AIR FORCE INSTITUTE OF TECHNOLOGY

HYPERSONICS

ACADEMIC & RESEARCH PROGRAM

ACADEMIC SUCCESS

AFIT produces master's and doctoral graduates who are experts in hypersonic systems, components, and counter-measures. Our students develop technical knowledge and critical thinking skills during their coursework and research projects – and leverage their enhanced capabilities throughout the remainder of their careers.

RESEARCH EXPERTISE

Our military faculty provide both academic leadership and operational insights to guide student projects. Through teaching and advising, military faculty are particularly well prepared for post-AFIT assignments to teams entrusted with the development of future hypersonic systems and employment strategies.

AFIT PARTNERSHIPS

AFIT partners with the Air Force Research Laboratory, the University Consortium for Applied Hypersonics, the DOD High-Performance Computing Modernization Program, and others to execute hypersonics research addressing vehicle design, engine development, control approaches, and high temperature materials development.

ADVANCING HYPERSONICS

AFIT has a long history in hypersonic instruction going back over three decades. Starting with **Introductory Hypersonics, first offered in 1988**, AFIT's Department of Aeronautics and Astronautics now routinely offers five courses on hypersonic topics.

AFIT is one of only a select few universities to offer a graduate certificate in hypersonic topics. AFIT also provides students the advantage of

CLASSIFIED RESEARCH CAPABILITIES

AFIT faculty are active members of university-led research teams working on projects for the **University Consortium for Applied Hypersonics (UCAH)**. The 18 research teams garnered a combined total of

$25.5M **IN FUNDING FOCUSING ON CRITICAL HYPERSONIC TECHNOLOGY**

AFIT faculty have collaborated on research proposals and activities with over seven universities and provides consultation to many government entities within the **Department of the Air Force and NASA**.

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GRADUATE THESES & DISSERTATIONS

advised by AFIT faculty since 2002 with clear hypersonic weapon system applicability

HYPERSONIC RESEARCH AREAS

- Hypersonic systems
- Hypersonic phenomenology
- Defense against hypersonic weapons
- Propulsion
- Fluid dynamics
- Structures and materials
- Sensors

RESEARCH CONTRACT AWARD

AFIT to Collaborate on Contract to Develop MDO Hypersonic Vehicle Design

Recently, AFIT (in collaboration with the University of Michigan, The Ohio State University and Virginia Tech) received a three-year contract for developing Multidisciplinary Design Optimization (MDO) based hypersonic vehicle design techniques addressing propulsion, heat transfer, aerodynamics, controls, structures, and materials disciplines for creating feasible vehicle configurations. This contract was awarded through a national competition spanning a diverse realm of 17 topics under the University Consortium for Applied Hypersonics (UCAH). The UCAH mission is to serve the U.S. Department of Defense (DOD) requirements in science and technology, workforce development, and technology transition. It does this by mobilizing and leveraging the academic community and its partners to deliver time-sensitive applied solutions to the DOD-defined research and prototype projects in the areas of core technology, next-generation projects (enabling technologies), and challenge projects (multidisciplinary efforts).

AFIT will serve as the contract lead in fulfillment of this UCAH award with support from the aforementioned three universities embarking in research oriented towards utilization of appropriate fidelity models that will enable new tactical capabilities for the warfighter. This will be achieved through goal-driven design and optimization methodologies that exploit advancements in modeling, physics-based analysis, and machine learning techniques. Research conducted in fulfillment of this award will expand our understanding of tradeoffs between subsystems in complex offensive and defensive hypersonic systems and to produce conceptual design studies and algorithms (software code, algorithm design documents) to optimize total system performance. Therefore, the methods identified and developed throughout this research will aim to optimize performance for flight, sensor, internal thermal loading, control surfaces/ guidance/maneuverability, launch loads, and offensive and defensive lethality and be demonstrated on the GHV.

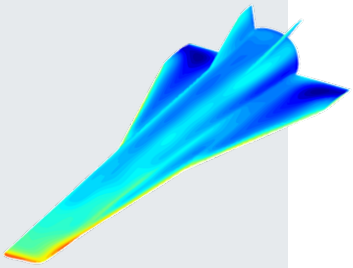
Photos & cover graphic: U.S. Air Force

Simulating Hypersonic Flight

In recent years, interest in hypersonics has increased within the defense community. AFIT, as a premier institution for defense-focused education, research, and consulting, is ideally suited to meet the defense community's needs. Accordingly, AFIT has risen to meet those needs by educating Airmen on hypersonic topics, either through the hypersonics sequence of the graduate program or the hypersonics short course, both of which are offered by the Department of Aeronautics and Astronautics and by engaging in cutting edge defense-focused research.

Hypersonic velocities, those above Mach 5, pose significant technical challenges in terms of vehicle design and employment. The high energy flowfield associated with such speeds induces a highly complicated and fully coupled aerothermodynamic environment. The high temperatures can cause chemical reactions, fundamentally changing the physical properties of the 'air' in which the vehicle is flying. Furthermore, the flowfield can reach a state of thermodynamic non-equilibrium in which the energy state of the fluid must be defined using multiple temperatures. In turn, the effect on aerothermodynamics complicates the vehicle's thermal management processes, navigation, guidance, and controllability.

Due to the high cost of flight and ground testing, simulations are a very cost-effective method of investigating hypersonic phenomena. The computational fluid dynamists at AFIT have access to state-of-the-art computer resources. Both Government and industry flowfield and radiation solvers are available to characterize the complex hypersonic flows in the simulated environments. Researchers and students utilize both the local AFIT network and the Department of Defense (DoD) High-Performance Computing Modernization Program (HPCMP) centers, enabling effective scaling of simulations. Smaller projects are run on the local network while larger problems are solved using one of the DoD HPCMP systems.



"Having an operationally informed set of priorities is very meaningful and that's a thing that distinguishes AFIT from the other graduate institutes – the impetus of this institution to prioritize the needs of the Department of Defense. The junior force coming out of institutions like AFIT will be the people really running and leading operations in the future force."

Lt. Col. Jeffrey Komives, PhD, USAF
AFIT M.S. Aeronautical Engineering, 2009

Hypersonics technical expert and airpower strategist working on Air Staff in Air Force Futures (HAF A5/7)

RESEARCH ACTIVITY

Hypersonic Computational Simulations to Further Defense Community Interests

The ability to detect, identify, and track hypersonic vehicles is of particular interest to the defense community. One observation method is to use the optical emissions, or radiance, produced by the vehicle and both the surrounding and trailing flowfield. However, the source, strength, and distribution of the radiance produced by a hypersonic vehicle is not well understood. To investigate this phenomenon, simulations were run to depict a simple cone in hypersonic flight. The simulation included the cone and extended behind the vehicle into the near and far wake regions. In addition, the flowfield simulation allowed for variations to the vehicle's surface conditions to include modeling of thermal protection system ablation products, which were allowed to enter the flowfield. The radiance of the flowfield was then calculated using a radiation solver.

The subsequent analysis and reporting of the simulation resulted in data that required protection at either the Controlled Unclassified Information (CUI) or higher classified levels, highlighting yet another advantage of AFIT. As a Government university, AFIT can perform, protect, and disseminate limited distribution research at the appropriate levels without the need for an exterior sponsor. The ability to conduct research with enhanced protections is critical to meeting current and future defense community needs.

AFIT will continue to be at the forefront of defense-focused hypersonic simulations to support the defense community's needs. As a result, students departing AFIT have the toolset needed to hit the ground running with respect to hypersonic simulation environments. Concurrently, AFIT's resident faculty and staff will continue to provide quality research and consultation products to their defense community partners.

GRADUATE CERTIFICATE PROGRAM

Hypersonic Flight Certificate

The Air Force Institute of Technology's Department of Aeronautics and Astronautics is proud to offer a Graduate Certificate Program in Hypersonic Flight. The field of hypersonics has emerged as a technical discipline that is critical to ensure the United States will be able to fight and win future conflicts. The Graduate Certificate in Hypersonic Flight is specifically designed to produce technical professionals who can understand, evaluate, and communicate the unique complexities of the hypersonic flight environment.

The program consists of a rigorous collection of graduate level courses. The courses are offered in-residence at the AFIT main campus located on Wright-Patterson Air Force Base, Ohio. Students must complete three core classes and then select one elective course, for a total of 16 quarter hours of graduate level studies. The three core courses cover the areas of inviscid hypersonic flows, high temperature gas dynamics, and hypersonic propulsion. The one elective course may further the student's understanding in either computational fluid dynamics, nonequilibrium phenomena, reentry dynamics, or chemical propulsion.

Upon completion of the program, graduates will have a general understanding of the differences between hypersonic flight regimes and the subsonic and super-sonic flight regimes which make the hypersonic environment unique. They will also have a thorough understanding of the aerothermodynamic properties of hypersonic flows and how to approach and appropriate engineering analysis given hypersonic flight conditions. Finally, graduates will be equipped with the skills needed to critically analyze hypersonic vehicle systems and subsystems at the appropriate fidelity.

HYPERSONIC FLIGHT PROGRAM COURSE LIST

Hypersonic Flight Core Courses [required]

- AERO 622 – Introductory Hypersonics
- AERO 729 – Theory of Gases for Aerodynamics and Propulsion
- MENG 634 – Hypersonic Propulsion

Hypersonic Flight Elective Courses [choose one of the following]

- AERO 640 – Hypersonic Computational Fluid Dynamics
- AERO 740 – Nonequilibrium Hypersonic Flows
- MECH 637 – Astrodynamic Reentry
- MENG 530 – Chemical Rocket Propulsion

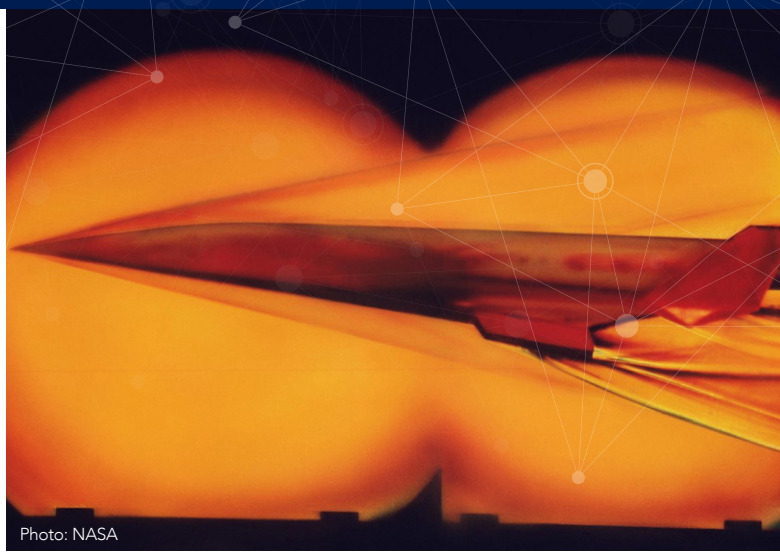


Photo: NASA

PROGRAM DETAILS

PROGRAM REGISTRATION

Registration is currently open for students who wish to apply. Visit the AFIT admissions web page for more information on eligibility and admission steps:

www.AFIT.edu/admissions

APPLICATION REQUIREMENTS

Degree Required: ABET-accredited degree in aeronautical, aerospace, astronautical, or mechanical engineering

GPA Required: Cumulative GPA – 3.0 on a 4.0 point basis in the required degree

Application note: Waivers to the degree or GPA requirement may be considered on an individual basis.

MORE INFORMATION

Email questions to Lt. Col. Robert MacDermott, PhD, USAF, AFIT Hypersonic Flight Program Chair and Assistant Professor of Aerospace Engineering:

robert.macdermott@us.af.mil

Visit the AFIT Hypersonic Flight Certificate web page:

https://e.AFIT.edu/4qq52CC

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DEPARTMENT OF AERONAUTICS & ASTRONAUTICS: www.AFIT.edu/ENY

AFIT HYPERSONICS OVERVIEW: www.AFIT.edu/hypersonics