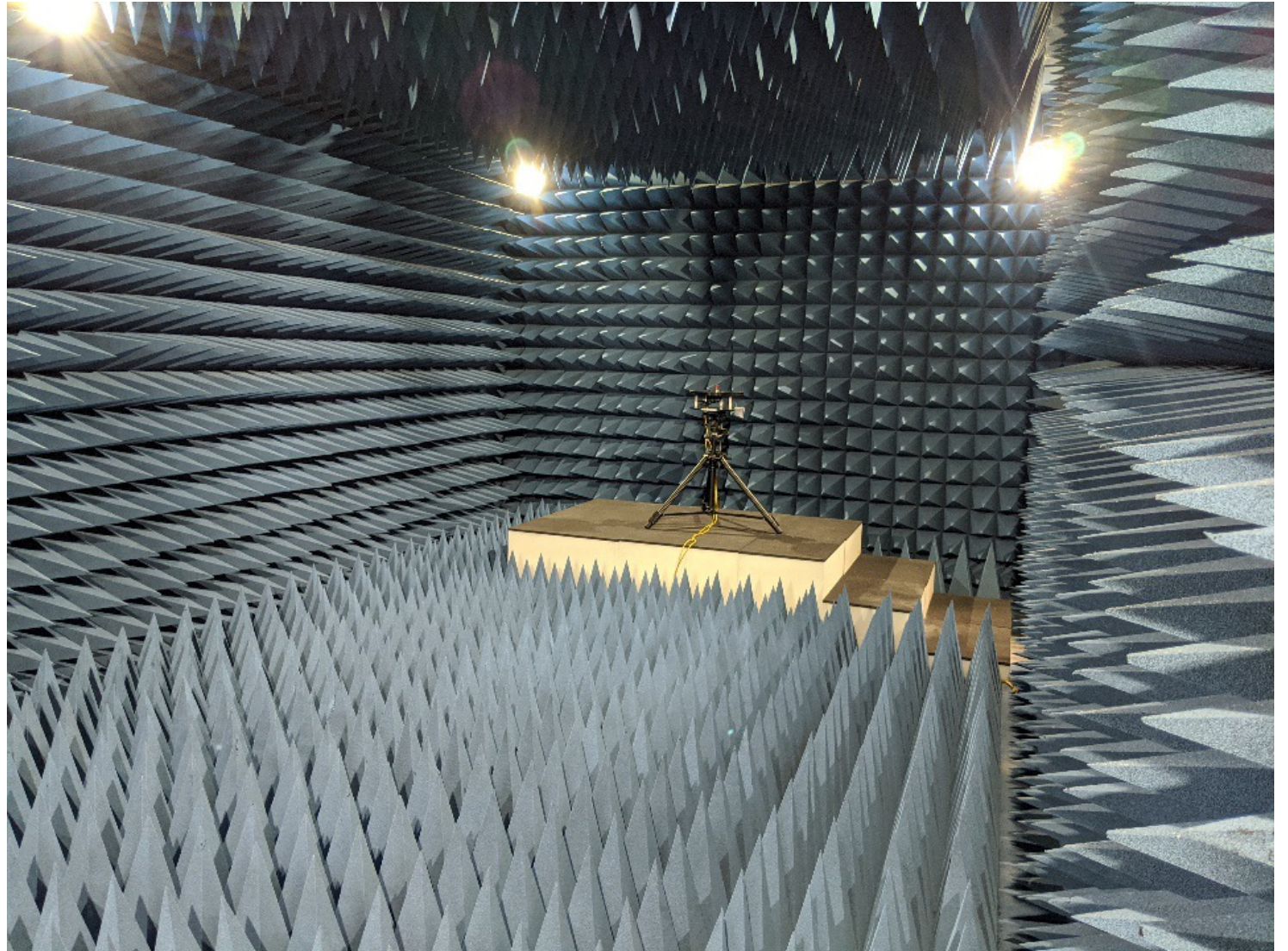


Space Vehicle Integration and RF Test Labs

Dr. Mark Adams, Electrical and Computer Engineering



Helmholtz Cage



Antenna Measurement Chamber

Tour Stops

TIME	LABORATORY	LOCATION	HOST
11:00 AM	Design and Innovation Center Walk By	Brown-Kopel	Brian Thurow
11:05 AM	Auburn University Rocketry Association Display	Brown-Kopel 0211 Foyer outside Brown-Kopel 0211	Eldon Triggs Dustin Harris
11:15 AM	Aerospace Wind Tunnels and Flight Simulators Walk Through	Brown-Kopel 0211	Brian Thurow
11:20 AM	Aero and Astro Computational and Experimental Laboratory Drone Flight Demonstration	Brown-Kopel 0212	Ehsan Taheri
11:30 AM	Immersive, Interactive, Intelligent Space Dynamics Laboratory Virtual Reality Demonstration	Gavin 257	David Guzzetti
11:45 AM	Auburn University Small Satellite Program Display	Broun 408	Mike Fogle
11:50 AM	Space Vehicle Integration and Test Lab RF Test Facility Walk Through	Broun 408	Mark Adams

Alabama Space Authority

- Created within the Alabama Department of Economic and Community Affairs (ADECA)
 - **To promote the research and development of new space exploration and spaceport technologies**
 - To sponsor conferences and business roundtables within the aerospace, aviation, and related industries
 - To promote activities and industries related to space exploration
- Duties
 1. **Encourage the education and training of aerospace professionals to pioneer the frontier of space and to develop new methods and technologies for the exploration of space**
 2. **Promote new space exploration, space tourism, and spaceport technologies** across a wide spectrum of corporate, academic, public, and private innovation infrastructures
 3. Sponsor aerospace conferences and business roundtables to enable networking among key aerospace leaders and public officials
 4. Propose business initiatives, tax credits, small business incubator programs, and other initiatives to stimulate economic development and innovation within the aerospace and space system communities
 5. Perform a study on the feasibility of securing approval for the State of Alabama to have a federally licensed spaceport
 6. Encourage space research and education centers to support these programs and facilitate technology transfer
 7. Work with the Department of Tourism, the Alabama Science Exhibit Commission, and other public agencies **to communicate the multiple scientific, educational, and commercial benefits of space exploration** and the legacy of Alabama's contributions to the America's space program to the public and to promote space tourism and training