The School of Aerospace Engineering at Georgia Tech is committed to advancing the field of aerodynamics and fluid mechanics as a means of developing highly capable, efficient, and safe aircraft, launch and reentry vehicles, rotorcraft, novel UAV configurations, and wind energy systems.

Aerodynamics and fluid mechanics focus on fluid flow around and within aircraft, rotorcraft, planetary entry vehicles, engines and other complex systems. The School conducts fundamental studies of flow physics and employs advanced computational and experimental techniques and facilities to extend the understanding and capabilities of many essential aerospace applications.

The School has a strong experimental research program in aeroacoustics, vortex dominated flows, and low speed applications; a strong computational fluid dynamics (CFD) research program in fixed- and rotary-wing applications from incompressible through hypersonic speed regimes; and a strong research program in turbulence and turbulent combustion.

Aerospace engineering students and faculty are conducting aerodynamics and fluid mechanics in several areas, including integration of CFD in aircraft, UAV and spacecraft design. This work relies on unstructured, Cartesian and gridless methodologies for complex geometry definition and analysis. Efficient utilization of CFD in formal design methodologies that include gradient and non-gradient based optimizers, adjoint methods, and Response Surface Methods is investigated.

Experimental and computational investigation of rotorcraft and wind energy flow physics is another crucial part of the AE program. This research studies performance and acoustics for large- and small-scale aircraft, and also vertical-axis and horizontal-axis wind turbines. Of critical importance in this area is understanding aeroelastic effects and energy-absorbing structures for reduced vibration/fatigue and energy harvesting. Another key area is high Reynolds Number turbulence simulation through petascale computing. Here, investigators conduct cyber-enabled turbulence research and simulations of stratified, reacting, and wall-bounded flows.

Ultimately, AE’s focus is on the future. The growth and success of unmanned aerial vehicles (UAVs) and critical need for highly fuel-efficient and environmentally responsible systems is leading to substantial innovation in aerospace configurations. The commonplace aircraft, with a cylindrical fuselage and moderately swept wings, is giving way to a wide array of blended wing-body, joined-wing, vertical take-off and land, hypersonic waverider, and even flapping wing vehicle designs. Many of these designs utilize highly integrated wing/body aerodynamics, composite structures, and integrated propulsion systems.
Faculty

Krishan Ahuja  
Regents Professor  
And Regents Researcher (GTRI)

Narayanan Komerath  
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Suresh Menon  
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Georgia Tech  
School of Aerospace Engineering  
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At Georgia Tech’s School of Aerospace Engineering, research in aeroelasticity and structural dynamics is led by a group of world-class experts who span the fields of fixed- and rotary-wing aircraft, as well as spacecraft and wind energy.

The interdisciplinary field of aeroelasticity addresses these issues. It deals with interactions among aerodynamics, structural mechanics and dynamics. The related field of structural dynamics examines interactions between structural mechanics and dynamics.

In flight, aircraft do not behave as rigid bodies. Structural deformation causes airloads to differ substantially from what they would be were the vehicle rigid. Wing and control surface flexibility mean that there are a variety of unstable behaviors that lead to degradation of structural integrity over time. These can shorten the life of the vehicle or even destroy it.

One major area of research focuses on developing conservative, high-fidelity nonlinear aeroelastic simulations algorithms and methodologies. Computational aeroelasticity may require the utilization of high-order aerodynamic methods to capture the correct flow physics. This requires the marriage of computational fluid dynamics (CFD) and structural mechanics (CSM). Georgia Tech Aerospace Engineering faculty are developing these CFD/CSD methods with state-of-the-art solvers including OVERFLOW, FUN3D, and OpenFoam.

Meanwhile, research projects related to rotary-winged aircraft and wind energy focuses on techniques for vibration reduction, improved methods for calculation of stability, and methods for modeling composite rotor blades, dynamic stall, stall flutter, and tail wag/buffet. They are also investigating of the effects of tightly-coupled elastic coupling on blade performance and stability, along with control algorithms.

In addition to research for rotating systems, fixed-wing projects focus on computational methods (transition and turbulence models, conservative algorithms), as well as analytical and experimental studies of buffeting, and aeroservoelasticity of composite-winged aircraft with wings of high-aspect ratio.

To exploit aeroelastic behavior, active and passive control devices, including biomimetically engineered devices such as multiple winglets, are in the works. Faculty are participating in the Aeroelastic Prediction Workshop, an international research effort to explore and refine the details of computational aeroelasticity in the nonlinear transonic flight regime.
### Faculty

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<thead>
<tr>
<th>Name</th>
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<tbody>
<tr>
<td>Robert Braun</td>
<td>David and Andrew Lewis Professor in Space Technology</td>
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<td>Eric Johnson</td>
<td>Lockheed Martin Associate Professor of Avionics Integration</td>
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**Questions?**

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At the Georgia Tech School of Aerospace Engineering, we are addressing current challenges in the Flight Mechanics and Control (FMC) group include placing unmanned aerial vehicles in domestic airspace, advanced airport automation, and aerial robots.

Flight mechanics and control deals with the body and brain of an aerospace system – whether that system is an aircraft, a spacecraft, an airport, or the air-traffic control system.

The “body” of a system consists of all the electrical and mechanical elements that define its dynamic tendencies – that is, its behaviors under the usual laws of physics. Flight mechanics is the science associated with understanding how aerospace bodies behave in the atmosphere and in outer space.

The “brain” of a system may consist of the actual human cognitive system, or computers, or a combination of both. The brain influences or “controls” the behavior of its body by receiving information about its state and desired behavior, and by synthesizing orders that are passed onto the body. A good design combines the proper understanding of the flight mechanics with effective design of decision procedures where computers and humans cooperate effectively.

Modeling and identification are the core disciplines that enable good understanding of system behavior. Common sense and mathematical techniques allow engineers and researchers to create sophisticated models of system behaviors.

Control and autonomy are the engineering disciplines that aim at designing real-time, computer- or human-based procedures that give a desired behavior to the system under study. Common examples include automotive cruise control systems, aircraft autopilots, and engine controls. In fact, almost all engineered systems today operate thanks to some kind of control system: hard disk drives, robotic surgery assistants, cars, trains and our electric supply system all rely on control algorithms. Advances in computing power have allowed engineers to extend basic functionalities to include the management of entire missions for unmanned helicopters and aircraft, space probes, or Mars rovers.

Modeling and control involve humans as well. Cognitive Engineering is primarily concerned with understanding the behavior of humans in the context of tasks that require their presence. Several important aerospace systems cannot operate without humans: All passenger aircraft are flown by human pilots and guided to their destination without colliding with other aircraft by human air traffic controllers, sometimes assisted by computers.

Cognitive Engineering recognizes that humans can be an important asset to aerospace systems, but requires domain-specific understanding to decide what and how information should be presented, and how computers and humans can harmoniously share important control and supervision responsibilities.
Faculty

John-Paul Clarke  
Associate Professor

Mark Costello  
Professor

Karen Feigh  
Assistant Professor

Eric Feron  
Dutton/Ducoffe Professor of Aerospace Software Engineering

Wassim Haddad  
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The Daniel Guggenheim School of Aerospace Engineering

Propulsion & Combustion

The School of Aerospace Engineering at Georgia Tech understands that the improvement propulsion and energy systems is a major challenge for the engineers both today and in the future. The School trains next-generation researchers to tackle these issues, offering world-class research and academic programs in propulsion and combustion.

The AE Propulsion and Combustion (PC) group focuses on the interplay between complex fluid dynamics and high-temperature chemical and plasma energy conversion processes that underpin propulsion and energy systems. PC research includes aircraft turbine engines and augmenters, scramjets, chemical rockets, in-space electric propulsion systems, ground power gas turbines, thermal processing, energetics and explosions.

AE grad students learn in one of the most productive and well-respected combustion and in-space electric propulsion research programs in the world. Working closely with a faculty adviser, research engineers and other students, AE grad students tackle multidisciplinary problems sponsored by industry and government agencies. The PC faculty includes experts in unsteady combustion and combustion instability, combustion control, electric propulsion, plasmas, development and application of advanced diagnostic and sensor technology, and computational modeling and simulation approaches. Along with traditional goals such as improving thrust or efficiency, students focus on issues related to emissions, robustness and reliability. For example, a key challenge in combustion is developing systems compatible with the current energy and propulsion infrastructure that still allow for reduced net carbon emissions. Similarly, our development of efficient high-power thrusters can revolutionize in-space electric propulsion applications. For computational modeling, tools are being developed to exploit both current petaflop and future exaflop resources to simulate full-scale engines and meet the challenges of Big Data processing. Research in propulsion and combustion at Tech involves close collaboration between these computational and experimental efforts.

At GT-AE students have access to state-of-the-art facilities and instrumentation that are not available at other university labs. The School’s extensive experimental combustion facilities include sophisticated, high-pressure and high-temperature systems, which allow students to work on systems ranging from table-top experiments to full-scale burners. Students also work with state-of-the-art instrumentation like high-speed laser imaging systems capable of resolving real-time flow variations. The School has two vacuum test facilities to support experiments in high-power plasma propulsion and plasma physics at pressures, flow rates and powers relevant to full-scale devices. Students working in these facilities work with a wide range of diagnostics, including probes and optical methods. For full-scale simulations, students have access to supercomputing facilities at the School that can sustain more than 25 Teraflops at peak performance level.
Faculty

Krishan Ahuja
Regents Professor
And Regents Researcher (GTRI)

Jeff Jagoda
Professor and Associate Chair for
Graduate Studies and Research

Tim Lieuwen
Professor and Executive Director,
Strategic Energy Institute

Suresh Menon
Professor

Jerry Seitzman
Professor

Wenting Sun
Assistant Professor

Mitchell Walker
Associate Professor

Vigor Yang
William R. T. Oakes Professor
and Chair, School of Aerospace
Engineering

Ben Zinn
Regents Professor, Retired and David
S. Lewis, Jr. Chair and Joint Regents
Professor Mechanical Engineering

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The Systems Design and Optimization (SDO) group researches the design of effective, efficient, and economical aerospace vehicles and systems. Faculty and students in the SDO group share common research interests in fundamental methods for vehicle design including multidisciplinary optimization, design space visualization and exploration, surrogate modeling, computer aided design and computer aided engineering, uncertainty quantification, reliability and robustness, safety, manufacturing, and systems engineering. The group applies these methods to design problems relevant to classes of aerospace vehicles that include fixed wing aircraft, rotorcraft, and space systems.

**Fixed Wing Aircraft**
The fixed wing design track focuses on the formulation, development, maturation, and application of design methods to problems related mainly to civil and military aircraft. Research areas include aircraft sizing and synthesis, systems engineering, system-of-systems modeling, multidisciplinary optimization, and design decision making. Applications span topics in propulsion, civil aviation, unmanned systems, defense systems, and energy systems. Graduates from this program are typically employed as mid-to-high level systems analysts, designers, and systems engineers, as well as researchers and subject matter experts in aerospace and defense fields.

**Rotorcraft**
There is a sequence of two Rotorcraft Design capstone courses at both the undergraduate and graduate level. The first course, Rotorcraft Design I, addresses conceptual design and the sizing and synthesis process. The second course, Rotorcraft Design II, addresses preliminary design and multidisciplinary design and analysis around an Integrated Product and Process Development (IPPD) approach. Research areas include the application of IPPD through Robust Design Simulation, along with an emphasis on Product Lifecycle Engineering supported by Product Lifecycle Management integrated tools.

**Space Systems**
Space systems design research focuses on the identification and assessment of new technologies and architectures for human and robotic exploration, space commerce and national security. Advanced technologies relevant to the challenges of access to space, atmospheric entry, space mission operations, and space systems engineering are in development. Projects rely heavily on analytic methods to assess next-generation space missions, vehicles, and architecture concepts, including the development and application of novel design methods, new disciplinary analysis tools and multidisciplinary analysis and optimization techniques to the design of future space systems.
**Faculty**

**Robert Braun**  
David and Andrew Lewis Professor in Space Technology

**David and Andrew Lewis Professor in Space Technology**

**John-Paul Clarke**  
Associate Professor

**Associate Professor**

**Mark Costello**  
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**Questions?**

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In the School of Aerospace Engineering at Georgia Tech, research in structural mechanics and materials (SMM) behavior is led by world-class researchers who investigate, characterize, test and design materials and material systems for aerospace vehicles and components. The investigations span a broad range of length and time scales, and cover analytical, numerical and experimental aspects. The research is conducted through collaborations with and funding from government agencies, and all major aerospace industries have a presence and regularly seek the advice of SMM faculty.

SMM research at AE covers traditional areas of structural mechanics dealing with stress analysis, failure analysis, fracture mechanics and durability of metallic, composite and hybrid structural components, including sandwich construction. In addition, significant emphasis is placed in the development of non-destructive techniques (NDE) and structural health monitoring (SHM) systems for the assessment of structural integrity through thermal and acoustic techniques.

SMM at AE is also addressing the needs for multifunctional materials and structures with embedded sensing and energy harvesting capabilities. On the experimental side, the group has unique capabilities for testing materials under extreme environment, such as high temperatures and high velocity impacts, and combined loads.

The SMM group is renowned for its manufacturing at the micro and nano scale of complex conductive structures which can be used as sensors and transducers for the micro/nano scale characterization of material behavior, or which find applications well beyond aerospace such as in biomedical engineering.

The computational expertise of the SMM group includes knowledge in all leading FE commercial packages, along with the ability to develop innovative user defined routines or element formulations that provide improved accuracy without adding to the computational costs. In addition, expertise in ad-hoc, in-house developments of codes with unique capabilities is an area of growth for the SMM group. Multi-scale, multi-physics computations performed by our faculty investigate fracture phenomena, fatigue and embrittlement of materials and structures due to exposure to static and dynamic loads, as well as to extreme thermal, acoustic and chemical environments.
Faculty

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