PURDUE
UNIVERSITY

School of Aeronautics & Astronautics

Research Report 2006 - 2008

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OUR MISSION

Established as an independent school on July 1, 1945, the School of Aeronautics and Astronautics is committed to be a world-class leader in aerospace engineering education and fundamental and breakthrough research for aerospace vehicles and systems. Our mission of preparing men and women to be leaders in aerospace engineering by providing exceptional education and research programs for them is the focus of our life's work.

ACADEMIC HIGHLIGHTS

Undergraduate enrollment was 457 for the Fall of 2007. Graduate enrollment of 250 was the largest graduate enrollment in the School's history. During academic year 2007-08, 115 students earned their Bachelor of Science degree, 49 earned their Master of Science degree, and 12 earned their Doctor of Philosophy degrees. The *US News and World Report* ranked our graduate program 5th in the nation and our undergraduate program 4th amongst universities that award Ph.D.s. The School continues to appear on the list of "key schools" for the major US aerospace manufacturers.

Year	**02-03**	**03-04**	**04-05**	**05-06**	**06-07**	**07-08**
B.S.	90	116	142	133	116	115
M.S.	24	47	42	76	44	49
Ph.D.	10	11	12	15	13	12

Purdue University's Program for Study Abroad Office currently offers more than 200 programs in over 45 countries around the world. The School of Aeronautics and Astronautics currently has active student exchanges: Bristol University, United Kingdom; Royal Melbourne Institute of Technology, Melbourne, Australia; University of New South Wales, Sydney, Australia; Ecole Superieure des Techniques Aeronautiques et de Construction Automobile (ESTACA), Paris, France.

The School of Aeronautics and Astronautics, through Purdue University's Engineering Professional Education (EPE) Program, offers graduate level courses in aerospace engineering. This opportunity to reach students through distance education, along with our history of quality education, gives us confidence that our School's participation with EPE will be a benefit to all participants. The School is developing its first M.S. in Aeronautics and Astronautics through EPE.

DEVELOPMENT HIGHLIGHTS

Ducommun, The Boeing Company, Lockheed-Martin, Northrop Grumman, and Rolls-Royce supported the Industrial Affiliates Program (IAP) this year. The School's Industrial Advisory Council (IAC) continued its bi-annual meeting schedule, meeting in April 2007 and 2008 and October 2007 and 2008. IAC members are: Mr. Frank Bauer, NASA Headquarters; Mr. Bradley Belcher, Rolls Royce; Dr. Paul Bevilaqua, Lockheed Corporation; Ms. Andrea Chavez, Ball Aerospace; Mr. Michael Corso, Henderson, Franklin, Starnes & Holt; Mr. Daniel Devitt, Vought Aircraft Industries, Inc; Mr. Darryl Davis, Boeing Integrated Defense Systems; Mr. Michael Dreessen, Miltec Missiles & Space; Mr. John Gallman, Cessna Aircraft Co.; Dr. Carl Gran, The Aerospace Corp.; Mr. Andrew Kasowski, Cessna Aircraft Co.; Dr. Andrew King, Boeing; Ms. Mary Kriebel, Northrop Grumman; Dr. Donald Lamberson, Major General, USAF (ret.); Mr. Kerry D. Masher, Hawker Beechcraft Corporation; Mr. Thomas Maxwell, GE Aircraft; Mr. David McGrath, ATK Tactical Systems; Mr. Gary E. Mitchell, Boeing Integrated Defense System; Ms. Erika J. Pearson, Boeing Company; Mr. James Renna, Sikorsky Aircraft; Mr. Charles Saff, Boeing; Mr. Randal Secor, Northrop Grumman Corp.; and Dr. Robert Strickler, Sangamon LLC.; Dr. Anthony Thornton, Sandia National Labs; Mr. William Ted Torgerson, Boeing Integrated Defense Systems; and Mr. John Walsh, Sypris Electronics LLC Technologies.

As of June 30, 2008, the School of Aeronautics and Astronautics had raised $911,856.00 for the Access and Success Campaign for the Schools' overall $3.5 million goal.

ALUMNI HIGHLIGHTS

On October 4, 2007, the following seven Outstanding Aerospace Engineers (OAEs) were honored: Ms. Nancy L. B. Anderson (BSESc 1961, MSAAE 1962); Mr. Thomas M. Beutner (BSAAE 1987); Mr. Steven C. Drury (MSAAE 1989); .Mr. Rune C. Eliasen (BSAAE 1977); Dr. Michael W. Hyer (MSESc 1966); Mr. Andrew H. Kasowski (BSAAE 1972); and Mr. Miroslav A. Simo (BSAE 1961).

The following eight Outstanding Aerospace Engineers were honored on October 2, 2008: Mr. Frank H. Bauer (BSAAE 1979; MSAAE 1980); Mr. Darryl W. Davis (BSAAE 1978); Dr. Wayne Eckerle (BSAE 1975 and MSAE 1976); Dr. Walter Eversman (BSAE 1959); Mr. Troy M. Gaffey (BSAE 1960); Dr. Markus B. Heinimann (BSAAE 1992, MSAAE 1994 and PhD 1997); Mr. Timothy A. Kinnan (MSAAE 1971); and Mr. Kenneth B. Sanger (BSAAE 1981 and MSAAE 1983).

Mr. William H. Gerstenmaier (BSAAE 1977) was awarded the College of Engineering 2007 Distinguished Engineering Alumnus (DEA). Mr. Gerstenmaier is currently Associate Administrator for Space Operations, NASA.

Ms. Debra Haley (BSAAE 1978) and Mr. Michael J. Cave (BSE 1982) were awarded the College of Engineering 2008 Distinguished Engineering Alumnus Award. Ms. Haley is currently Special Assistant to the Commander (Ret.), Aeronautical Systems Center, Wright-

Patterson Air Force Base; and Mr. Cave is the Senior Vice President, Business Development and Strategy, The Boeing Company.

Dr. Martin Jischke was awarded the Honorary Doctorate degree during the May 2007 graduation ceremonies. Dr. Jischke served as the President of Purdue University August 2000-June 2007. Under his leadership, the University brought in close to $2 billion in private gifts. In carrying out the strategic plan for Purdue, he oversaw the university's undertaking of more than 50 capital projects, including construction of 40 new buildings.

PUBLICATIONS

Listings of books, journal articles, and other printed conference papers and reports published in calendar years 2006 and 2007 are given in the "Faculty Summary" section of this report. Only documents that actually appeared in print during 2006 and 2007 are listed. Note that 135 journal articles or book chapters, and 288 conference papers or technical reports, were presented or published. In addition to the published technical reports listed, many other technical progress reports were submitted directly to project sponsors.

CO-OP PROGRAM

During the 2007 academic year, 51 students were enrolled in the Cooperative Engineering Program with the companies listed on the following page. This popular program is limited only by the number of industry positions available. About 9 of 33 new applicants in Spring 2008 received appointments this year. Many other students gain industrial experience through internships.

During the past academic year several new certificate programs have been initiated under the umbrella of the Co-op program, which has been renamed "Professional Practice" to reflect its expanded role. The new programs are generally shorter than the traditional 5 term Co-op, typically expecting three work sessions from students after their sophomore year. We hope that these new programs will bring in more employers and greatly expand the professional practice opportunities open to AAE students.

Co-Op Companies
School of Aeronautics and Astronautics
July 1, 2006-June 30, 2008

Company	Location	# of A&AE Co-op Students 2006-2007	# of A&AE Co-op Students 2007-2008
ATA Engineering Inc.	San Diego, CA	11	7
Ball Aerospace & Tech. Corp.	Boulder, CO	2	5
General Electric GE Transportation/Aircraft Engines	Cincinnati, OH	12	11
Rockwell Collins	Cedar Rapids, IA	3	2
Structural Analysis Engineering Corp.	Cincinnati, OH	2	1
U.S. Gov. Air Force Research Lab.	Edwards AFB, CA		2
U.S. Gov. NASA-Dryden Flight Research Center	Edwards, CA	2	2
U.S. Gov. NASA-Johnson Space Center	Houston, TX	9	8
U. S. Gov. Wright-Patterson AFB	Dayton, OH	1	1
United Parcel Service (Air Group)	Louisville, KY	1	
United Technologies Pratt & Whitney	East Hartford, CT		1
U.S. Gov. NASA Marshall		1	1
Gulfstream Aerospace	Savannah, GA		5
U.S. Gov. Army Engineering & Support Center	Redstone Arsenal, AL		2

OVERVIEW OF RESEARCH AREAS AND FACILITIES

Purdue University has outstanding facilities, including several research facilities under construction in Purdue's Discovery Park, as a part of Purdue's strategic plan. Purdue has also excellent computing facilities. Purdue owns a 320-CPU IBM SP supercomputer and has just created a state-of-the-art visualization center.

The School of Aeronautics and Astronautics houses some of the nation's top research labs for the study of evolving aerospace industry technologies. Both computational and experimental facilities are available for graduate student use. With the recent support of the Boeing Company and the Intel Corporation, the School was able to enhance the Design/Build/Test (DBT) Laboratory, which prepares students for integrated product teams in industry. In addition, many workstations and personal computers are located throughout the School. The *High Performance Computing Cluster for Aerospace Applications* consists of a 57 quad node cluster (228 total processors) for distributed and parallel processing.

AERODYNAMICS

Aerodynamics research is directed toward a better understanding of the fundamental laws governing the flow of fluids in aerospace systems. Research topics of recent interest include aerodynamic noise, low-gravity fluid mechanics, computational methods in aerodynamics and fluid mechanics, experimental measurements using optical systems, and laminar-turbulent transition in hypersonic boundary layers.

Experimental facilities include four low-speed wind tunnels located at the **Aerospace Sciences Laboratory** (ASL). **The Boeing Wind Tunnel** is a large subsonic wind tunnel with two test sections: a closed 4-by-6 foot section with a maximum speed of 250 miles per hour, and a long test section adapted for high-lift research. The first test section is equipped with a six-component motorized pitch-and-yaw balance system.

Three smaller low-speed wind tunnels are also located at ASL. One has an 18 inch diameter test section, and the other two have test sections of 12 by 18 inches. Several small calibration tunnels are also available, along with a 20-by-20-inch water tunnel.

Four high-speed facilities are located in the **Boeing Compressible-Flow Laboratory** at ASL. The **Boeing/AFOSR Mach-6 Quiet Tunnel** is a large Ludwieg tube with a 9.5-inch Mach-6 test section. It is the only hypersonic wind tunnel in the world with low noise levels comparable to flight, for unit Reynolds numbers up to about 3.5 million per foot. It can also be operated under conventional noise to a unit Reynolds number of 6 million per foot. Instrumentation is specialized for study of laminar-turbulent instability and transition, and includes high-speed hot wires, fast-response pressure transducers, hot-film arrays and anemometers, a high-sensitivity laser-differential interferometer, a glow-discharge perturber, and a pulsed laser perturber.

The Boeing Compressible-Flow Laboratory also includes a smaller Ludwieg tube with a 4-inch Mach-4 test section that remains quiet to a length Reynolds number of about 400,000. A 4-inch transonic test section, completed in 2004, can also be installed. A 3000-gal. air receiver supplies a 2-inch Mach-2.5 blowdown tunnel and a one-inch supersonic jet designed for nozzle-

flow studies. Both can exhaust to a 500 cubic foot vacuum tank, and are used primarily for teaching. The jet apparatus also includes a heater and particle filter to enable supersonic hot-wire calibrations. A 4-inch shock tube is also available in Armstrong Hall.

AEROSPACE SYSTEMS

The Aerospace Systems (AeS) area within the School is producing a world-class academic program linking learning with pioneering research that radically improves aerospace products and product development and is creating opportunities for students to excel in multidisciplinary investigations in aerospace engineering; contribute and grow, both at Purdue and in their careers.

The research undertaken in AeS develops, exercises, and validates new approaches and methods for the design & operation of aerospace systems and products. With these approaches, AeS students and faculty produce new concepts for space, air transportation, military systems, and their components for improved operations. This includes identification and investigation of "disruptive technologies". Researchers in AeS must have knowledge and skills in multiple aerospace disciplinary areas and an understanding of how aerospace systems are designed, developed, operated, managed, and how they interact. Examples of research topics in AeS include: Multidisciplinary Design Optimization (MDO), Modeling and Simulation, and Product Life-cycle Management (PLM).

The educational intent of the AeS area is to educate graduates and undergraduates to be strong, innovative engineers and researchers who are "system thinkers" for aerospace industry and government, as well as developing students who will be future faculty that will provide continuing intellectual contributions.

With the move to Armstrong Hall, the Aerospace Systems area is building a **Collaborative Design Facility** in ARMS 3085 where research teams will participate in aerospace systems design and integration studies. This facility will have features similar to JPL's well-known "TeamX" facility, providing multiple PC workstations for individual participants and large-screen shared displays. In the collaborative design facility, teams will exercise the methods and approaches developed by researchers in the AeS area. The facility also utilizes video/teleconferencing capability to allow collaboration with off-campus partners.

ASTRODYNAMICS AND SPACE APPLICATIONS

In the area of astrodynamics, the complex missions envisioned in the next few decades will demand innovative spacecraft trajectory concepts and efficient design tools for analysis and implementation. In support of such plans, current research efforts focus on spacecraft navigation and maneuver requirements, and mission planning, both in the neighborhood of the Earth and in interplanetary space. Some of the current research efforts focus on the following: 1) libration point orbits in the three- and four-body problems 2) trajectory design and optimization including optimal control strategies for out-of-plane motion in consideration of communication and other

operational specifications 3) analyses of station-keeping requirements for such trajectories are also currently under study.

Current research efforts also include 1) analytic theory and control of spinning-up and thrusting vehicles, 2) mission design and trajectory design for interplanetary flight, 3) orbit decay and reentry problems, and 4) tethers in space 5) finding and developing new applications of the Global Positioning System (GPS). GPS has emerged as one of the most prevalent uses of satellite technology in people's everyday lives today. 6) Three dimensional reconstruction of biological structures obtained from serial electron microscope sections 7) computer applications to research and teaching of Microbiology 8) digital signal processing. 9) nonlinear dynamics and chaotic system analysis as applied to biological diversity. 10) satellite design 11) ground station design for acquisition satellite data.

DYNAMICS AND CONTROL

All modern aerospace vehicles rely upon an understanding of dynamics and control to improve system performance. Successful system design requires an understanding of the interactions of dynamic elements and the trade-offs between vehicle dynamic characteristics, control system properties, and system performance.

Current research is divided into the following areas: aircraft design for improved handling qualities, astrodynamics, robust and nonlinear control theory and applications, estimation theory and applications, dynamics and control of flexible spacecraft, mission design, modeling and control of aeroelastic aircraft, spacecraft maneuvers and trajectory analysis, and optimization.

Certain research projects and teaching activities require advanced and specialized laboratory facilities. The **Control Systems Laboratory** (CSL) contains high-end workstations. The mission of the CSL is to develop methods and tools (software) for the analysis and design of complex dynamical systems and to promote the availability and use of the methods by teaching relevant courses and interacting with industry. Experiments used for undergraduate instruction include a two-degree-of-freedom helicopter experiment, a three-degree-of freedom rotational system to emulate the attitude dynamics of a flexible spacecraft, and an inverted pendulum. The **Remotely Piloted Vehicle**, currently under development, represents a unique research facility upon which to perform many experiments in vehicle dynamics and control. Data communication with a computer based ground station is provided by a seven channel telemetry downlink.

PROPULSION

The Propulsion group has unique facilities, which are highly beneficial for the study of rocket propulsion and energy conversion. Laboratories are housed at two major remote campus facilities: the Maurice Zucrow Laboratory (MZL), and the Aerospace Sciences Laboratory (ASL). The research group is presently studying combustion in solid, liquid, hybrid and airbreathing propulsion systems, electric propulsion concepts, gas turbine nozzles, heat exchangers for high Mach airbreathing systems, and gelled and advanced propellants for chemical rocket applications.

The ***Advanced Propellants and Combustion Laboratory*** is housed at MZL, and is comprised of two test cells. The test cells are of poured, reinforced concrete design with containment steel doors and explosive rated viewing windows. These cells are classed for both Class 1.1 and 1.3 explosives and are equipped with a frangible blowout wall in case of major catastrophic events. Test Cell A currently contains a rocket thrust stand capable of handling thrust loads of up to 1000 lbf. Test Cell B is used for hybrid rocket combustion studies and vacuum ignition studies for a variety of new nontoxic hypergolic propellants. These cells are both equipped to handle advanced storable oxidizers with emphasis on high concentration hydrogen peroxide. In local proximity is a dedicated oxidizer storage building and a dedicated explosive/propellant storage bunker, rated for Class 1.1 materials.

The ***High Pressure Laboratory (HPL)***, also located at MZL, is a major new facility shared with Mechanical Engineering. This facility has two 500 square-foot test cells rated for propulsion testing up to 10,000 lbf thrust levels. The airbreathing propulsion cell has a cyclic pulse detonation rig capable of simultaneous firing of up to four tubes. A 5 million sample-per-second high speed data system and associated pressure instrumentation is available in addition to a more standard suite of pressure/temperature/thrust instrumentation. A high-pressure gas turbine combustor experiment is also housed in this cell. The rocket propulsion cell has capabilities to test liquid oxygen/hydrocarbon thrust units at thrust levels up to 10,000 lbf and pressures up to 5,000 psi. Experiments in both the airbreathing and rocket propulsion cells are controlled remotely with a state-of-the-art data acquisition and control panel.

The ***HPL Annex*** is a new facility located adjacent to the High Pressure Lab. The facility is roughly 1,200 square feet in size and houses a large gas turbine nozzle test facility, the BiAnnular Nozzle Test Rig (BANR) and a Wave Rotor Combustion Rig (WRCR). The BANR facility provides simulation of turbofan nozzle flows using a Rolls-Royce 501K combustor to replicate turbine exit conditions and cold air to simulate bypass conditions. The facility is capable to flowrates in the 50 lbm/s range at nozzle pressure ratios as high as 10 with a six-axis force measurement system. The WRCR facility is being developed to study advanced combustor designs under development at Rolls-Royce. The rig will feature a 20 tube rotor with rotational speeds to 4000 RPM with airflows in the 20 lbm/s range and propane fuel flows near 1 lbm/s.

The ***Gel Propellant Laboratory (GPL)*** is a new laboratory under development in support of a Multidisciplinary University Research Initiative (MURI) program on Spray and Combustion of Gelled Hypergolic Propellants awarded to Purdue and its partners in Spring 2008. The GPL is dedicated to small scale combustion experiments with hydrazine based fuels and strong nitric acid based oxidizers. Personnel exposure to potentially toxic vapors is mitigated by the use of small quantities of propellants (typically less than 100 ml per experiment), self-contained containers, audible sensor alarms and a dedicated ventilation system allowing for a 0.02" H_2O pressure differential between the laboratory and its associated and dedicated control room. The laboratory will be equipped with separate fume-hood like work stations for fuel and oxidizer systems. These stations are fitted with contained atmosphere features and face velocities of 100 feet per minute thus shielding the operator from vapors. Most experiments can be remotely operated and monitored from the control room via a LabView Virtual Instrument program.

The ***Solid Propellant Laboratory (SPL)*** contains provisions for mixing and evaluating solid rocket propellants. The lab features a 1 pint Ross Mixer capable of remote temperature controlled vacuum mixing operations. A Grieve curing oven and a Revco Thermo Scientific freezer provide capabilities for processing and storing/temperature conditioning propellants.

Two Crawford bombs are available to evaluate propellant burning rates at pressures up to 6000 psi.

The ***Fuel Thermal Management Laboratory*** is housed at MZL, and includes a 15Kw power supply for electrically heating tubes containing flowing aviation fuels. The cell contains a fully temperature conditioned fuel tank, sparging system, nitrogen purging of test apparatus, and pressure/temperature/flow instrumentation for operation to roughly 1000 psi and 1200 deg. F operations. Data acquisition is achieved using LabView software and National Instruments acquisition cards in personal computers. Cameras are used for remote observation of the test cell.

The ***Laboratory for Electric and Advanced Propulsion*** is housed at the Aerospace Science Laboratory (ASL). There are two vacuum systems located at ASL to simulate operating conditions for electric propulsion devices. A smaller vacuum chamber (17-in diameter, 3-foot long cylindrical vessel) is primarily used for component testing. Depending on introduced gas flow, the vacuum system enables vacuum pressures between 10^{-2} to 10^{-6} Torr. A torsional thrust stand was designed and built capable of resolving forces below 1 mN. The recent addition of a large vacuum chamber substantially increases the testing capability of the Laboratory. The vacuum chamber features a 5–foot diameter, 9–foot long cylindrical vessel and various feedthroughs for power, diagnostics, and instrumentation. A 20,000–l diffusion pump in series with a 400–cfm mechanical pump establishes vacuum pressures below 10^{-6} Torr ($2 \cdot 10^{-8}$ psi). Both vacuum systems have their individual pumping systems, diagnostics, and propellant feed systems.

STRUCTURES AND MATERIALS

Structures and materials research includes work in composite materials, computational structural mechanics, damage tolerance analysis, experimental structural analysis, structural mechanics and aeroelasticity, dynamic behavior of advanced materials, tribology, manufacturing, wave propagation, smart materials and structures, and optimal design methods.

The **Fatigue and Fracture Laboratory** is well-equipped to conduct structural integrity motivated research directed at evaluating the damage tolerant properties of materials and components. Two computer-controlled electro-hydraulic test machines (11 and 22 kip capacity), and associated equipment, are used to measure fracture loads and to study fatigue crack formation and propagation in test specimens subjected to simulated aircraft or spacecraft load histories. A scanning electron microscope is available to examine fracture surfaces.

The **Laboratory for Dynamic Response of Advanced Materials**, resided in Purdue's new Bowen Large-scale Testing Laboratory, contains unique equipment and facilities for the characterization of engineering materials under high-rate conditions. A variety of split Hopkinson bars (Kolsky bars) have been developed and modified for testing materials ranging from a single Kevlar fiber and soft tissues to metals and armor ceramics at strain rates from intermediate to impact level. A high-speed optical digital camera with the frame rate of up to 2,000,000 frames per second is used to record the high-rate deformation and failure processes. High-rate experiments are also conducted at different temperatures and different stress states, in addition to different strain rates.

The **Composite Materials Laboratory** contains equipment and facilities for general material testing and for fabrication of composite laminates. An autoclave designed for curing epoxy-matrix composites is available for laminate fabrication. A hot press is used for forming thermoplastic composites, and an EnTec filament winding machine is available for making cylindrical composite structures. A water jet cutting machine is used for specimen preparation. Three complete MTS material and fatigue testing machines (55 kip, 22 kip, and 1 kip capacity) and associated equipment are used to perform ultimate strength, stiffness, and fatigue tests on various composite materials. An environmental chamber and thermally insulated grips can be used on the 22 kip or 1 kip systems for both hot and cold testing. An Applied Test Systems creep machine is available for constant load creep tests at room temperature or elevated temperatures. Dynamic material testing equipment includes a compressed air gun capable for launching a 33 gram projectile to about 500m/s, a drop tower for low velocity impact test, and a Hopkinson pressure bar for high strain rate test. Nondestructive inspection equipment includes an x-ray machine and an ultrasonic C-scan system. Additional facilities for preparing nanocomposites and microscopic observations of materials are also available. These include a Misonix Sonicator and an Olympus Bx60 Optical Microscope with digital camera.

The **Structural Dynamics Laboratory** has the latest equipment for recording ultra-dynamic events. Major equipment includes Norland and Nicolet digital recorders, a one-million-frame-per-second dynamic camera, impact gun, and various computer peripherals for data acquisition. The primary research interest is in the impact of structures and the analysis of consequent stress waves.

The **Tribology and Materials Processing Laboratory,** maintained jointly with the **Center for Materials Processing and Tribology** contains tribological instrumentation as well as up-to-date machines for manufacturing processes. Equipment includes a 22 kip computer-controlled electro-hydraulic test machine and associated equipment for fretting fatigue testing at room and elevated temperatures, infrared sensors for full-field temperature measurements, a friction apparatus for both low and high speed sliding indentation, lapping and polishing equipment, a vibration isolation table, micropositioning stages, a sliding wear experiment, Talysurf profilometers, phase shift interferometric profilometer, an atomic force microscope, a nanoindenter, a talysurf instrument for measurements of form, cylindricity cuts and taper, and an SEM and optical microscopes. A piezo-electric based load frame has been constructed to perform high frequency fretting fatigue experiments related to HCF of aircraft engines. Also, access is available to a variety of machine tools: a precision high speed surface grinder, a centerless grinder, and a super finishing machine, as well as associated piezoelectric force transducers.

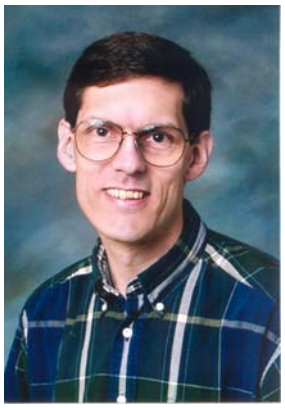
School of Aeronautics and Astronautics

Faculty Summaries

Aerodynamics

Faculty Members

A. A. Alexeenko, Assistant Professor, Penn State, 2003, computational rarefied gas dynamics, kinetic theory of gases, numerical methods for model kinetic equations, direct simulation Monte Carlo techniques, microscale gas flows, coupled thermal-fluid analysis of microdevices, high-altitude aerothermodynamics, two-phase plume flows



G. A. Blaisdell, Associate Professor, Ph.D. Stanford, 1991, computational fluid mechanics, transition, and turbulence

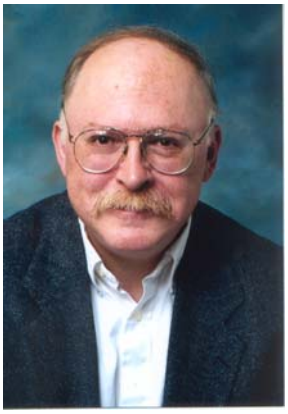
S. H. Collicott, Professor, Ph.D., Stanford, 1991, experimental and low-gravity fluid dynamics, optical diagnostics, and applied optics

M. C. Jischke, President Emeritus, Ph.D., Massachusetts Institute of Technology, 1968

A. S. Lyrintzis, Professor, Ph.D., Cornell, 1988, computational aeroacoustics, aerodynamics for rotorcraft and jet flows

S. P. Schneider, Professor, Ph.D. Caltech, 1989, hypersonic and supersonic laminar-turbulent transition, development of the Boeing/AFOSR Mach-6 Quiet Tunnel and associated instrumentation

J. P. Sullivan, Professor, Sc.D., MIT, 1973, experimental aerodynamics laser instrumentation, luminescent sensors for temperature and pressure measurements



M. H. Williams, Professor and Associate Head, Ph.D., Princeton, 1975, aerodynamics and computational fluid mechanics

ALINA ALEXEENKO
2006
Assistant Professor

Degrees

B. S., Novosibirsk State University, Mathematics, 1997
M. S., Novosibirsk State University, Applied Mathematics, 1999
Ph.D., The Pennsylvania State University, Aerospace Engineering, 2003

Interests

Rarefied gas dynamics
Computational fluid mechanics

Awards and Major Appointments

Air Force – ASEE Summer Faculty Fellowship 2007

Research Areas

Dr. Alexeenko's research is in computational rarefied gas dynamics and its applications to high-altitude aerothermodynamics of spacecraft and satellites and to emerging technologies such as micro-electro-mechanical systems (MEMS) for space communications. The principal goals of the research are the development of accurate and robust numerical modeling tools for gas flow phenomena in regimes from continuum to free molecular, and their application to a wide range of practical problems from low-speed flows in micro- and nanodevices to high-enthalpy flows near space vehicles.

Sponsored Research Summaries

Aerodynamic Damping in MEMS.

Dr. Alexeenko is the Lead PI for Aerodynamic Damping Thrust at the NNSA Center for Prediction of Reliability, Integrity and Survivability of Microsystems(PRISM). As part of this research effort we develop computational algorithms and solvers for deterministic – as opposed to the stochastic DSMC – solution of rarefied flow problems. Such new techniques are especially useful in studying low-speed and/or unsteady flows such as the aerodynamic damping and shock waves propagation in microsystems. Additionally, such computational approaches are especially attractive for uncertainty quantification (UQ). Our recent application of this flow simulation technique has enabled prediction of probability density functions for quantities of interest in aerodynamic damping based on uncertain inputs.

Low-Density Supersonic Jets

Supersonic flows expanding into vacuum are encountered in a number of applications including high-altitude plumes, spacecraft contamination studies and vacuum technology. In this research we study gas-droplet flows in an ultra-high vacuum environment encountered during the deposition of thin film photovoltaic materials. Molecular models for metal vapors are developed based on the direct simulation Monte Carlo studies and the optical and electron microscopy characterization of thin-film deposition samples. Momentum and energy coupling between the liquid and vapor phases is applied to predict transport of droplets originating at the nozzle due to condensation of the rapidly expanding vapor. This research is supported by Veeco Instruments, a

major US manufacturer of vacuum deposition systems.

Java Parallel Computing for Heat Transfer and Fluid Dynamics Simulations
This research aims at development of Java parallel computing environment for heat transfer and fluid dynamics simulations. We are utilizing research codes that has been developed by Dr. Alexeenko: (a) three-dimensional finite-volume code for unsteady heat transfer; (b) two-dimensional code for the direct simulation Monte Carlo modeling; and (c) two-dimensional discrete-ordinate code for solution of the Boltzmann equation for modeling low-speed flows. Java implementation of Message Passing Interface (MPI), MPJ, is applied for parallelization of the codes on both distributed and shared memory systems. The codes take advantage of Java's extensibility and make use of several common Java packages, such as Gas Dynamics Toolbox for computing thermophysical properties of gas mixtures and a linear algebra package Jama. This research is supported by Sun Microsystems Inc., 2007 Academic Excellence Grant program.

Publications

Alexeenko, A. A., Fedosov, D. A., Gimelshein, S. F., and Levin, D. A., "Transient Heat Transfer and Gas Flow in a MEMS-based Thruster," *Journal of Microelectromechanical Systems*, Vol. 15, No. 1, 2006, pp. 181-194.

Alexeenko, A. A., Gimelshein, S. F., Muntz, E. P., and Ketsdever, A. D., "Kinetic Modeling of Temperature-Driven Flows in Short Microchannels," *International Journal of Thermal Sciences,* Vol. 45, No. 11, 2006, pp. 1045-1051.

Han, Y.-L., **Alexeenko, A. A.**, Muntz, E. P., and Young, M., "Experimental and Computational Studies of Temperature Gradient Driven Molecular Transport in Gas Flows through Nano/Micro-Scale Channels," *Nanoscale and Microscale Thermophysical Engineering*, Vol. 11, Nos. 1 & 2, April 2007, pp. 151-175.

Conference Proceedings, Presentations, Invited Lectures, Reports

Alexeenko, A. A., Muntz, E. P., Gallis, M., and Torczynski, J. R., "Comparison of Kinetic Models for Gas Damping of Moving Microbeams," AIAA Paper 2006-3715, 36th AIAA Fluid Dynamics Conference and Exhibit, San Francisco, CA, June 5-8, 2006.

Han, Y.-L., **Alexeenko, A. A.**, Young, M., and Muntz, E. P., "Experimental and Computational Studies of Temperature Gradient Driven Molecular Transport in Gas Flows through Nano/Micro-Scale Channels," 2nd International Conference on Transport Phenomena in Micro and Nanodevices, Barga, Italy, June 11-15, 2006.

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Alexeenko, A. A., "Numerical Error Analysis for Deterministic Kinetic Solutions of Low-Speed Flows," 25th International Symposium on Rarefied Gas Dynamics, St. Petersburg, Russia, July 21-28, 2006.

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Alexeenko, A. A., Gimelshein, S. F., Ngalande, C., "Modeling of Radiometric Force Actuation using the DSMC and ES/BGK Approaches," Bulletin of the American Physical Society, Vol. 51, No. 9, p. 180, 59th Annual Meeting of the APS Division of Fluid Dynamics, Tampa Bay, Florida, November 19-21, 2006.

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Zilic, A., Hitt, D., and **Alexeenko, A. A.**, "Numerical Simulations of Supersonic Flow in a Linear Aerospike Micro Nozzle," AIAA Paper 2007-3984, 37th AIAA Fluid Dynamics Conference and Exhibit, Miami, FL, June 25-28, 2007.

Stein, W. B., **Alexeenko, A. A.**, **Hrbud, I**., and Bondar, Y., "Performance Modeling of RF Co-Axial Thruster," AIAA Paper 2007-5292, 43rd AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit, Cincinnati, OH, July 8-11, 2007.

Medlock, K. L. Gates, **Alexeenko, A. A.**, and **Longuski, J. M.**, "Trajectory and Aerothermodynamic Analysis of Towed-Ballute Aerocapture Using DSMC," AAS Paper 07-307, AAS/AIAA Astrodynamics Specialist Conference, Mackinac Island, MI, August 19-24, 2007.

Stein, W., **Alexeenko, A.,** and **Hrbud, I.**, "PIC/DSMC Model of RF Glow Discharge Thruster", DSMC: Theory, Methods & Applications Workshop, Santa Fe, NM, September 30 – October 3, 2007, p. 58-59.

Stein, W., **Alexeenko, A**., and **Hrbud, I**., "PIC/DSMC Model of RF Glow Discharge Thruster," DSMC: Theory, Methods & Applications Workshop, Santa Fe, NM, September 30–October 3, 2007, pp. 58-59.

Alexeenko, A.,"High-Order Discontinuous Galerkin Method for Boltzmann-BGK Equations," Air Force - ASEE Summer Faculty Report, September 2007, 23 pages.

Alexeenko, A., "Thermally Driven Microflows: Phenomena and Modeling Approaches," invited seminar given in the Department of Mathematical Sciences at the George Mason University, November 30, 2007.

GREGORY A. BLAISDELL
1991
Associate Professor

Degrees

B. S., California Institute of Technology, Applied Mathematics, 1980
M. S., California Institute of Technology, Applied Mathematics, 1982
Ph.D., Stanford University, Mechanical Engineering, 1991

Interests

Computational fluid mechanics
Transition and turbulence

Awards and Major Appointments

NASA-ASEE Summer Faculty Fellowship, 1995-1996
W. A. Gustafson Teaching Award, Fall 1997

Research Areas

Current research interests involve the study of transitional and turbulent fluid flows using computational fluid dynamics (CFD) as an investigative tool. Most flows of engineering interest are turbulent and turbulence has a significant impact on the performance of engineering systems. The drag on a body is generally much greater if the boundary layer is turbulent. Turbulence also increases heat transfer between a fluid and a surface. In addition, turbulent mixing is important to combustion.

The physics of basic turbulent flows are studied using direct numerical simulations (DNS) and large-eddy simulations (LES). With LES, the motion of the largest eddies are solved for directly while the effects of the unresolved small scale eddies are modeled. In contrast, with DNS all the relevant length scales within the turbulence are resolved and no modeling is needed. The results of the simulations are used to increase our understanding of turbulence and to test and improve turbulence models.

Current research projects are described below. Many of these investigations are being carried out using parallel processing computers. Parallel computing and advanced numerical methods is another area of interest.

Development of Large Eddy Simulation Methodology and Application to a Turbulent Axial Vortex (Sponsored by Purdue Research Foundation; Student: Brijesh Eshpuniyani; Computer resources: PUCC (IBM SP 2))

Axial vortices form in many engineering systems but are of particular importance to the wake hazard problem for commercial aircraft. A previous study used direct numerical simulation (DNS) to investigate an isolated turbulent axial vortex. However, the DNS are limited to low Reynolds numbers—the DNS are at a Reynolds number that is three orders of magnitude lower than that of the wake vortices behind a typical large commercial airliner. Although LES on currently available computers will not be able to achieve full scale Reynolds numbers, it will allow the trends with increasing Reynolds numbers to be determined. This is important because

Reynolds number is believed to have a significant effect on the development of turbulence within a vortex.

Development of Low Jet Noise Aircraft Engines (Project Leader: Anastasios Lyrintzis, G. Blaisdell, L. Mongeau, S. Bolton, and (W. Dalton of Rolls-Royce), Sponsored by Indiana 21st Century Research and Technology Fund)

The regional and corporate aircraft engine market's rapid expansion will be severely compromised, unless jet noise is drastically reduced. Rolls-Royce, Indianapolis, with a commanding share of 37% in this sector of the world market, may lose business to out-of-state competitors if its engines fail to meet stringent airport noise regulations. In this project experts from Purdue University and Rolls-Royce will advance the science of jet noise reduction for turbofan engines by studying the noise of internally mixed engines, where the hot core flow is mixed with the cooler fan flow inside the exhaust nozzle by lobed mixers. The turbulent mixing of these two flows and their mixing with the atmosphere causes jet noise. Although empirical methods can be used to reduce noise, optimal engine design is not possible without deeper scientific understanding. Our team of experts will synthesize computational, theoretical, and experimental techniques to generate a new level of understanding of jet noise reduction. Rolls-Royce has a plan in place for the rapid commercialization of such scientific breakthroughs. Thus the accelerated technology transfer of our new science will impact about 1200 highly skilled employees at Rolls-Royce in Indiana and also its many local suppliers.

Publications

Garrison, L. A., Dalton, W. N., **Lyrintzis, A. S.**, and **Blaisdell, G. A.**, "Semi-empirical Noise Models for Forced Mixer Jet Noise Predictions," *International Journal of Aeroacoustics*, Vol. 5, No. 2, April 2006, pp. 139-171.

Wright, C. W., **Blaisdell, G. A.**, and **Lyrintzis, A. S.**, "Investigating Correlations Between Reynolds Averaged Flow Fields and Noise for Forced Mixed Jets," *Journal of Aircraft*, Vol. 43, No. 4, July-August, 2006, pp. 886-894.

Uzun, A., **Blaisdell, G. A.,** and **Lyrintzis, A. S.**, "Impact of Subgrid-Scale Models on Jet Turbulence and Noise," *AIAA Journal*, Vol. 44, No. 6, June 2006, pp. 1365-1368.

Conference Proceedings, Presentations, Invited Lectures, Reports

Garrison, L. A., **Lyrintzis, A. S**., **Blaisdell, G. A.**, and Dalton,W. N., "Computational Fluid Dynamics Analysis of Jets with Internal Forced Mixers," AIAA Paper 2005-2887, 11th AIAA/CEAS Aeroacoustics Conference, Monterey, CA, May 2005.

Lew, P., **Blaisdell, G. A.**, and **Lyrintzis, A. S.**, "Recent Progress of Hot Jet Aeroacoustics Using 3-D Large Eddy Simulation," AIAA Paper 2005-3084, 11th AIAA/CEAS Aeroacoustics Conference, Monterey, CA, May 2005.

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Portillo, J. E., and **Blaisdell, G. A.**, "Spatial Stability Analysis of a Liquid Jet," Bulletin of the American Physical Society, Vol. 50, No. 9, p. 175, 58th Annual Meeting of the Division of Fluid Dynamics of the American Physical Society, Chicago, IL, November 20-22, 2005.

Churchfield, M. J., and **Blaisdell, G. A.**, "Near Field Wingtip Vortex Computation Using the WIND Code," AIAA Paper 2006-633, 44th AIAA Aerospace Sciences Meeting and Exhibit, Reno, NV, January 2006.

Lew, P., Uzun, A., **Blaisdell, G. A.**, and **Lyrintzis, A. S.**, "Development of a Parallel 3-D LES Methodology for Jet Aeroacoustics via the Schur Complement," AIAA Paper 2006-796, 44th AIAA Aerospace Sciences Meeting and Exhibit, Reno, NV, January 2006.

Oliver, A., B., Lillard, R. P., **Blaisdell, G. A.**, and **Lyrintzis, A. S.**,"Validation of High-Speed Turbulent Boundary Layer and Shock-Boundary Layer Interaction Computations with the OVERFLOW Code," AIAA Paper 2006-894, 44th AIAA Aerospace Sciences Meeting, Reno, NV, January 2006.

Garrison, L. A., **Lyrintzis, A. S.**, and **Blaisdell, G. A.**, "RANS-Based Noise Predictions of Jets with Internal Forced Mixers," AIAA Paper 2006-2599, 12th AIAA/CEAS Aeroacoustics Conference, Boston, MA, May 2006.

Portillo, J. E., and **Blaisdell, G. A.**, "Spatial Stability Analysis of a High Speed Liquid Jet," ILASS Americas 19th Annual Conference on Liquid Atomization and Spray Systems, Toronto, Canada, May 2006.

Churchfield, M. J., and **Blaisdell, G. A.**, "The LagRST Model Applied to a q-Vortex," Bulletin of the American Physical Society, Vol. 51, No. 9, p. 130, 59th Annual Meeting of the Division of Fluid Dynamics of the American Physical Society, Tampa, Florida, November 19-21, 2006.

Lew, P. **Blaisdell, G. A.**, and **Lyrintzis, A. S.**, "Investigation of Noise Sources in Turbulent Hot Jets Using Large Eddy Simulation Data," AIAA Paper 2007-16, 45th AIAA Aerospace Sciences Meeting and Exhibit, Reno, NV, January 8-11, 2007.

Oliver, A. B., Lillard, R. P., Schwing, A. M., **Blaisdell, G. A.**, and **Lyrintzis, A. S.**, "Assessment of Turbulent Shock-Boundary Layer Interaction Computations using the OVERFLOW Code," AIAA Paper 2007-104, 45th AIAA Aerospace Sciences Meeting and Exhibit, Reno, NV, January 8-11, 2007.

Lo, S.-C., **Blaisdell, G. A.**, and **Lyrintzis, A. S.**, "High-Order Shock Capturing Schemes for Turbulence Calculations," AIAA Paper 2007-827, 45th AIAA Aerospace Sciences Meeting and Exhibit, Reno, NV, January 8-11, 2007.

Blaisdell, G. A., "On the Decay of Axial Flow in a q-Vortex," Bulletin of the American Physical Society, Vol. 52, No. 17, p. 177, 60th Annual Meeting of the Division of Fluid Dynamics of the American Physical Society, Salt Lake City, UT, November 18-20, 2007.

Blaisdell, G. A., "Assessment of Turbulent Shock-Boundary Layer Interaction Computations for Space Shuttle Heat Transfer Analysis," seminar given in the Department of Aerospace Engineering at the University of Illinois at Urbana-Champaign, IL, March 14, 2007.

STEVEN C. COLLICOTT

1991
Professor

Degrees

B. S., University of Michigan, Aerospace Engineering, magna cum laude, 1983
M. S., Stanford University, Aeronautics & Astronautics, 1984
Ph.D., Stanford University, Aeronautics & Astronautics, 1991

Interests

Experimental fluid mechanics
Low-gravity fluid dynamics
Optical diagnostics
Applied optics

Awards and Major Appointments

Presented the American Institute of Aeronautics and Astronautics "Special Service Citation," March 1997

Research Areas

Four topics are being researched: high-bypass turbofan duct-strut flow, cavitation in spray orifices, low-gravity fluid dynamics, and optical methods for studying hypersonic boundary layer transition.

A source of total pressure loss and non-uniform back pressure on the fan in modern and proposed high bypass ratio turbofan engines is the strut-endwall flow in the bypass duct. NASA-funded experiments, coordinated with advanced concepts research at Pratt & Whitney, explore the flow structure at Reynolds numbers typical of full-scale cruise conditions. The experiment is designed to also provide valuable checkpoints for the integrated design codes being developed by Pratt & Whitney.

Spraying of a liquid is a common commercial operation, yet little attention has been paid to the flow inside the spray orifice. Particularly in diesel fuel injectors, small-scale non-equilibrium cavitation exists, the behavior of which cannot presently be predicted to any useful extent. This research, funded by the NSF-Career Award, probes the internal flow with specialized optics to uncover the physics of cavitation and turbulence in these flows. Coordination with Professor Heister's simulations with a pseudo-density model for non-equilibrium cavitating flows is crucial to the value of these experiments.

Design of fuel tanks to control sloshing liquids during weightless space flight requires incorporation of nonlinear contact-line dynamics into numerical models. Even the determination of equilibrium interface topology requires considerable numerical work in many situations. Validation and application of an existing model for determining equilibrium interface topologies in main liquid helium tank of the Gravity Probe-B spacecraft has been performed for Lockheed and the GP-B project. Incorporation of physically important stick-slip contact line motion as non-linear boundary conditions in a Boundary Element Method (BEM) code for low-g large-amplitude fluid slosh prediction is being pursued with Professor Heister.

Hypersonic boundary layer transition is a critical event on high speed flight vehicles, including the Space Shuttle during re-entry. Professor Schneider's experiments involve an optical perturber and optical diagnostics, both under the responsibility of Professor Collicott. The perturber has been developed and is in regular use. High-sensitivity, high bandwidth Laser Differential Interferometry is being applied to detect and measure instability waves in millimeter and thinner boundary layers in flows at speeds in excess of one-half of a kilometer per second.

Publications

Lindsley, W. G., **Collicott, S. H.,** Franz, G. N., Stolarik, B., McKinney, W., and Frazer, D.G., "Asymmetric and Axisymmetric Constant Curvature Liquid-Gas Interfaces in Pulmonary Airways," *Annals of Biomedical Engineering,* Vol. 33, No. 3, March 2005, pp. 365-375.

Kim, B.-D., **Heister, S. D.**, and **Collicott, S. H.**, "Three-Dimensional Flow Simulations in the Recessed Region of a Coaxial Injector," *Journal of Propulsion and Power,* Vol. 21, No. 4, July-August 2005, pp. 728-742.

Chen, Y., and **Collicott, S. H.**, "Experimental Study on the Capillary Flow in a Vane-Wall Gap Geometry," *AIAA Journal,* Vol. 43, No. 11, November 2005, pp. 2395-2403.

Hoverman, T. J., and **Collicott, S. H.**, "Inexpensive Air-Assist Atomization from 80,000 Orifices," *Atomization and Sprays*, Vol. 16, No. 7, 2006, pp. 737-748.

Li H., and **Collicott, S. H.**, "Visualization of Cavitation in High Pressure Diesel Fuel Injector Orifices," *Atomization and Sprays*, Vol. 16, No. 8, December 2006, pp. 875-886.

Chen, Y., and **Collicott, S. H.**, "Study of Wetting in an Asymmetrical Vane-Wall Gap in Propellant Tanks," *AIAA Journal,* Vol. 44, No. 4, April 2006, pp. 859-867.

Slobozhanin, L. A, Alexander J. I. D., **Collicott, S. H.**, and Gonzalez, S. R, "Capillary Pressure of a Liquid in a Layer of Close-packed uniform spheres," *Physics of Fluids*, Vol. 18, No. 8, August 2006, 15 pages.

Collicott, S. H., Lindsley, W. G., Frazer, D. G., "Zero-Gravity Liquid-Vapor Interfaces in Circular Cylinders," *Physics of Fluids*, Vol. 18, No. 8, August 2006, 8 pages.

Salyer, T. R., **Collicott, S. H.,** and **Schneider, S. P.**, "Characterizing Laser-Generated Hot Spots for Receptivity Studies," *AIAA Journal*, Vol. 44, No. 12, December 2006, pp. 2871-2878.

Yendler, B., **Collicott, S. H.**, and Martin, T. A., "Thermal Gauging and Rebalancing of Propellant in Multiple Tank Satellites," *Journal of Spacecraft and Rockets,* Vol. 44, No. 4, July-August 2007, pp. 878-883.

Collicott, S. H., "Example Impact of Nonuniform Acceleration Fields on Liquids in Spacecraft," *Journal of Spacecraft and Rockets*, Vol. 44, No.3, May-June 2007, pp. 725-727.

Conference Proceedings, Presentations, Invited Lectures

Collicott, S. H., "Zero-Gravity Liquid-Vapor Interface Solutions and Stability in Circular Cylinders," AIAA Paper 2005-1147, 43rd AIAA Aerospace Sciences Meeting, Reno, NV, January 2005.

Collicott, S. H., invited presenter and panelist, 8th Annual Federal Aviation Administration Commercial Space Transportation Conference, Washington, D. C., February 10-11, 2005.

Manning, Jr., R. E., and **Collicott, S. H.**, "Bubble Penetration through a Single Layer Sphere Bed," AIAA Paper 2006-736, 44th AIAA Aerospace Sciences Meeting, Reno, NV, January 2006.

Collicott, S. H., and Rodriguez, E., "Mass Center Anomalies from Asymmetric Propellant Positions in Spacecraft," AIAA Paper 2006-934, 44th AIAA Aerospace Sciences Meeting, Reno, NV, January 2006.

Collicott, S. H., and Braun, J. P., "Stability of Droplets and Bubbles in a Bent Tube," AIAA Paper 2006-732, 44th AIAA Aerospace Sciences Meeting, Reno, NV, January 2006.

Collicott, S. H., "Bubbles and Droplets in Tubing in Reduced Gravity," Earth and Space 2006 Conference – The 10th International Conference on "Engineering, Construction and Operations in Challenging Environments," American Society of Civil Engineers, Houston, TX, March 5-8, 2006.

Collicott, S. H., and Li, H., "True-scale True-Pressure Internal Flow Visualization for Diesel Injectors," 2006 SAE World Congress, Detroit, MI, April 3-7, 2006.

Tseng, K., and **Collicott, S. H.**, "Internal Flows in Fluidic Spray Control," Institute for Liquid Atomization and Spray Sciences-Americas 2006, Toronto, Canada, May 2006.

Tseng, K., and **Collicott, S. H.**, "Internal Flows in Fluidic Spray Control," 36th AIAA Fluid Dynamics Conference and Exhibit, San Francisco, California, June 5-8, 2006. AIAA-2006-3731.

Jaron, J., and **Collicott, S. H.,** "Static Two-Phase Solutions in non-Circular Cylinders in Zero Gravity," Drop Tower Days 2006, Toki-shi and Tskuba, Japan, October 30-November 1, 2006.

Braun, J. P., and **Collicott, S. H.**, "Zero-Gravity Stability Solutions of Droplets in a Bent Circular Cylinder," AIAA Paper 2007-5517, 43rd AIAA/ASME/SAE/ASEE Joint Propulsion Conference, Cincinnati, OH, July 2007.

Collicott, S. H., "Impact of Non-uniform Acceleration Fields on Future Spacecraft with Large Tanks," AIAA Paper 2007-5554, 43rd AIAA/ASME/SAE/ASEE Joint Propulsion Conference, Cincinnati, OH, July 2007.

Rodkey, S., **Heister, S. D.**, and **Collicott, S. H.**, "Physics of Gas Turbine Engine Bearing Chambers," AIAA Paper 2007-5033, 43rd AIAA/ASME/SAE/ASEE Joint Propulsion Conference, Cincinnati, OH, July 2007.

Collicott, S. H., Invited Presentation, "Real-life and Research in Zero-Gravity Fluid Dynamics," IX International Symposium of Physics, Technológico de Monterrey, Monterrey, Mexico, Feb. 15-17, 2007.

Collicott, S. H., Invited plenary lecture: "Computing Capillary-Dominated Fluid States and Stabilities," World Scientific and Engineering Academy and Society (WSEAS), 4th International Conference on Fluid Mechanics, Gold Coast, Australia, January 17-19, 2007.

ANASTASIOS S. LYRINTZIS
1994
Professor

Degrees

Diploma, National Technical University, Athens Greece, Mechanical Engineering, 1981
M.S., Cornell University, Aerospace Engineering, 1985
Ph.D., Cornell University, Aerospace Engineering, 1988

Interests

Computational Aeroacoustics
Aerodynamics for rotorcraft and jet flows

Awards and Major Appointments

AHS (American Helicopter Society), Acoustics Committee
AIAA Aeroacoustics, Technical Committee; Awards Subcommittee (Chairman 96-97)
ASME: coordinating group for CFD
Associate Fellow AIAA

Research Areas

Dr. Lyrintzis' current research interests can be divided mainly into three areas:

a. The Use of Integral Techniques in Computational Aeroacoustics

Dr. Lyrintzis has made significant contributions in the use of integral techniques Computational Aeroacoustics (CAA). CAA is concerned with the prediction of the aerodynamic sound source and the transmission of the generated sound starting from the time-dependent governing equations. The goal is to improve the state-of-the-art predictive techniques, so that aircraft and rotorcraft noise can be reduced. Dr. Lyrintzis has pioneered the use of integral techniques, (i.e. the Kirchhoff method and the porous Ffowcs Williams Hawkings [FWH] equation) for describing noise propagation. The methods are attractive because they utilize surface integrals (over a source region) to determine far-field acoustics, as opposed to the memory intensive volume integrals found in traditional acoustic analogy methods. Dr. Lyrintzis' research has demonstrated that a simple set of versatile portable Kirchhoff/Acoustic Analogy subroutines can be developed to analyze and reduce noise generation in a number of applications including fans, propellers, air-conditioning units etc. This work has been funded by NASA Langley Research Center, NASA Glenn Research Center, Sikorsky Aircraft Company and the Indiana 21st Research and Technology Fund, and the Aeroacoustics Research Consortium.

b. Aircraft Jet and Fan Noise for Supersonic Business Jet Engines (with Professor Blaisdell)

Operating behind a supersonic inlet the fan of an SSBJ engine will experience flow distortion characteristics quite different to those of a conventional turbofan installation. The effect of large inflow distortions will be addressed using a nonlinear CFD methodology. The study will investigate fan noise issues, including how inlet distortion may affect buzz saw noise from the fan, i.e. tones at multiples of fan rotation produced by

non-uniform leading edge shock spacing on the fan leading edge. We are using the BASS code currently being developed at NASA Glenn as part of the QAT (Quiet Aircraft Technology) program. The code has been designed for aeroacoustic applications and has several high-order schemes.

The noise emissions of nozzles with internal mixers and ejectors employing geometry and conditions used for the new Rolls-Royce engine of the proposed supersonic business jet is being studied. The main objectives are to examine the effects of forced mixer and ejector design on the noise generation mechanisms, and to develop novel noise attenuation concepts. In our previous studies (in collaboration with Rolls-Royce and ISVR researchers), the noise from internal mixers was investigated based on a RANS approach coupled with semi-empirical models (i.e., the two-source model). We have analyzed experimental results obtained at NASA Glenn. We have also developed a high-order LES code for jet noise prediction and integral acoustics techniques for the computation of the noise signal. We are studying the flow with mixers and ejectors. The ejector will add additional dipolar noise sources; thus the existing two-source model will be extended to a multi-source model to capture the emissions from various nozzle components. This project is being funded by Rolls-Royce.

c. Shock Boundary Layer Interactions Modeling Enhancements (with Professor G. Blaisdell)

The purpose of this study is to evaluate current turbulence models and to test new turbulence modeling ideas for shock boundary layer interactions using the OVERFLOW code. The OVERFLOW code will be used because it is currently the dominant computational fluid dynamics (CFD) tool for Space Shuttle ascent aerodynamics and it is being considered for future use in aerothermal analyses. We are evaluating the standard turbulence models currently available within OVERFLOW to determine their performance on a variety of high-speed boundary layer flows by comparing results with experimental data. We will then determine the behavior of modifications to the near wall scaling and added compressibility corrections. The test cases to be considered will include simple boundary layer flows, shock-boundary layer interactions, and the Space Shuttle during ascent. This work has been funded by NASA Johnson Space Center.

Publications

Garrison L., Dalton, W., **Lyrintzis, A. S.**, and **Blaisdell G. A.**, "Semi-Empirical Noise Models for Predicting the Noise from Jets with Internal Forced Mixers," *International Journal of Aeroacoustics*, Vol. 5, No. 2, April 2006, pp. 139-171.

Wright, C., **Blaisdell G. A.**, and **Lyrintzis, A. S.**, "Investigating Correlations Between Reynolds Averaged Flow Fields and Noise for Forced Mixed Jets," *AIAA Journal of Aircraft*, Vol. 43, No. 4, Jul.-Aug. 2006, pp. 886-894.

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Namgoong, H., **Crossley, W. A.**, and **Lyrintzis, A. S.**, "Global Optimization Issues for Transonic Airfoil Design," *AIAA Journal* Vol. 49, No. 9, Sept. 2007, pp. 2113-2124.

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Lew, P., **Blaisdell, G. A.**, and **Lyrintzis, A. S.**, "Development of a Parallel 3D LES Methodology for Jet Aeroacoustics via the Schur Complement," AIAA Paper 2006-0796, 44th Aerospace Science Meeting, Reno, NV, Jan. 2006.

Oliver, A. B., Lillard, R. P., **Blaisdell G. A.**, and **Lyrintzis, A. S.**, "Validation of High-Speed Turbulent Boundary Layer and Shock Boundary Layer Interaction Computations with the OVERFLOW code," AIAA Paper 2006-0894, 44th Aerospace Science Meeting, Reno, NV, Jan. 2006.

Namgoong, H, **Crossley, W. A.**, and **Lyrintzis, A. S.**, "Aerodynamic Optimization of a Morphing Aircraft Using Energy as an Objective," AIAA Paper 2006-1234, 44th Aerospace Science Meeting, Reno, NV, Jan. 2006.

Namgoong, H, **Crossley, W. A.**, and **Lyrintzis, A. S.**, "Using Aerodynamic Pressure to Reduce Actuation Energy for a Morphing Airfoil," AIAA Paper 2006-2041, 2nd Multidisciplinary Design and Optimization Specialists' Meeting, Newport, RI, May 2006.

Garrison L., **Lyrintzis, A. S.**, and **Blaisdell, G. A.**, "RANS-Based Noise Predictions of Jets with Internal Flow Mixers," AIAA Paper 2006-2599, 12th AIAA/CEAS Aeroacoustics Conference, Cambridge, MA, May 2006.

Lew, P., **Blaisdell G. A.**, and **Lyrintzis, A. S.**, "Investigation of Noise Sources in Turbulent Hot Jets Using Large Eddy Simulation Data," AIAA Paper 2007-0016, 45th Aerospace Science Meeting, Reno, NV, Jan. 2007.

Oliver, A. B., Lillard, R. P., Schwig, A., **Blaisdell G. A.**, and **Lyrintzis, A. S.**, "Assessment of Turbulent Shock-Boundary Layer Interaction Computations Using the OVERFLOW Code," AIAA Paper 2007-0104, 45th Aerospace Science Meeting, Reno, NV, Jan. 2007.

Lo, S-C, **Blaisdell, G. A.**, and **Lyrintzis A. S.** "High-Order Shock Capturing Schemes for Turbulence Calculations," AIAA Paper 2007-0827, presented at the 45th Aerospace Science Meeting, Reno, NV, Jan. 2007.

Lew, P-T., **Lyrintzis, A. S.**, Crouse B., Balasubramanian, G., Freed, D., and Mongeau L., "Noise Prediction of a Subsonic Turbulent Round Jet Using the Lattice-Boltzmann Method," AIAA Paper 2007-3636, 13th AIAA/CEAS Aeroacoustics Conference, Rome Italy, May 2007.

STEVEN P. SCHNEIDER

1989
Professor

Degrees

B. S., California Institute of Technology, Engineering & Applied Science, with Honors, 1981
M. S., California Institute of Technology, Aeronautics, 1984
Ph.D., California Institute of Technology, Aeronautics, 1989

Interests

Laminar-turbulent transition at hypersonic and supersonic speeds
Experimental fluid mechanics

Research Areas

High-speed laminar-turbulent transition is critical for applications including scramjet-powered cruise vehicles, gliding and ballistic re-entry vehicles, supersonic transports, and some types of interceptor missiles. Unfortunately, nearly all existing high-speed experimental results are contaminated by facility noise, such as that radiating from the turbulent boundary layers normally present on the test-section walls of supersonic and hypersonic tunnels. Just as at low speeds, reliable experimental progress requires low-turbulence wind tunnels with noise levels comparable to those in flight.

Sponsored Research Summaries

Quiet supersonic tunnels with low noise levels comparable to flight were developed at NASA Langley during the 1970's and 1980's to address problems such as laminar-turbulent transition that are strongly affected by noise level. Detailed measurements of the mechanisms of transition are needed, under low noise conditions, in order to develop computational models that are based on the correct flow physics. To perform these measurements, quiet Ludwieg tubes have been developed at Purdue, for operation at Mach 4 and Mach 6.

The Boeing/AFOSR Mach-6 Quiet Tunnel at Purdue is the only hypersonic quiet tunnel presently in operation. Quiet flow operation to a unit Reynolds number of 3.5 million per foot has been demonstrated in the 9.5-inch diameter nozzle. Modern digital and optical instrumentation enables efficient use of the 7-second run-time, and the short duration keeps operating costs low. Measurements are made on various models using hot wires, temperature-sensitive paints, high-sensitivity laser differential interferometry, high-frequency pressure transducers, and arrays of surface hot films. Instability waves can be generated in a controlled manner using a glow-discharge perturber at the model surface or using a laser-induced hot spot in the freestream.

Publications

Taskinoglu, E. S., Knight, D. D., and **Schneider, S. P.**, "Computational Fluid Dynamics Evaluation of Bleed Slot of the Purdue Mach 6 Quiet Tunnel," *AIAA Journal*, Vol. 44, No. 6, June 2006, pp. 1360-1362.

Aradag, S., Knight, D. D., and **Schneider, S. P.**, "Bleed Lip Geometry Effects on the Flow in a Hypersonic Wind Tunnel," *AIAA Journal*, Vol. 44, No. 9, Sept. 2006, pp. 2133-2136.

Schneider, S. P., "Laminar-Turbulent Transition on Reentry Capsules and Planetary Probes," *Journal of Spacecraft and Rockets*, Vol. 43, No. 6, Nov.-Dec. 2006, pp. 1153-1173. See erratum with correct color figures, Vol. 44, No. 2, Mar-Apr. 2007, pp. 464-484.

Salyer, T. R., **Collicott, S. H.**, and **Schneider, S. P.**, "Characterizing Laser-Generated Hot Spots for Receptivity Studies," *AIAA Journal*, Vol. 44, No. 12, December 2006, pp. 2871-2878.

Conference Proceedings, Presentations, Invited Lectures

Aradag, S., Knight, D. D., and **Schneider, S. P.,** "Simulations of the Purdue Mach-6 Wind Tunnel," AIAA Paper 2006-1434, AIAA Aerospace Sciences Meeting, Reno, NV, Jan. 2006.

Borg, M. P., **Schneider, S. P.**, and Juliano, T. J., "Inlet Measurements and Quiet-Flow Improvements in the Boeing/AFOSR Mach-6 Quiet Tunnel," AIAA Paper AIAA-2006-1317, AIAA Aerospace Sciences Meeting, Reno, Nevada, Jan. 2006. Selected as an Outstanding Paper by the AIAA Ground Testing Technical Committee, one of three so selected.

Schneider, S. P., "Hypersonic Boundary-Layer Transition," Deutsches Zentrum für Luft- und Raumfahrt (DLR), Göttingen, Germany, 11 May 2006.

Schneider, S. P., Juliano, T. J., Borg, M. P., "High-Reynolds-Number Laminar Flow in the Mach-6 Quiet-Flow Ludwieg Tube," AIAA Paper 2006-3056, AIAA Fluid Dynamics Meeting, San Francisco, CA, June 2006.

Rufer, S. J., and **Schneider, S. P.,** "Hot-Wire Measurements of Instability Waves on Cones at Mach 6," AIAA Paper 2006-3054, AIAA Fluid Dynamics Meeting, San Francisco, CA, June 2006.

Horvath, T. J., Berry, S. A., Merski, N. R., Berger, K. T., Buck, G. M., Liechty, D. S., and **Schneider, S. P.,** "Shuttle Damage/Repair from the Perspective of Hypersonic Boundary Layer Transition – Experimental Results," AIAA Paper 2006-2919, AIAA Joint Thermophysics and Heat Transfer Conference, San Francisco, CA, June 2006.

Schneider, S. P., "Hypersonic Boundary-Layer Transition," Deutsches Zentrum für Luft- und Raumfahrt (DLR), Göttingen, Germany, 11 May 2006.

Juliano, T. J., Swanson, E. O., and **Schneider, S. P.**, "Transition Research and Improved Performance in the Boeing/AFOSR Mach-6 Quiet Tunnel," AIAA Paper 2007-0535, Aerospace Sciences Meeting, Reno, NV, Jan. 2007.

Schneider, S. P., "Effects of Roughness on Hypersonic Laminar-Turbulent Transition," AIAA Paper 2007-0305, invited paper, AIAA Aerospace Sciences Meeting, Reno, NV, January 2007.

Naiman, H., Knight, D. D., Aradag, S., Juliano, T. J., and **Schneider, S. P.**, "Performance Improvements in Boeing/AFOSR Mach 6 Quiet Wind Tunnel Based on CFD Predictions," 3rd International Symposium on Integrating CFD and Experiments in Aerodynamics, Colorado Springs, CO, June 20-21, 2007. 10 pages.

Schneider, S. P., "The Development of Hypersonic Quiet Tunnels," AIAA Paper 2007-4486, AIAA Fluid Dynamics Meeting, Miami, FL, June 2007. 42 pages.

Schneider, S. P., and Juliano, T. J., "Laminar-Turbulent Transition Measurements in the Boeing/AFOSR Mach-6 Quiet Tunnel," AIAA Paper 2007-4489, AIAA Fluid Dynamics meeting, Miami, FL, June 2007. 12 pages.

Schneider, S. P., "Hypersonic Boundary-Layer Transition," Graduate Aeronautics Laboratory, California Institute of Technology, Pasadena, CA, 12 Oct. 2007.

Schneider, S. P., "Hypersonic Boundary-Layer Transition," Mechanical Engineering Dept., McGill University, Montreal, Canada, 23 Nov. 2007.

JOHN P. SULLIVAN
1975
Professor

Degrees

B. S., University of Rochester, Mechanical & Aerospace Sciences (with honors), 1967
M. S., Massachusetts Institute of Technology, Aeronautical Engineering, 1969
Sc.D., Massachusetts Institute of Technology, Aeronautical Engineering, 1973

Interests

Experimental aerodynamics
Laser instrumentation
Luminescent sensors for temperature and pressure measurements

Research Areas

Current research interest is in the area of experimental aerodynamics with particular emphasis on comparison of experimental data with computational analysis. Current programs include:

1. High lift systems
2. Suction/blowing airfoils

In addition to the above programs, work also continues on developing laser instrumentation (laser Doppler velocimeter, particle image velocimeter, laser sheet concentration, etc.) and pressure and temperature paint for:

1. Wind tunnels - low speed to hypersonic
2. Gas turbine engines
3. Flight tests

Publications

Gregory J. W., **Sullivan J. P.**, Wanis S. S., and Komerath N. M., "Pressure-sensitive Paint as a Distributed Optical Microphone Array," *Journal of the Acoustical Society of America,* Vol. 119, No. 1, 2006, pp. 251-261.

Gregory, J. W., and **Sullivan, J. P.**, "Effect of Quenching Kinetics on Unsteady Response of Pressure-Sensitive Paint," *AIAA Journal*, Vol. 44, No. 3, March 2006, pp. 634-645.

Crafton, J., Carter, C., **Sullivan J. P.,** and Elliott, G., "Pressure Measurements on the Impingement Surface of Sonic and Sub-sonic Jets Impinging onto a Flat Plate at Inclined Angles," *Experiments in Fluids*, Vol. 40, No. 5, May 2006, pp. 697-707.

Gregory, J. W., **Sullivan, J. P.**, Raman, G., and Raghu, S., "Characterization of the Micro Fluidic Oscillator," *AIAA Journal*, Vol. 45, No. 3, 2007, pp. 568-576.

Huang, C. Y., Gregory, J. W., and **Sullivan, J. P.**, "Microchannel Pressure Measurements Using Molecular Sensors," *Journal of Microelectromechanical Systems*, Vol. 16, No. 4, 2007, pp. 777-785.

Huang, C., Lee, S., **Sullivan, J. P.**, "In Situ Measurement of Fluid Film Thickness in Machining," *Tribology Letters*, Vol. 28, No. 1, 2007, pp. 39-44.

Huang, C., Gregory, J. W., and **Sullivan, J. P.**, "Modified Schlieren Technique for Micro Flow Visualization," *Measurement Science and Technology*, Vol. 18, No. 5, 2007, pp. N32-N34.

Huang, C., Gregory, J. W., and **Sullivan, J. P.**, "Flow Visualization and Pressure Measurement in Micronozzles," *Journal of Visualization*, Vol. 10, No. 3, 2007, pp. 281-288.

Conference Proceedings, Presentations, Invited Lectures

Crafton, J., Fonov, S., Goss, L., Jones, E., Gnanimanickam, E., and **Sullivan, J. P.**, "Validation of an Image-Based Skin friction Sensor in a Fully Developed Channel Flow," AIAA Paper 2006-3839, 25th AIAA Aerodynamic Measurement Technology and Ground Testing Conference, San Francisco, CA, June 5-8, 2006.

Huang, C., Gregory, J. W., **Sullivan, J. P.**, Nagai, H., and Asai, K., "Molecular Sensors in Microturbine Measurement," IMECE Paper 2006-13814, Proceedings of IMECE2006, ASME International Mechanical Engineering Congress and Exposition, Chicago, IL, November 5-10, 2006.

Miller, C., **Sullivan, J. P.**, and McDonald, S., "High Altitude Airship Simulation Control and Low Altitude Flight Demonstration," AIAA Paper 2007-2766, AIAA Infotech@Aerospace 2007 Conference and Exhibit, Rohnert Park, CA, May 7-10, 2007.

Huang, C., Lee, S., Hwang, J., **Sullivan, J. P.** and Chandrasekar, S., "Micro-Scale Characterization of Fluid Action in Machining," 10th CIRP International Workshop Modeling of Machining Operations, Reggio Calabria, Italy, 2007.

Murthy, T. G., Huang, C., Chandrasekar, S., **Sullivan, J. P.**, "Direct Observation of Deformation Field in Plane Strain Indentation," Proceedings of the SEM Annual Conference and Exposition on Experimental and Applied Mechanics 2007, Vol. 2, 2007, pp. 817-823.

Gnanimanickam, E. P., Lee, S., **Sullivan, J. P.**, Chandrasekar, S., "Direct Measurement of Large-Strain Deformation Field in Machining," Proceedings of the SEM Annual Conference and Exposition on Experimental and Applied Mechanics 2007, Vol. 2, 2007, pp. 1080-1087.

MARC H. WILLIAMS
1981
Professor and Associate Head

Degrees

B. S., University of Pittsburgh, Aeronautical Engineering, magna cum laude, 1969
M. A., Princeton University, Aerospace & Mechanical Sciences, 1971
Ph.D., Princeton University, Aerospace & Mechanical Sciences, 1975

Interests

Aerodynamics
Computational fluid Mechanics

Research Areas

The determination of aeroelastic stability and forced response characteristics of flight vehicles requires methods for predicting the unsteady aerodynamic loads that are induced by structural deformation and/or free stream disturbances. Current research is directed at developing such methods for transonic flight and for rotating machinery.

Much of this work has been done for advanced propfan applications. These engines are intended for use on medium range commercial transports, which operate at low transonic Mach numbers. In order to maintain high operating efficiency and low noise, the blades are very thin and flexible. Therefore, they are subject to substantial static and dynamic deformations which alter the aerodynamic loads on the blades. Computational methods have been developed to predict these loads, both for single and counter rotating systems. Flutter boundaries and forced vibration amplitudes have been successfully predicted for a variety of current propfan designs. The most successful schemes developed so far have been based on linearized aerodynamic models. Work is under way on including nonlinear transonic effects through three-dimensional potential formulation with moving grids.

Aerospace Systems

Faculty Members

D. Andrisani II, Associate Professor, Ph.D., SUNY at Buffalo, 1979, estimation, control, and dynamics

B. Caldwell, Associate Professor of Industrial Engineering, Ph.D., University of California-Davis, 1990; Human factors engineering; Distributed human supervisory control; Tam coordination and performance using information technology

W. A. Crossley, Associate Professor, Ph.D., Arizona State, 1995, optimal design methods, genetic algorithms and aerospace applications, aircraft and conceptual design, composite and smart structure design

D. DeLaurentis, Assistant Professor, Ph.D., Georgia Institute of Technology, 1998, design methods, and aerospace systems and flight vehicles, system-of-systems

I. Hwang, Assistant Professor, Ph.D., Stanford, 2004, hybrid system theory, information inference of complex dynamical systems, safety verification, and their application to the control of multiple-vehicle systems, especially air traffic surveillance and control

J. P. Sullivan, Professor, Sc.D., MIT, 1973, experimental aerodynamics laser instrumentation, luminescent sensors for temperature and pressure measurements

Terrence A. Weisshaar, Professor, Ph.D., Stanford, 1971, aircraft structural mechanics, aeroelasticity, integrated design

DOMINICK ANDRISANI II
1980
Associate Professor

Degrees

B. S., Rensselaer Polytechnic Institute, Aeronautical Engineering, 1970
M. S., State University of New York at Buffalo, Electrical Engineering, 1975
Ph.D., State University of New York at Buffalo, Electrical Engineering, 1979

Interests

Estimation
Control
Dynamics
Flight Aircraft Flying Qualities

Research Areas

Extensive experience in experimental methods in the study of vehicle dynamics and control has focused teaching and research on practical and important aerospace problems in four areas. First is the area of estimation theory, where new estimation algorithms have been developed using the partitioning approach. The second area involves the application of estimation theory to aerospace problems. Here estimation theory has been used to develop a new class of target trackers. These trackers incorporate knowledge of the aerodynamic and thrust vectors to help improve the trackers ability to estimate target acceleration. The third area involves research towards the development of design specifications for helicopter flight control systems, i.e., helicopter flying qualities. The fourth area involves analysis and detection of pilot-in-the-loop oscillations.

Publications

Krozel, J., and **Andrisani II, D.**, "Intent Inference with Path Prediction," *AIAA Journal of Guidance, Control, and Dynamics*, Vol. 29, No. 2, March-April 2006, pp. 225-236.

BARRETT S. CALDWELL
(by courtesy), 2007
Associate Professor of Industrial Engineering

Degrees

B. S., MIT, Humanities, 1985
B. S., MIT, Aeronautical and Astronautical Engineering, 1985
M. S., University of California-Davis, Social Psychology, 1987
Ph.D., University of California-Davis, Social Psychology, 1990

Interests

Human factors engineering
Distributed human supervisory control
Team Coordination and performance using information technology

Research Areas

Professor Caldwell's research is focused on how people get, share, and use information in complex task settings. His work is especially relevant to team performance in time critical environments such as space flight operations, healthcare operations, and other tasks where distributed human experts manage complex systems. He has worked with state government agencies, companies, hospitals, and NASA research centers, and has been an invited participant in several programs of the National Research Council / National Academy of Engineering.

Conference Proceedings, Presentations, Invited Lectures

Caldwell, B. S., Group Performance and Space Flight Teams. In Bowers, C., Salas, E., and Jentsch, F. (Eds.) *Creating High-Tech Teams*. Washington, DC: American Psychological Association, pp 161-182 (2006).

Caldwell, B. S. and Garrett, S, K., "Team-Based Coordination of Event Detection and Task Management in Time-Critical Settings," 8th International Conference on Naturalistic Decision Making, Pacific Grove, CA, 2007.

Caldwell, B. S. and Cuevas, H.M., "Team Cognition in Human-Automation Teams," 8th International Conference on Naturalistic Decision Making, Pacific Grove, CA, 2007.

Caldwell, B. S., and Boustany, K.C., "Dimensions of Information and Resource Flow in Healthcare Systems," Proceedings of the 51st Annual Meeting of the Human Factors and Ergonomics Society, Baltimore, MD, pp. 1268-1271, 2007.

Caldwell, B. S., Team-Based Coordination of Event Detection and Task Management in Time-Critical Settings (with Sandra K. Garrett), 8th International Conference on Naturalistic Decision Making, Pacific Grove, CA (2007).

WILLIAM A. CROSSLEY
1995
Associate Professor

Degrees

B.S.E. University of Michigan, Aerospace Engineering, 1990
M. S. Arizona State University, Aerospace Engineering, 1992
Ph.D. Arizona State University, Aerospace Engineering, 1995

Interests

Optimization
Rotorcraft and aircraft design
Structure design

Research Areas

Professor Crossley's major research interests are in the area of design methodologies and optimization, with emphasis on techniques like the GA that will allow optimization-like methods to be applied in the conceptual design phase, which traditionally has been dominated by qualitative or subjective decision making. Significant contributions have been made in applications to discrete actuator placement, topology design, and satellite constellation design.

Sponsored Research Summaries

Topology Design of Rotor Blades for Aerodynamic and Structural Concerns. This computational research effort strives to develop a rotor blade design strategy with the potential to improve the aerodynamic, structural, and dynamic performance of advanced rotorcraft. This work investigates the Genetic Algorithm (GA) as a means to combine aerodynamic and structural concerns for topology design of rotor blades. Inverse airfoil design and optimal airfoil design are receiving much attention in both industry and academia; the same holds true for structural optimization. The combination of the two concerns for topology design has not been fully addressed. A multi-disciplinary approach combining structural and aerodynamic concerns for optimal topology design of rotor blades provides potential benefit to the rotorcraft design process. The aerodynamic optimization portion of this research was cited in the technical research highlights of the NASA Ames Research Center, Rotor Aeromechanics Branch for 1999. Contributions in the structural portion of the research have demonstrated capabilities for discrete (on/off) topology; most notably handing connectivity issues and performing design of sections under combinations of bending and torsion that several authors had previously claimed were not possible.

Genetic Algorithm Issues for Optimal Smart Actuator Placement. This research is investigating approaches for smart actuator placement to provide aircraft maneuverability without requiring hinged flaps or other control surfaces. The effort supports many of the goals of the Multidisciplinary Design Optimization focus efforts in NASA's Aircraft Morphing program. Computational studies are being conducted to allow comparison and selection of appropriate techniques for posing and solving an actuator placement problem. The work began with a geometrically simple wing model, but the approaches identified during this research have been applied to complete aircraft configurations. The problem statement and algorithm application are being used at NASA Langley by researchers working on the Aircraft Morphing

Program. Research in this area has been cited twice as technical highlights for the NASA Langley Multidisciplinary Optimization Branch; once in 1998 and again in 1999.

Improved Satellite Constellation Design and Optimization. Improving satellite constellation design is of great interest to any users of satellite communication (e.g. cellular phones, television), location (e.g. global positioning system) and/or observation (e.g. weather). Many of today's satellite constellation designs rely on the "Walker Constellations," a series of designs developed in 1970, which have rarely been improved upon. These constellations make use of symmetric constellations with circular orbits. Using the genetic algorithm to search the constellation design space has begun to yield constellation designs not previously envisioned but with performance equal to or greater than comparable Walker or "streets of coverage" constellations. Research is ongoing for sparse coverage constellations, constellation build-up problems, multiobjective constellation concerns and elliptic orbit constellations. The Aerospace Corporation performs satellite constellation design for its US Air Force customers using the design techniques developed as part of this research. In one of these studies, a multiobjective GA approach was able to generate constellation designs that outperformed constellations that had been under development for several months. The GA was able to do this in a matter of days.

Development of a Genetic Algorithm for Conceptual Design of Aircraft. Air vehicle conceptual design appears to be a promising area for application of the genetic algorithm as an approach to help automate part of the design process. Because the GA-based approach to conceptual design helps to reduce the number of qualitative decisions needed from the design team, this appears to have great potential for application to aircraft design. Work has been extensively conducted for helicopters, some additional work has been conducted for high-speed VTOL rotorcraft (e.g. tilt-rotor and tilt-wing aircraft), and work is currently underway for fixed-wing aircraft. The Systems Analysis Branch at NASA Langley Research Center supports this research.

Methods to Assess Commercial Aircraft Technologies. Increasing competition in the commercial aircraft industry requires that airframe manufacturers be judicious with technology research and development efforts. Currently, technology development strategies for commercial aircraft appear to be lacking; this research presents a methodology to assess new technologies in terms of both cost and performance. This methodology encompasses technologies that can be applied to the aircraft design and technologies that improve the development, manufacturing, and testing of the aircraft. This differs from past studies that focused upon a small number of performance-based technologies. The method is divided into two phases. The first phase evaluates technologies based on cost measures alone. The second phase redesigns an aircraft with new technologies, assesses the relative importance of performance-based technologies, and recognizes technology interactions using Taguchi's Design of Experiments. For a wide-body transport aircraft example, the methodology identifies promising technologies for further study. Recommendations and conclusions about the methodology are made based on the results. This work was done in collaboration with the Configuration Engineering and Analysis group at Boeing Commercial Aircraft.

Response Surface Methods as Approximation Models for Optimization. Approximation techniques, particularly the use of response surfaces (RS), have achieved wide popularity in engineering design optimization, especially for problems with computationally expensive analyses. The chief aims of using RS is to lower the cost of optimization and to smooth out the problem (e.g., for analyses solved iteratively, with a convergence tolerance). In one part of this

research effort, an investigation of RS methods to minimize drag of a turbofan nacelle is being pursued in conjunction with engineers at Allison Advanced Development Company. This approach can improve the nacelle design practices at AADC by providing a formalized optimization framework for this CFD-based design exercise. The use of RS raises practical questions about the solution accuracy and computational expense. In particular, building response surfaces may involve a prohibitively large number of high-fidelity function evaluations, depending on problem dimensionality. In another part of this research effort, a computational study to address questions of expense and accuracy was undertaken with researchers in the Multidisciplinary Optimization Branch at NASA Langley Research Center. Important observations about the impact of constructing and using response surfaces for moderately high-dimensional problems were made. NASA researchers are using the RS models constructed during this portion of the research to further investigate techniques to manage approximation models in engineering optimization.

Publications

Nusawardhana, A., Zak, S. H., and **Crossley, W. A.**, "Nonlinear Synergetic Optimal Controllers," *Journal of Guidance, Control, and Dynamics*, Vol. 30, No. 4, July-Aug. 2007, pp. 1134-1147.

Mane, M., and **Crossley, W. A.**, Nusawardhana, A., "System of Systems Inspired Aircraft Sizing and Airline Resource Allocation via Decomposition," *Journal of Aircraft*, Vol. 44, No. 4, July-Aug. 2007, pp. 1222-1235.

Namgoong, H., **Crossley, W. A.**, Lyrintizis, A. S., "Aerodynamic Optimization of a Morphing Airfoil using Energy as an Objective," *AIAA Journal*, Vol. 45, No. 9, 2007, pp. 2113-2124.

Hassan, R. A., and **Crossley, W. A.**, "Approach to Discrete Optimization Under Uncertainty: The Population-Based Sampling Genetic Algorithm," *AIAA Journal*, Vol. 45, No. 11, 2007, pp. 2799-2809.

Conference Proceedings, Presentations, Invited Lectures

Namgoong, H., **Crossley, W.**, and **Lyrintzis, A.,** "Aerodynamic Optimization of a Morphing Airfoil Using Energy as an Objective," AIAA Paper 2006-1324, AIAA 44th Aerospace Sciences Meeting, Reno, NV, Jan. 9-12. 2006.

Nusawardhana, and **Crossley, W.**, "NeuroDynamic Programming Approaches for Problems of Combined System- Design and Its Operational Management," AIAA Paper 2006-1914, 2nd AIAA Multidisciplinary Design Optimization Specialist Conference, Newport, RI, May 1-4, 2006.

Namgoong, H., **Crossley, W.**, and **Lyrintizis, A.**, "Morphing Airfoil Design for Minimum Aerodynamic Drag and Actuation Energy Including Aerodynamic Work," AIAA Paper 2006-2041, 14th AIAA/ASME/AHS Adaptive Structures Conference, Newport, RI, May 1-4, 2006.

Skillen, M., and **Crossley, W.**, "Developing Morphing Wing Weight Predictors with Emphasis on the Actuating Mechanism," AIAA Paper 2006-2042, 14th AIAA/ASME/AHS Adaptive Structures Conference, Newport, RI, May 1-4, 2006.

Crossley, W. A., and **DeLaurentis, D. A.**, "Methods for Designing, Planning and Operating Systems of Systems," proceedings of an AFOSR-sponsored workshop, June 2006.

Crossley, W. A., "Systems of Systems: A perspective on the academic research agenda," invited presentation and panelist, Academic Forum, 16th INCOSE Annual International Symposium, Orlando, FL, July 10, 2006.

Nusawardhana and **Crossley, W.**, "On Synergetic Extremal Control for Aerospace Applications," AIAA Paper 2006-6359, AIAA Guidance, Navigation, and Control Conference and Exhibit, Keystone, CO, Aug. 21-24, 2006.

Frommer, J., and **Crossley, W.**, "Building Surrogate Models for Capability-Based Evaluation: Comparing Morphing and Fixed Geometry Aircraft in a Fleet Context," AIAA Paper 2006-7700, 6th AIAA Aviation Technology, Integration and Operations Conference (ATIO), Wichita, KS, Sep. 25-27, 2006.

Mane. M., and **Crossley, W.**, "Preliminary Cost Feasibility Study of Air Taxi Operations," AIAA Paper 2006-7734, 6th AIAA Aviation Technology, Integration and Operations Conference (ATIO), Wichita, KS, Sep. 25-27, 2006.

Skillen, M., and **Crossley, W.**, "Modeling and Optimization for Morphing Wing Concept Generation," NASA/CR-2007-214860, Mar. 2007.

Nusawardhana, and **Crossley, W.**, "A Theoretical Framework of Vehicle Design for Multi-Modal Dynamic System-of-Systems," AIAA Paper 2007-2944, AIAA Infotech@Aerospace 2007 Conference and Exhibit, Rohnert Park, CA, May 7-10, 2007.

Crossley, W. A., "System-of-Systems Inspired Optimization Problems: Experiments in Formulation and Solution," Research Consortium for Multidisciplinary System Design: Second Annual Workshop, Stanford, CA, July 12, 2007.

Mane, M. and **Crossley, W.**, "Probabilistic Approach for Selection of Maintenance Facilities for Air Taxi Operations," AIAA-2007-7786, 7th AIAA Aviation Technology, Integration and Operations Conference, Belfast, Northern Ireland, UK, Sep. 18-20, 2007.

Mane, M. and **Crossley, W.**, "An Approach to Predict Impact of Demand Acceptance on Air Taxi Operations," AIAA Paper 2007- 7787, 7th AIAA Aviation Technology, Integration and Operations Conference, Belfast, Northern Ireland, UK, Sep. 18-20, 2007.

Crossley, W. A., "Systems of Systems Inspired Optimization Problems: Updates and Recent Progress," invited presentation to the Math and Computational Technologies group, Boeing Phantom Works, Bellevue, WA, Nov. 8, 2007.

Frommer, J., and **Crossley, W.**, "Aircraft Sizing and Allocation as a System-Of-Systems Problem via Surrogates and Multiobjective Design," INFORMS Annual Meeting, Seattle, WA, Nov. 4-7, 2007.

Mane, M., and **Crossley, W.**, "Allocation of Variable Resources as a System of Systems Problem," INFORMS Annual Meeting, Seattle, WA, Nov. 4-7, 2007.

Skillen, M., and **Crossley, W.**, "Modeling and Optimization for Morphing Wing Concept Generation, Part I: Morphing Wing Modeling and Structural Sizing Techniques," NASA/CR-2007-214902, Dec. 2007.

Skillen, M., and **Crossley, W.**, "Modeling and Optimization for Morphing Wing Concept Generation, Part II: Morphing Aircraft Sizing Via Multi-Level Optimization," NASA/CR-2007-214903, Dec. 2007.

DANIEL DELAURENTIS
2004
Assistant Professor

Degrees

B.S., Florida Institute of Technology, Aerospace Engineering, June 1992.
M.S., Georgia Institute of Technology, Aerospace Engineering, August 1993.
Ph.D., Georgia Institute of Technology, Aerospace Engineering, December, 1998.

Research Interests

Design Methods:

1. Mathematical modeling and object-oriented frameworks for the design of system-of-systems, especially those for which air vehicles are a main element (transportation and mobility networks, uninhabited air vehicle networks, etc.)
2. Approaches for robust design, including robust control analogies and uncertainty modeling/management in multidisciplinary design

Aerospace Systems and Flight Vehicles:

1. Sizing/Synthesis algorithms for design & performance estimation of revolutionary flight vehicles
2. Exploration of Personal Air Vehicle designs and concept of operations
3. Aircraft flight stability and control, especially as an integral part of conceptual design

Publications

Lewe, J. H., **DeLaurentis, D. A.**, Mavris, D., Schrage, D. P., "Entity-centric Abstraction and Modeling Framework for Transportation Architectures," *Journal of Air Transportation*, Vol. 11, No. 3, 2006. [received the Sorenson Best Paper Award, 2006-2007]

Utterwar, A., Rallabhandi, S., **DeLaurentis, D. A.**, Mavris, D., "A Two-Step Optimization Approach for Technology Selection," *Engineering Optimization*, Vol. 38, No. 8, Dec. 2006, pp. 889-908.

DeLaurentis, D., Dickerson, C., DiMario, M., Gartz, P., Jamshidi, M., Nahavandi, S., Sage, A., Sloane, E., and Walker, D.," A Case for an International Consortium on System of Systems Engineering," *IEEE Systems Journal,* Vol. 1, No. 1, Sept. 2007, pp. 68-73.

Conference Proceedings, Presentations, Invited Lectures

DeLaurentis, D., "Understanding Transportation as a System-of-Systems Design Problem," AIAA Paper 2005-0123, 43rd AIAA Aerospace Sciences Meeting and Exhibit, Reno, NV, January 10-13, 2005.

DeLaurentis, D., "System-of-Systems Panel," CEIAT 1st International Conference on Innovation and Integration in Aerospace Sciences, Belfast, Northern Ireland, August, 2005. **(invited panelist)**

DeLaurentis, D., Crossley, W., "A Taxonomy-based Perspective for Systems of Systems Design Methods," Paper 0-7803-9298-1/05, Proceedings of IEEE System, Man, & Cybernetics Conference, Hawaii, Oct. 10-12, 2005.

DeLaurentis, D., and Han, E., "System-of-Systems Simulation for Analyzing the Evolution of Air Transportation," 25th International Council on the Aeronautical Sciences (ICAS) Congress, Hamburg, Germany, Sep. 3-8, 2006.

DeLaurentis, D., and Han, E., "A Network Theory-Based Approach for Modeling System-of-Systems," AIAA Paper 2006-6989, 11th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference, Portsmouth, VA, Sep. 6-7, 2006.

DeLaurentis, D., and Kotegawa, T., "Establishment of a Network-based Simulation of Future Air Transportation Concepts," AIAA Paper 2006-7719, 6th AIAA Aviation Technology, Integration and Operations Conference (ATIO), Wichita, KS, Sep. 25-27, 2006.

DeLaurentis, D., and Sindiy, O., "Developing Sustainable Space Exploration via System of Systems Approach," AIAA Paper 2006-7248, AIAA Space 2006, San José, CA, Sep. 19-21, 2006.

DeLaurentis, D., and Sindiy, O., "Improved Decision Support in Space Exploration via System-of-System Analysis," Proceedings of the 2007 IEEE International Conference on System of Systems Engineering, San Antonio, Texas, 16–18 April 2007; proceedings on CD-ROM: paper no. 96.

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Polzer, H., **DeLaurentis, D.**, Fry, D., "Multiplicity of Perspectives, Context Scope, and Context Shifting Events," Proceedings of the 2007 IEEE International Conference on System of Systems Engineering, San Antonio, TX, 16–18 April 2007; proceedings on CD-ROM: paper no. 68.

Vander Schaaf, R., **DeLaurentis, D.**, and Abraham, D., "Effective Decision-Making for DoD Humanitarian Infrastructure Projects using Agent-based Modeling", Proceedings of the 2007 IEEE International Conference on System of Systems Engineering, San Antonio, TX, 16–18 April 2007; proceedings on CD-ROM: paper no. 73.

Peeta, S., Paz, A., **DeLaurentis, D.**, "Stated-Preference Analysis of New Microjet On-Demand Air Service," Paper 07-1100, 2007 Transportation Research Board Annual Meeting, Washington, D.C., 2007.

Sindiy, O., and **DeLaurentis, D.**, "Exploration of a Solar System Mobility Network via a System-of-Systems Engineering Framework," AIAA Paper 2007-6527, AIAA Space 2007, 18-20 September 2007.

Kotegawa, T., and **DeLaurentis, D.**, "Evolution of Service Provider Behaviors via Network-Based Analysis," AIAA Paper 2007-7755, 7th AIAA ATIO Conference, Belfast, Northern Ireland, 18-20 September 2007.

INSEOK HWANG
2004
Assistant Professor

Degrees

B. S., Seoul National University, Seoul, Korea, Aerospace Engineering, 1992.

M. S., Korea Advanced Institute of Science and Technology (KAIST), Taejeon, Korea, Aerospace Engineering, 1994.

Ph.D., Stanford University, Aeronautics and Astronautics, 2004

Research Interests

Hybrid Systems/Nonlinear Systems

Applications to Air Traffic Control

Other applications

Publications

Hwang, I., Balakrishnan, H., and Tomlin, C., "State Estimation for Hybrid Systems: Applications to Aircraft Tracking," *IEE Proceedings of Control Theory and Applications*, Vol. 153, No. 5, September 2006, pp. 556-566.

Seah, C.-E., and **Hwang, I.**, "Hybrid Estimation for Stochastic Piecewise Linear Systems," In *Hybrid Systems: Computation and Control, Lecture Notes in Computer Science*, Springer, 2007.

Hwang, I., Balakrishnan, H.**,** Roy, K., and Tomlin, C., "Multiple-Target Tracking and Identity Management Algorithm with Application to Aircraft Tracking," *AIAA Journal of Guidance, Control and Dynamics*, Vol. 30, No. 3, 2007, pp. 641-653,.

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Yepes, J. L., **Hwang, I.**, and Rotea, M., "Algorithms for Aircraft Intent Inference and Trajectory Prediction," *AIAA Journal of Guidance, Control and Dynamics*, Vol. 30, No. 2, pp. 370-382, March-April 2007.

Conference Proceedings, Presentations, Invited Lectures, Reports

Hwang, I., "Pilot's Intent Inference and Aircraft Trajectory Prediction with Applications to Air Traffic Control," Coordinated Science Laboratory, University of Illinois at Urbana-Champaign, IL, April 2006.

Hwang, I., "Hybrid Systems Approach for Complex Networked Systems with Application to Air Traffic Control, AFOSR System-of-Systems Workshop, Indianapolis, IN, May 2006.

Hwang, I., "Hybrid Systems Approach for Complex Networked Systems," Raytheon, Fort Wayne, IN, June 2006.

Seah, C.-E., and **Hwang, I.**, "Hybrid Estimation Algorithm using State-Dependent Mode Transition Matrix for Aircraft Tracking," Proceedings of the AIAA Guidance, Navigation, and Control Conference, Keystone, CO, August 2006.

Seah, C.-E., and **Hwang, I.**, "Target Tracking of Arrival Aircraft using Hybrid Estimation," Proceedings of the 44th Allerton Conference on Communication, Control, and Computing, Monticello, IL, September 2006.

Seah, C.-E., and **Hwang, I.**, "An Estimation Algorithm for Stochastic Linear Hybrid Systems with Continuous-State-Dependent Mode Transition," Proceedings of the 45th IEEE Conference on Decision and Control, San Diego, CA, December 2006.

Lee, K. D., Lee, S. W., Wie, B., Yeom, C. H., and Seah, C.-E., and **Hwang, I.**, "Aerospace Research and Development Trend Study," Technical Report as a part of the Project: Overseas Science and Technology Policy, Organization, and Trends, Korea Federation of Science and Technology, December 2006.

Li, J., Du, D., and **Hwang, I.**, "A Differential Transform Based Computational Method for Switched Linear Quadratic Optimal Control," 46th IEEE Conference on Decision on Control, New Orleans, LA, 2007.

Du, D., Li, J., and **Hwang, I.**, "A Computational Method for Optimal Control of Hybrid Systems using Differential Transformation," 46th IEEE Conference on Decision and Control, New Orleans, LA, 2007.

Hwang, I., "Hybrid Estimation and Information Inference and its Application to Large-scale Networked Systems," Department of Aerospace Engineering, Ohio State University, Columbus, OH, May 2007.

Seah, C.-E., and **Hwang, I.**, "A Hybrid Estimation Algorithm for Terminal Aircraft Tracking," AIAA Guidance, Navigation, and Control Conference, Hilton Head, SC, August 2007.

Du, D., and **Hwang, I.**, "A Computational Approach to Solving Optimal Control Problems Using Differential Transformation," AACC American Control Conference, New York, NY, July 2007.

Hwang, I., "An Plane Matching Algorithm for Accurate UAV Navigation Using Laser Range Finders in GPS-Latent Urban Environments," UKC Aerospace Science and Technology Symposium, Washington D.C., August 2007

Hwang, I., and Goppert, J., "Information Inference and Control of Complex Networked Systems: Application to Aerospace Systems," ATAIN Conference, September 2007.

Hwang, I., "Hybrid Estimation and Intent Based Probabilistic Conflict Detection for the Next Generation Air Transportation System (NextGen)," Dept. of Aerospace & Mechanical Engineering, University of Notre Dame, Notre Dame, IN, November 2007.

JOHN P. SULLIVAN
1975
Professor

Degrees

B. S., University of Rochester, Mechanical & Aerospace Sciences (with honors), 1967
M. S., Massachusetts Institute of Technology, Aeronautical Engineering, 1969
Sc.D., Massachusetts Institute of Technology, Aeronautical Engineering, 1973

Interests

Experimental aerodynamics
Laser instrumentation
Luminescent sensors for temperature and pressure measurements

Research Areas

Current research interest is in the area of experimental aerodynamics with particular emphasis on comparison of experimental data with computational analysis. Current programs include:

1. High lift systems
2. Suction/blowing airfoils

In addition to the above programs, work also continues on developing laser instrumentation (laser Doppler velocimeter, particle image velocimeter, laser sheet concentration, etc.) and pressure and temperature paint for:

1. Wind tunnels - low speed to hypersonic
2. Gas turbine engines
3. Flight tests

Publications

Gregory J. W., **Sullivan J. P.**, Wanis S. S., and Komerath N. M., "Pressure-sensitive Paint as a Distributed Optical Microphone Array," *Journal of the Acoustical Society of America,* Vol. 119, No. 1, 2006, pp. 251-261.

Gregory, J. W., and **Sullivan, J. P.**, "Effect of Quenching Kinetics on Unsteady Response of Pressure-Sensitive Paint," *AIAA Journal*, Vol. 44, No. 3, March 2006, pp. 634-645.

Crafton, J., Carter, C., **Sullivan J. P., and** Elliott, G., "Pressure Measurements on the Impingement Surface of Sonic and Sub-sonic Jets Impinging onto a Flat Plate at Inclined Angles," *Experiments in Fluids*, Vol. 40, No. 5, May 2006, pp. 697-707.

Gregory, J. W., **Sullivan, J. P.**, Raman, G., and Raghu, S., "Characterization of the Micro Fluidic Oscillator," *AIAA Journal*, Vol. 45, No. 3, 2007, pp. 568-576.

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Huang, C., Lee, S., **Sullivan, J. P.**, "In Situ Measurement of Fluid Film Thickness in Machining," *Tribology Letters*, Vol. 28, No. 1, 2007, pp. 39-44.

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Conference Proceedings, Presentations, Invited Lectures

Crafton, J., Fonov, S., Goss, L., Jones, E., Gnanimanickam, E., and **Sullivan, J. P.**, "Validation of an Image-Based Skin friction Sensor in a Fully Developed Channel Flow," AIAA Paper 2006-3839, 25th AIAA Aerodynamic Measurement Technology and Ground Testing Conference, San Francisco, CA, June 5-8, 2006.

Huang, C., Gregory, J. W., **Sullivan, J. P.**, Nagai, H., and Asai, K., "Molecular Sensors in Microturbine Measurement," IMECE Paper 2006-13814, Proceedings of IMECE2006, ASME International Mechanical Engineering Congress and Exposition, Chicago, IL, November 5-10, 2006.

Miller, C., **Sullivan, J. P.**, and McDonald, S., "High Altitude Airship Simulation Control and Low Altitude Flight Demonstration," AIAA Paper 2007-2766, AIAA Infotech@Aerospace 2007 Conference and Exhibit, Rohnert Park, CA, May 7-10, 2007.

Huang, C., Lee, S., Hwang, J., **Sullivan, J. P.** and Chandrasekar, S., "Micro-Scale Characterization of Fluid Action in Machining," 10th CIRP International Workshop Modeling of Machining Operations, Reggio Calabria, Italy, 2007.

Murthy, T. G., Huang, C., Chandrasekar, S., **Sullivan, J. P.**, "Direct Observation of Deformation Field in Plane Strain Indentation," Proceedings of the SEM Annual Conference and Exposition on Experimental and Applied Mechanics 2007, Vol. 2, 2007, pp. 817-823.

Gnanimanickam, E. P., Lee, S., **Sullivan, J. P.**, Chandrasekar, S., "Direct Measurement of Large-Strain Deformation Field in Machining," Proceedings of the SEM Annual Conference and Exposition on Experimental and Applied Mechanics 2007, Vol. 2, 2007, pp. 1080-1087.

TERRENCE A.WEISSHAAR
1980
Professor

Degrees

B. S., Northwestern University, Mechanical Engineering, (highest distinction), 1965
M. S., Massachusetts Institute of Technology, Aeronautics & Astronautics, 1966
Ph.D., Stanford University, Aeronautics & Astronautics, 1971

Interests

Aircraft structural mechanics
Aeroelasticity
Integrated Design

Research Areas

Primary research areas include optimization of structural concepts for smart aeroelastic structures and efficient multidisciplinary design. Currently, two primary areas are of interest:

- *Aeroelastic tailoring and active flexible wings.* This includes using conventional articulated surfaces such as ailerons and leading edge devices for roll control, as well as using smart materials to change the camber of advanced wing concepts for aircraft control. Objectives also include aeroelastic design for reduced drag and optimization of smart wing flutter suppression systems for micro-air vehicles. We are also developing innovative techniques with advanced composite structure design to find optimal designs and reduce time to develop new concepts.
- *Design methodology – developing new methods and algorithms to improve the ability of a design team to generate innovative, creative concepts for aerospace vehicles.* This includes examining how the external aerodynamic and internal structural topology of lifting surfaces can be addressed simultaneously in the design process. This also includes introducing manufacturing concerns and decisions early in the design process and creating, through the early use of finite element models, more feed-forward/feed-back paths.

  We have been examining how to use new modeling software to generate and present accurate, useful information to designers by displaying load paths and theoretically optimal designs. This leads to an improved conceptual design process for airplane structures that begins with a few participants and quickly proceeds to a high level with diverse technical groups represented. We are involved in the creation of an object-oriented system, using Adaptive Modeling Language (AML), to provide a natural, integrated, virtual environment for modeling, linking and simulating the aircraft design process from its earliest conceptual phase into preliminary design. When completed, this system will allow an integrated product team access to a virtual environment that scientifically simulates the iterative, collaborative process required to design an airplane in a short amount of time.

Publications

Weisshaar, T. A., and Duke, D. K., "Induced Drag Reduction using Aeroelastic Tailoring with Adaptive Control Surfaces," *Journal of Aircraft*, Vol. 43, No. 1, 2006, pp. 157-164.

Taylor, R. M., **Weisshaar, T. A.**, and Sarukhanov, V., "Structural Design Process Improvement using Evolutionary Finite Element Methods," *Journal of Aircraft*, Vol. 43, No. 1, 2006, pp. 172-181.

Conference Proceedings, Presentations, Invited Lectures

Lee, D., and **Weisshaar, T. A.**, "Aeroelastic Studies on a Folding Wing Configuration," 46th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference & 13th AIAA/ASME/AHS Adaptive Structures Conference, Austin, TX, April 2005.

Weisshaar, T. A., "Critical Technologies for Shape Changing Aircraft," Keynote talk, 46th AIAA Structural Dynamics and Materials Conference, Structural Dynamics and Materials Lecture, Austin, TX, April 2005.

Weisshaar, T. A., "Morphing Aircraft Systems," AIAA 5th Aviation Technology, Integration and Operations (ATIO) Forum, Arlington, VA, November 2005.

Weisshaar, T. A., "Changing Shape and Shaping Change in Aeronautical Structures," RPI Distinguished Lecture Series, Rensselaer Polytechnic Institute, Troy, NY, April 2006.

Weisshaar, T. A., "Shaping the Change and Changing the Shape of Aeronautical Structures and Materials," SDM Keynote Lecture, 47th AIAA Structural Dynamics and Materials Conference, Structural Dynamics and Materials Lecture, Newport, RI, May 2006.

Weisshaar, T. A. and Sanders, B., "Morphing Wing Technology," NATO RTO conference on Advanced Flight Concepts, Vilnius, Lithuania, October 2006.

Ivanco, T. G., Scott, R. C., Love, M. H., Zink, S., **Weisshaar, T. A.**, "Validation of the Lockheed Martin Morphing Concept with Wind Tunnel Testing," 48th AIAA/ASME/ ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, Waikiki, HI, April 2007.

Bowman, J., Sanders, B., Cannon, J., Kudva, J., Joshi, S., **Weisshaar, T. A.**, "Development of Next Generation Morphing Aircraft Structures," 48th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, Waikiki, HI, April 2007.

Weisshaar, T. A., "Future Flight Structures," *AFOSR Flight Structures Workshop*, Arlington, VA, 15-16 October 2007.

Astrodynamics and Space Applications

Faculty Members

J. L. Garrison, Associate Professor of Aeronautics and Astronautics, Associate Professor of Electrical and Computer Engineering (by courtesy), Ph.D., University of Colorado, 1997, satellite navigation, GPS, and remote sensing

K. C. Howell, Hsu Lo Professor of Aeronautical and Astronautical Engineering, Ph.D., Stanford, 1983, orbit mechanics, spacecraft dynamics, control, and trajectory optimization

J. M. Longuski, Professor, Ph.D., Michigan, 1979, spacecraft dynamics, orbit mechanics, control, orbit decay and reentry

JAMES L. GARRISON
Associate Professor
2000

Degrees

B.S. Rensselaer Polytechnic Institute, Aeronautical Engineering, 1988
M.S. Stanford University, Aeronautics and Astronautics 1990
Ph.D. The University of Colorado, Aerospace Engineering Sciences, 1997

Interests

Satellite navigation
GPS
Remote sensing

Awards and Major Appointments

Institute of Navigation, Early Achievement Award, June 2002.

Publications

You, H., **Garrison, J. L.**, Heckler, G., and Smajlovic, D., "The Autocorrelation of Waveforms Generated from Ocean-Scattered GPS Signals," *IEEE Geoscience and Remote Sensing Letters*, Vol. 3, No. 1, January 2006.

You, H., **Garrison, J. L.**, Heckler, G., and Smajlovic, D., "The Autocorrelation of Delay-Doppler Waveforms Generated from Ocean-Scattered GPS Signals," *IEEE Geoscience and Remote Sensing Letters*, Vol. 3, No. 1, January 2006, pp. 78-82.

Garrison, J. L., and Eichel, B.E., "An Extended Propagation Ephemeris for GNSS," *Navigation*, Vol. 53, No. 3, Fall 2006, pp. 167-180.

Heckler, G., and **Garrison, J.L.**, "GPS Toolbox: SIMD Correlator Library for GNSS Software Receivers," *GPS Solutions*, Vol. 10, No. 4, November 2006, pp. 269-276.

Dautermann, T., Calais, E., Haase, J, and **Garrison, J. L.**, "Investigation of Ionospheric Electron Content Variations Before Earthquakes in Southern California, 2003-2004," *Journal of Geophysical Research - Solid Earth*, Vol. 112, 2007, pp. B02106, doi:10.1029/2006JB004447.

Garrison, J. L., Lee, S. G., Haase, J. S., and Calais, E., "A method for detecting ionospheric disturbances and estimating their propagation speed and direction using a large GPS network," *Radio Sci.*, Vol. 42, 2007, pp. RS6011, doi:10.1029/2007RS003657.

Conference Proceedings, Presentations, Invited Lectures

Ventre, B. D., **Garrison, J. L.**, Boehme, M., and Haase, J. S., "Implementation and testing of open-loop tracking for airborne GPS occultation measurements," ION GNSS 2006, Fort Worth, TX, September 26-29, 2006.

Heckler, G. W., and **Garrison, J. L.**, "Experimental Tests of Unaided Weak Signal Acquisition Methods Using a Software Receiver," ION GNSS 2006, Fort Worth, TX, September 26-29, 2006.

Dautermann, T., Calais, E., Haase, J., **Garrison, J. L.**, "Investigation of Ionospheric Electron Content Variations Before Earthquakes in Southern California, 2003-2004," American Geophysical Union Fall Meeting, San Francisco, CA, December 11-15, 2006.

Garrison, J. L., Ventre, B. D., Haase, J., Boehme, M. H., "Development and testing of the GNSS Instrument System for Multistatic and Occultation Sensing (GISMOS) airborne instrument," American Geophysical Union Fall Meeting, San Francisco, CA, December 11-15, 2006.

Lee, S-C., **Garrison, J. L.**, Haase, J., Calais, E., "A Correlation method for detection short-period perturbations in the ionosphere, from a large network of GPS receivers," American Geophysical Union Fall Meeting, San Francisco, CA, December 11-15, 2006.

Parrin, J., and **Garrison, J. L.**, "Application of airborne laser scanner measurements of ocean roughness to the calibration and validation of a satellite bistatic radar experiment," American Geophysical Union Fall Meeting, San Francisco, CA, December 11-15, 2006.

Garrison, J. L., Walker, M., Haase, J., Lulich, T., Xie, F., Ventre, B.D., Boehme, M. H., Wilmhoff, B., and Katzberg, S. J., "Development and testing of the GISMOS instrument," International Geosciences and Remote Sensing Symposium, Barcelona, Spain, July 23-27, 2007.

Garrison, J. L., Parrin, J., "Application of an airborne laser scanner as in-situ verification data for bistatic GNSS measurements," International Geosciences and Remote Sensing Symposium, Barcelona, Spain, July 23-27, 2007.

KATHLEEN C. HOWELL
1982
Hsu Lo Professor of Aeronautical & Astronautical Engineering

Degrees

B. S., Iowa State University, Aerospace Engineering, 1973
M. S., Stanford University, Aeronautical & Astronautical Engineering, 1977
Ph.D., Stanford University, Aeronautical & Astronautical Sciences, 1983

Interests

Orbit mechanics
Spacecraft dynamics, control
Trajectory optimization

Research Areas

In the area of astrodynamics, the complex missions envisioned in the next few decades will demand innovative spacecraft trajectory concepts and efficient design tools for analysis and implementation. In support of such plans, current research efforts focus on spacecraft navigation and maneuver requirements, and mission planning, both in the neighborhood of the Earth and in interplanetary space. Some sample projects are mentioned below.

Much recent research activity has involved libration point orbits in the three- and four-body problems. The *n*-body problem in orbital mechanics generally considers trajectory solutions when (*n*-1) gravity fields are significant. Spacecraft in the vicinity of libration points thus operate in an environment in which gravity forces due to two or three (or more) celestial bodies may result in trajectories that appear as three-dimensional, quasi-periodic Lissajous paths. Such three-dimensional trajectories are of considerable interest in connection with any future lunar operations. In the near term, missions involving libration point satellites are included in a number of programs that the U. S. is planning with international partners. Technical studies involve trajectory design and optimization including optimal control strategies for out-of-plane motion in consideration of communication and other operational specifications. Analyses of station-keeping requirements for such trajectories are also currently under study.

The subject of optimal transfer trajectories is of considerable importance and rapidly growing in complexity as well. New types of problems now facing mission designers render standard optimization strategies inadequate, particularly for application in the *n*-body problem. Nominal transfer trajectory determination and optimization is the focus of an expanding investigation. Various projects range from development of new computational techniques to application of geometric nonlinear dynamical systems theory to these problems.

A related problem of interest involves Earth orbiting vehicles that repeatedly pass close to the Moon. Such trajectories use lunar gravity to effect trajectory changes. Not only can such a swingby aid in minimizing mission fuel requirements, it also creates trajectory options that may otherwise be impossible. Analysis is complicated, however, by the strong solar perturbation. Multi-conic analysis has proven promising and work is continuing to develop tools to make optimal trajectory design efficient and accurate. Design strategies can also be extended to other multi-body systems. Such applications are under considerations as well.

Publications

Howell, K. C., and Kakoi, M., "Transfers between the Earth-Moon and Sun-Earth Systems using Manifolds and Transit Orbits," *Acta Astronautica*, Vol. 59, 2006, pp. 367-380.

Howell, K. C., Beckman, M., Patterson, C., and Folta, D., "Representations of Invariant Manifolds for Applications in Three-Body Systems," *Journal of the Astronautical Sciences,* Vol. 54, No. 1, January-March 2006, pp. 69-93.

Marchand, B., **Howell, K. C.**, and Wilson, R., "An Improved Corrections Process for Constrained Trajectory Design in the *n*-Body Problem," *Journal of Spacecraft and Rockets*, Vol. 44, No. 4, July-August 2007, pp. 884-897.

Conference Proceedings, Presentations, Invited Lectures, Reports

Grebow, D., Ozimek, M., **Howell, K. C.**, and Folta, D., "Multi-Body Orbit Architectures for Lunar South Pole Coverage," AAS/AIAA Space Flight Mechanics Meeting, Tampa, FL, January 2006.

Howell, K. C., "Multi-Body Mission Design and Visualization," University of Missouri at Rolla, Rolla, MS, April 2006.

Howell, K. C., "A Representation of Invariant Manifolds for Trajectory Design," International Conference: New Trends in Astrodynamics and Applications, NASA Headquarters and Princeton University, Department of Astrophysical Sciences, Princeton University, Princeton, NJ, August 16-18, 2006.

Howell, K. C., and Millard, L., "Control of Satellite Imaging Formations in Multi-Body Regimes," Paper No. IAC-06-C1.8.01, IAF 57th International Astronautical Congress, Valencia, Spain, October 2006.

Howell, K. C., "Application of Dynamical Systems Theory, Control Methods, and Optimization Strategies to Trajectory Design and Mission Analysis Involving Formation Flying at Libration Points for GSFC Missions," Final Report NAG5-11839, prepared for NASA Goddard GNCC, 2006.

Millard, L. and **Howell, K. C.**, "Control of Interferometric Satellite Arrays for (u,v) Plane Coverage in Multi-Body Regimes," AAS/AIAA Space Flight Mechanics Meeting, Sedona, AZ, January 2007.

Howell, K. C., Grebow, D., and Olikara, Z., "Design Using Gauss' Perturbing Equations With Applications to Lunar South Pole Coverage," AAS/AIAA Space Flight Mechanics Meeting, Sedona, AZ, January 2007.

Howell, K. C., **Longuski, J. M.**, Craig Davis, D., Patterson, C., Kakoi, M., Chen, J., Okutsu, M., and Yam, C.H., "Encore and End-of-Life Options for the Cassini Spacecraft," Final Report JPL 1283234, prepared for the Jet Propulsion Laboratory, February 2007.

Howell, K. C., "Design Strategies for Libration Point Missions: Theory to Application," 6th International Congress on Industrial and Applied Mathematics, Zurich, Switzerland, July 2007.

Yam, C., Craig Davis, D., **Longuski, J.**, and **Howell, K. C.**, "Saturn Impact Trajectories for Cassini End-of-Life," AAS/AIAA Astrodynamics Specialist Conference, Mackinac Island, Michigan, August 2007.

Craig Davis, D., Patterson, C., and **Howell, K. C.**, "Solar Gravity Perturbations to Facilitate Long-Term Orbits: Application to Cassini," AAS/AIAA Astrodynamics Specialist Conference, Mackinac Island, MI, August 2007.

Patterson, C., Kakoi, M., **Howell, K. C.**, Yam, C., and **Longuski, J.**, "500-year Eccentric Orbits for the Cassini Spacecraft within the Saturnian System," AAS/AIAA Astrodynamics Specialist Conference, Mackinac Island, MI, August 2007.

Ozimek, M., and **Howell, K. C.**, "Low-Thrust Transfers in the Earth-Moon System Including Applications to Libration Point Orbits," AAS/AIAA Astrodynamics Specialist Conference, Mackinac Island, Michigan, August 2007.

Howell, K. C., and Millard, L., "Optimal Reconfiguration Maneuvers for Spacecraft Imaging Arrays in Multi-Body Regimes," IAF 58th International Astronautical Congress, Hyderabad, India, September 2007.

Howell, K. C., "Libration Point Satellites and the Contribution to Spaceflight," Special John V. Breakwell Memorial Lecture, IAF 58th International Astronautical Congress, Hyderabad, India, September 2007.

Howell, K. C., "Investigation of The Vertical Orbits for NASA's Vision for Space Exploration Communications Architecture," Final Report NNG05GM76G, prepared for NASA Goddard Space Flight Center, 2007.

JAMES M. LONGUSKI
1988
Professor

Degrees

B.S.E., The University of Michigan, Aerospace Engineering, cum laude, 1973
M.S.E., The University of Michigan, Aerospace Engineering, 1975
Ph.D., The University of Michigan, Aerospace Engineering, 1979

Interests

Spacecraft Dynamics
Orbit Mechanics
Control
Orbit decay and reentry

Awards and Major Appointments

NOVA (Notable Organizational Value-Added) Award from Jet Propulsion Laboratory

Research Areas

Current research efforts include 1) analytic theory and control of spinning-up and thrusting vehicles, 2) mission design and trajectory design for interplanetary flight, 3) orbit decay and reentry problems, and 4) tethers in space.

In 1) the current goal is to develop a general analytic theory (which provides solutions for angular velocity, the attitude, the angular momentum vector and the translational velocity of rigid and elastic bodies subject to arbitrary body-fixed torques and forces) and to develop control laws based on the analytic theory.

In 2) mission design tools developed at the Jet Propulsion Laboratory have been acquired for research use at Purdue. Both theoretical and computational techniques are being employed to analyze the gravity-assist problem in terms of identifying potential trajectories (such as the Voyager Grand Tour, the Galileo VEEGA, and the Europa Orbiter Tour) and optimizing the launch energy and propellant requirements for these missions.

In 3) analytic solutions have been obtained for the probability of immediate reentry and of orbit decay, as well as escape, in the event of misdirected interplanetary injection maneuvers occurring at low earth orbit. The solutions have relevance to safety issues involving nuclear power plants aboard deep space probes.

In 4) the feasibility of using tethers for aerobraking has been demonstrated. The basic idea is to connect an orbiter and a probe together by a long tether, for missions to planets with atmospheres. The probe enters the atmosphere and is used to reduce the hyperbolic speed of the orbiter to capture speed, thus eliminating the large retro maneuver normally required. New issues being addressed include analysis of the flexible tether, tether guidance and control, and spacecraft (endpoint) attitude control.

Book

Longuski, J. M., The Seven Secrets of How to Think Like a Rocket Scientist, Springer, New York, 2007.

Publications

McConaghy, T. T., Landau, D.F., Yam, C.H., and **Longuski, J. M.**, "Notable Two-Synodic-Period Earth–Mars Cycler," *Journal of Spacecraft and Rockets*, Vol. 43, No. 2, March-April, 2006, pp. 456-465.

Landau, D.F., and **Longuski, J. M.**, "Trajectories for Human Missions to Mars, Part I: Impulsive Transfers," *Journal of Spacecraft and Rockets*, Vol. 43, No. 5, September-October, 2006, pp. 1035-1042.

Landau, D.F., and **Longuski, J. M.**, "Trajectories for Human Missions to Mars, Part II: Low-Thrust Transfers," *Journal of Spacecraft and Rockets*, Vol. 43, No. 5, September-October, 2006, pp. 1043-1047. Landau, D. F., **Longuski, J. M.**, and Aldrin, Buzz, "Continuous Mars Habitation with a Limited Number of Cycler Vehicles," *Journal of the British Interplanetary Society*, Vol. 60, No. 4, April 2007, pp. 122-128.

Landau, D. F. and **Longuski, J. M.**, "Guidance Strategy for Hyperbolic Rendezvous," *Journal of Guidance, Control, and Dynamics*, Vol. 30, No. 4, 2007, pp. 1209-1213.

Landau, D. F. and **Longuski, J. M.**, "Human Exploration of Mars via Earth-Mars Semicyclers," *Journal of Spacecraft and Rockets*, Vol. 44, No. 1, 2007, pp. 203-210.

Ayoubi, M. A. and **Longuski, J. M.**, "Axial Velocity Solution for Spinning-Up Rigid Bodies Subject to Constant Forces," *Journal of Guidance, Control, and Dynamics*, Vol. 30, No. 6, 2007, pp. 1610-1618.

Conference Proceedings, Presentations, Invited Lectures, Reports

Medlock, K.L. Gates and **Longuski, J. M.**, "A Dual-Use Ballute for Aerocapture and Descent During Planetary Missions," Prepared for Marshall Space Flight Center, Huntsville, AL, MSFC Contract Number NNM05AA22G, January 2006, 26 pages.

Smith, Tracey and **Longuski, J. M.**, "Optimal Atmospheric Trajectories for Aerogravity Assist Interplanetary Missions," Prepared for Daniel T. Lyons, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, April 2006, 75 pages.

Medlock, K.L. Gates and **Longuski, J. M.**, "An Approach to Sizing a Dual-Use Ballute System for Aerocapture, Descent and Landing," 4th International Planetary Probe Workshop, Pasadena, CA, June 27-30, 2006.

Henning, Greg and **Longuski, J. M.**, "Aerogravity Assist Optimization," Prepared by Daniel T. Lyons, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, August 2006, 33 pages.

Landau, D.F., and **Longuski, J. M.**, "Continuous Mars Habitation with a Limited Number of Cycler Vehicles," AIAA Paper 2006-6020, AIAA/AAS Astrodynamics Specialist Conference, Keystone, CO, August 21-24, 2006.

Chen, K., Okutsu, M., Landau, D., and **Longuski, J. M.**, "Low-Thrust Aldrin Cycler with Reduced Encounter Velocities," AIAA Paper 2006-6021, AIAA/AAS Astrodynamics Specialist Conference, Keystone, CO, August 21-24, 2006.

Medlock, K.L. Gates, Ayoubi, M.A., **Longuski, J. M.**, and Lyons, D.T., "Analytic Solutions for Aerocapture, Descent, and Landing Trajectories for Dual-Use Ballute Systems," AIAA Paper 2006-6026, AIAA/AAS Astrodynamics Specialist Conference, Keystone, CO, August 21-24, 2006.

Landau, D.F., and **Longuski, J. M.**, "Guidance Strategy for Hyperbolic Rendezvous," AIAA Paper 2006-6299, AIAA/AAS Astrodynamics Specialist Conference, Keystone, CO, August 21-24, 2006.

Ayoubi, M.A., and **Longuski, J. M.**, "Axial Velocity Solution for a Spinning-Up Rigid Body Subject to Constant Body-Fixed Forces and Moments," AIAA Paper 2006-6655, AIAA/AAS Astrodynamics Specialist Conference, Keystone, CO, August 21-24, 2006.

Yam, C.H., and **Longuski, J. M.**, "Reduced Parameterization for Optimization of Low-Thrust Gravity-Assist Trajectories: Case Studies," Paper No. AIAA 2006-6744, AIAA/AAS Astrodynamics Specialist Conference, Keystone, CO, August 21-24, 2006.

Okutsu, M., Yam, C.H., and **Longuski, J. M.**, "Low-Thrust Trajectories to Jupiter via Gravity Assists from Venus, Earth, and Mars," AIAA Paper 2006-6745, AIAA/AAS Astrodynamics Specialist Conference, Keystone, CO, August 21-24, 2006.

Howell, K. C., **Longuski, J. M.**, Davis, D. C., Patterson, C., Kakoi, M., Chen, J., Okutsu, M., and Yam, C. H., "Encore and End-of-Life Options for the Cassini Spacecraft," Final Report, prepared for the Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, JPL Contract Number 1283234, February 2007, 53 pages.

Gates Medlock, K. L. and **Longuski, J. M.**, "Aerocapture Ballutes for the Exploration of the Solar System," Poster Presentation, 5th International Planetary Probe Workshop, Bordeaux, France, June 25-29, 2007.

Patterson, C., Kakoi, M., **Howell, K. C.**, Yam, C. H., and **Longuski, J. M.**, "500-Year Eccentric Orbits for the Cassini Spacecraft within the Saturn System," AAS Paper 07-256, AAS/AIAA Astrodynamics Specialist Conference Mackinac Island, MI, Aug. 19-23, 2007.

Yam, C. H., Davis, D. C., **Longuski, J. M.**, and **Howell, K. C.**, "Saturn Impact Trajectories for Cassini End-of-Life," AAS Paper 07-257, AAS/AIAA Astrodynamics Specialist Conference, Mackinac Island, MI, Aug. 19-23, 2007.

Okutsu, M., Yam, C. H., and **Longuski, J. M.**, "Cassini End-of-Life Escape Trajectories to the Outer Planets," AAS Paper 07-258, AAS/AIAA Astrodynamics Specialist Conference, Mackinac Island, MI, Aug. 19-23, 2007.

Gates Medlock, K. L., **Alexeenko, A. A.,** and **Longuski, J. M.**, "Trajectory and Aerothermodynamic Analysis of Towed-Ballute Aerocapture Using Direct Simulation Monte Carlo," AAS Paper 07-307, AAS/AIAA Astrodynamics Specialist Conference, Mackinac Island, Michigan, Aug. 19-23, 2007.

Henning, G. A. and **Longuski, J. M.**, "Optimization of Aerogravity-Assist Trajectories for Waveriders," AAS 07-325, AAS/AIAA Astrodynamics Specialist Conference, Mackinac Island, Michigan, Aug. 19-23, 2007.

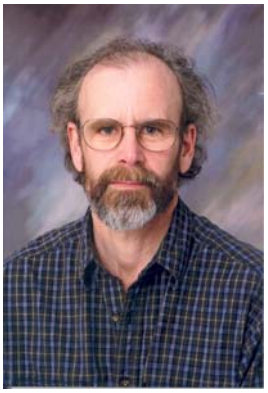
Dynamics and Control

Faculty Members

D. Andrisani II, Associate Professor, Ph.D., SUNY at Buffalo, 1979, estimation, control, and dynamics

M. J. Corless, Professor, Ph.D., Berkeley, 1984, dynamics, systems, and control

D. DeLaurentis, Assistant Professor, Ph.D., Georgia Institute of Technology, 1998, design methods, aerospace systems and flight vehicles, and system-of-systems



A. E. Frazho, Professor, Ph.D., Michigan, 1977, control systems

J. L. Garrison, Associate Professor of Aeronautics and Astronautics, Associate Professor of Electrical and Computer Engineering (by courtesy), Ph.D., University of Colorado, 1997, satellite navigation, GPS, and remote sensing

I. Hwang, Assistant Professor, Ph.D., Stanford, 2004, hybrid system theory, information inference of complex dynamical systems, safety verification, and their application to the control of multiple-vehicle systems, especially air traffic surveillance and control

M. A. Rotea, Professor, Ph.D., Minnesota, 1990, robust and nonlinear multivariable control, optimization, and system identification

DOMINICK ANDRISANI II
1980
Associate Professor

Degrees

B. S., Rensselaer Polytechnic Institute, Aeronautical Engineering, 1970
M. S., State University of New York at Buffalo, Electrical Engineering, 1975
Ph.D., State University of New York at Buffalo, Electrical Engineering, 1979

Interests

Estimation
Control
Dynamics
Flight Aircraft Flying Qualities

Research Areas

Extensive experience in experimental methods in the study of vehicle dynamics and control has focused teaching and research on practical and important aerospace problems in four areas. First is the area of estimation theory, where new estimation algorithms have been developed using the partitioning approach. The second area involves the application of estimation theory to aerospace problems. Here estimation theory has been used to develop a new class of target trackers. These trackers incorporate knowledge of the aerodynamic and thrust vectors to help improve the trackers ability to estimate target acceleration. The third area involves research towards the development of design specifications for helicopter flight control systems, i.e., helicopter flying qualities. The fourth area involves analysis and detection of pilot-in-the-loop oscillations.

Publications

Krozel, J., and **Andrisani II, D.**, "Intent Inference with Path Prediction," *AIAA Journal of Guidance, Control, and Dynamics*, Vol. 29, No. 2, March-April 2006, pp. 225-236.

MARTIN CORLESS
1984
Professor

Degrees

B. E., University College, Dublin, Ireland, Mechanical Engineering, (1st honors), 1977
Ph.D., University of California, Berkeley, Mechanical Engineering, 1984

Interests

Dynamics
Systems
Control

Research Areas

Most of the research is concerned with obtaining tools, which are useful in the analysis and control of systems containing significant uncertainty. These uncertainties are characterized deterministically, rather than stochastically. The systems treated can be linear or nonlinear and continuous-time or discrete-time. The major application of the research is in the analysis and control of aerospace and mechanical systems. In these applications, some of the research focuses on the effect of flexible elements.

Publications

Solmaz, S., **Corless, M. J.**, and Shorten, R. E., "A Methodology for the Design of Robust Rollover Prevention Controllers for Automotive Vehicles with Active Steering," *International Journal of Control*, Vol. 80, No. 11, November 2007, pp. 1763-1779.

Conference Proceedings, Presentations, Invited Lectures

Portillo, J. E., Sisco, J. C., **Corless, M. J.**, Sankaran, V., and Anderson, W. E., "Generalized Combustion Instability Model," 42nd AIAA/ASME/SAE/ASEE Joint Propulsion Conference, Sacramento, CA, 2006.

Solmaz, S., **Corless, M. J.**, and Shorten, R., "A Methodology for the Design of Robust Rollover Prevention Controllers for Automotive Vehicles: Part 1—Differential Braking," 45th IEEE Conference on Decision and Control, San Diego, CA, 2006.

Solmaz, S., **Corless, M. J.**, and Shorten, R., "A Methodology for the Design of Robust Rollover Prevention Controllers for Automotive Vehicles: Part 2—Active Steering," American Control Conference, New York, NY, 2007.

DANIEL DELAURENTIS

2004
Assistant Professor

Degrees

B.S., Florida Institute of Technology, Aerospace Engineering, June 1992.
M.S., Georgia Institute of Technology, Aerospace Engineering, August 1993.
Ph.D., Georgia Institute of Technology, Aerospace Engineering, December, 1998.

Research Interests

Design Methods:

3. Mathematical modeling and object-oriented frameworks for the design of system-of-systems, especially those for which air vehicles are a main element (transportation and mobility networks, uninhabited air vehicle networks, etc.)
4. Approaches for robust design, including robust control analogies and uncertainty modeling/management in multidisciplinary design

Aerospace Systems and Flight Vehicles:

4. Sizing/Synthesis algorithms for design & performance estimation of revolutionary flight vehicles
5. Exploration of Personal Air Vehicle designs and concept of operations
6. Aircraft flight stability and control, especially as an integral part of conceptual design

Publications

Lewe, J. H., **DeLaurentis, D. A.**, Mavris, D., Schrage, D.P., "Entity-centric Abstraction and Modeling Framework for Transportation Architectures," *Journal of Air Transportation*, Vol. 11, No. 3, 2006. [received the Sorenson Best Paper Award, 2006-2007]

Utterwar, A., Rallabhandi, S., **DeLaurentis, D. A.**, Mavris, D., "A Two-Step Optimization Approach for Technology Selection," *Engineering Optimization*, Vol. 38, No. 8, Dec. 2006, pp. 889-908.

DeLaurentis, D., Dickerson, C., DiMario, M., Gartz, P., Jamshidi, M., Nahavandi, S., Sage, A., Sloane, E., and Walker, D.," A Case for an International Consortium on System of Systems Engineering," *IEEE Systems Journal,* Vol. 1, No. 1, Sept. 2007, pp. 68-73.

Conference Proceedings, Presentations, Invited Lectures

DeLaurentis, D., and Han, E., "System-of-Systems Simulation for Analyzing the Evolution of Air Transportation," 25th International Council on the Aeronautical Sciences (ICAS) Congress, Hamburg, Germany, Sep. 3-8, 2006.

DeLaurentis, D., and Han, E., "A Network Theory-Based Approach for Modeling System-of-Systems," AIAA Paper 2006-6989, 11th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference, Portsmouth, VA, Sep. 6-7, 2006.

DeLaurentis, D., and Kotegawa, T., "Establishment of a Network-based Simulation of Future Air Transportation Concepts," AIAA Paper 2006-7719, 6th AIAA Aviation Technology, Integration and Operations Conference (ATIO), Wichita, KS, Sep. 25-27, 2006.

DeLaurentis, D., and Sindiy, O., "Developing Sustainable Space Exploration via System of Systems Approach," AIAA Paper 2006-7248, AIAA Space 2006, San José, CA, Sep. 19-21, 2006.

DeLaurentis, D., and Sindiy, O., "Improved Decision Support in Space Exploration via System-of-System Analysis," Proceedings of the 2007 IEEE International Conference on System of Systems Engineering, San Antonio, Texas, 16–18 April 2007; proceedings on CD-ROM: paper no. 96.

Sengstacken, A., **DeLaurentis, D.**, and Akbarzadeh-T, M.-R., "Fuzzy Logic Control for Shared-Autonomy in Automotive Swarm Environment," Proceedings of IEEE System, Man & Cybernetics Conference, Montreal, Oct. 7-10, 2007.

Polzer, H., **DeLaurentis, D.**, Fry, D., "Multiplicity of Perspectives, Context Scope, and Context Shifting Events," Proceedings of the 2007 IEEE International Conference on System of Systems Engineering, San Antonio, TX, 16–18 April 2007; proceedings on CD-ROM: paper no. 68.

Vander Schaaf, R., **DeLaurentis, D.**, and Abraham, D., "Effective Decision-Making for DoD Humanitarian Infrastructure Projects using Agent-based Modeling", Proceedings of the 2007 IEEE International Conference on System of Systems Engineering, San Antonio, TX, 16–18 April 2007; proceedings on CD-ROM: paper no. 73.

Peeta, S., Paz, A., **DeLaurentis, D.**, "Stated-Preference Analysis of New Microjet On-Demand Air Service," Paper 07-1100, 2007 Transportation Research Board Annual Meeting, Washington, D.C., 2007.

Sindiy, O., and **DeLaurentis, D.**, "Exploration of a Solar System Mobility Network via a System-of-Systems Engineering Framework," AIAA Paper 2007-6527, AIAA Space 2007, 18-20 September 2007.

Kotegawa, T., and **DeLaurentis, D.**, "Evolution of Service Provider Behaviors via Network-Based Analysis," AIAA Paper 2007-7755, 7th AIAA ATIO Conference, Belfast, Northern Ireland, 18-20 September 2007.

ARTHUR E. FRAZHO
Professor
1980

Degrees

B.S.E., The University of Michigan, Computer Engineering, 1973
M.S.E., The University of Michigan, Computer Information and Control Engineering, 1974
Ph.D., The University of Michigan, Computer Information and Control Engineering, 1977

Interests

Control systems

Research Areas

This research develops and applies operator theory to problems in deterministic and stochastic control systems. These techniques are used to design models for both linear and nonlinear control systems. We also obtain fast recursive algorithms for computing reduced order models. This also yields a theory of H^{∞} controller reduction and pole placement with applications to large space structure control. Finally, these techniques are used to solve problems in signal processing and inverse scattering theory.

Publications

Frazho, A. E., ter Horst, S., and Kaashoek, M. A., "Coupling and Relaxed Commutant Lifting," *Integral Equations and Operator Theory*, Vol. 54, 2006, pp. 33-67.

Frazho, A. E., ter Horst, S., and Kaashoek, M. A., "All Solutions to the Relaxed Commutant Lifting Problem," *Acta Sci. Math. (Szeged)*, Vol. 52, 2006, pp. 299-318.

Conference Proceedings, Presentations, Invited Lectures

Frazho, A. E., "Relaxed Commutant Lifting and Limit Theorems: Numerical Examples," Vrije Universiteit, Amsterdam, Netherlands, November 30, 2007.

JAMES L. GARRISON
Associate Professor
2000

Degrees

B.S. Rensselaer Polytechnic Institute, Aeronautical Engineering, 1988
M.S. Stanford University, Aeronautics and Astronautics 1990
Ph.D. The University of Colorado, Aerospace Engineering Sciences, 1997

Interests

Satellite navigation
GPS
Remote sensing

Awards and Major Appointments

Institute of Navigation, Early Achievement Award, June 2002.

Publications

You, H., **Garrison, J. L.**, Heckler, G., and Smajlovic, D., "The Autocorrelation of Waveforms Generated from Ocean-Scattered GPS Signals," *IEEE Geoscience and Remote Sensing Letters*, Vol. 3, No. 1, January 2006.

You, H., **Garrison, J. L.**, Heckler, G., and Smajlovic, D., "The Autocorrelation of Delay-Doppler Waveforms Generated from Ocean-Scattered GPS Signals," *IEEE Geoscience and Remote Sensing Letters*, Vol. 3, No. 1, January 2006, pp. 78-82.

Garrison, J. L., and Eichel, B.E., "An Extended Propagation Ephemeris for GNSS," *Navigation*, Vol. 53, No. 3, Fall 2006, pp. 167-180.

Heckler, G., and **Garrison, J. L.**, "GPS Toolbox: SIMD Correlator Library for GNSS Software Receivers," *GPS Solutions*, Vol. 10, No. 4, November 2006, pp. 269-276.

Dautermann, T., Calais, E., Haase, J, and **Garrison, J. L.**, "Investigation of Ionospheric Electron Content Variations Before Earthquakes in Southern California, 2003-2004," *Journal of Geophysical Research - Solid Earth*, Vol. 112, 2007, pp. B02106, doi:10.1029/2006JB004447.

Garrison, J. L., Lee, S. G., Haase, J. S., and Calais, E., "A method for detecting ionospheric disturbances and estimating their propagation speed and direction using a large GPS network," *Radio Sci.*, Vol. 42, 2007, pp. RS6011, doi:10.1029/2007RS003657.

Conference Proceedings, Presentations, Invited Lectures

Ventre, B. D., **Garrison, J. L.**, Boehme, M., and Haase, J. S., "Implementation and testing of open-loop tracking for airborne GPS occultation measurements," ION GNSS 2006, Fort Worth, TX, September 26-29, 2006.

Heckler, G. W., and **Garrison, J. L.**, "Experimental Tests of Unaided Weak Signal Acquisition Methods Using a Software Receiver," ION GNSS 2006, Fort Worth, TX, September 26-29, 2006.

Dautermann, T., Calais, E., Haase, J., **Garrison, J. L.**, "Investigation of Ionospheric Electron Content Variations Before Earthquakes in Southern California, 2003-2004," American Geophysical Union Fall Meeting, San Francisco, CA, December 11-15, 2006.

Garrison, J. L., Ventre, B. D., Haase, J., Boehme, M. H., "Development and testing of the GNSS Instrument System for Multistatic and Occultation Sensing (GISMOS) airborne instrument," American Geophysical Union Fall Meeting, San Francisco, CA, December 11-15, 2006.

Lee, S-C., **Garrison, J. L.**, Haase, J., Calais, E., "A Correlation method for detection short-period perturbations in the ionosphere, from a large network of GPS receivers," American Geophysical Union Fall Meeting, San Francisco, CA, December 11-15, 2006.

Parrin, J., and **Garrison, J. L.**, "Application of airborne laser scanner measurements of ocean roughness to the calibration and validation of a satellite bistatic radar experiment," American Geophysical Union Fall Meeting, San Francisco, CA, December 11-15, 2006.

Garrison, J. L., Walker, M., Haase, J., Lulich, T., Xie, F., Ventre, B.D., Boehme, M. H., Wilmhoff, B., and Katzberg, S. J., "Development and testing of the GISMOS instrument," International Geosciences and Remote Sensing Symposium, Barcelona, Spain, July 23-27, 2007.

Garrison, J. L., Parrin, J., "Application of an airborne laser scanner as in-situ verification data for bistatic GNSS measurements," International Geosciences and Remote Sensing Symposium, Barcelona, Spain, July 23-27, 2007.

INSEOK HWANG
2004
Assistant Professor

Degrees

B. S., Seoul National University, Seoul, Korea, Aerospace Engineering, 1992.
M. S., Korea Advanced Institute of Science and Technology (KAIST), Taejeon, Korea, Aerospace Engineering, 1994.
Ph.D., Stanford University, Aeronautics and Astronautics, 2004

Interests

Hybrid Systems/Nonlinear Systems
Applications to Air Traffic Control
Other applications

Research Areas

Research areas includes modeling and control of networked embedded systems such as air traffic systems, unmanned systems and space systems, which have both the continuous dynamics modeling physical systems and the discrete dynamics describing logical components such as computer software that controls the physical systems. Current research programs include:

Air Traffic Control

Development of algorithms for the Next Generation Air Transportation System (NextGen) such as:

1. Aircraft tracking and conflict detection and resolution for NextGen
2. Separation assurance
3. Pilot's/controller's intent inference
4. Dynamic airspace reconfiguration

Multiple Vehicle Control

1. Control of multiple unmanned systems (e.g., UAVs and satellites)
2. Multiple robot coordination: simultaneous localization and map building
3. Multiple target tracking and identity management

Space Applications

1. Interplanetary optimal low thrust orbit transfer
2. Tracking and discrimination of Non-Keplerian spacecraft

Publications

Hwang, I., Balakrishnan, H., and Tomlin, C., "State Estimation for Hybrid Systems: Applications to Aircraft Tracking," *IEE Proceedings of Control Theory and Applications*, Vol. 153, No. 5, September 2006, pp. 556-566.

Seah, C.-E., and **Hwang, I.**, "Hybrid Estimation for Stochastic Piecewise Linear Systems," In *Hybrid Systems: Computation and Control, Lecture Notes in Computer Science*, Springer, 2007.

Hwang, I., Balakrishnan, H.**,** Roy, K., and Tomlin, C., "Multiple-Target Tracking and Identity Management Algorithm with Application to Aircraft Tracking," *AIAA Journal of Guidance, Control and Dynamics*, Vol. 30, No. 3, 2007, pp. 641-653,.

Hwang, I., Kim J., and Tomlin, C., "Protocol-Based Conflict Resolution for Air Traffic Control," *Air Traffic Control Quarterly*, Vol. 15, No. 1, 2007.

Yepes, J. L., **Hwang, I.**, and Rotea, M., "Algorithms for Aircraft Intent Inference and Trajectory Prediction," *AIAA Journal of Guidance, Control and Dynamics*, Vol. 30, No. 2, pp. 370-382, March-April 2007.

Conference Proceedings, Presentations, Invited Lectures, Reports

Hwang, I., "Pilot's Intent Inference and Aircraft Trajectory Prediction with Applications to Air Traffic Control," Coordinated Science Laboratory, University of Illinois at Urbana-Champaign, IL, April 2006.

Hwang, I., "Hybrid Systems Approach for Complex Networked Systems with Application to Air Traffic Control, AFOSR System-of-Systems Workshop, Indianapolis, IN, May 2006.

Hwang, I., "Hybrid Systems Approach for Complex Networked Systems," Raytheon, Fort Wayne, IN, June 2006.

Seah, C.-E., and **Hwang, I.**, "Hybrid Estimation Algorithm using State-Dependent Mode Transition Matrix for Aircraft Tracking," Proceedings of the AIAA Guidance, Navigation, and Control Conference, Keystone, CO, August 2006.

Seah, C.-E., and **Hwang, I.**, "Target Tracking of Arrival Aircraft using Hybrid Estimation," Proceedings of the 44th Allerton Conference on Communication, Control, and Computing, Monticello, IL, September 2006.

Seah, C.-E., and **Hwang, I.**, "An Estimation Algorithm for Stochastic Linear Hybrid Systems with Continuous-State-Dependent Mode Transition," Proceedings of the 45th IEEE Conference on Decision and Control, San Diego, CA, December 2006.

Lee, K. D., Lee, S. W., Wie, B., Yeom, C. H., and Seah, C.-E., and **Hwang, I.**, "Aerospace Research and Development Trend Study," Technical Report as a part of the Project: Overseas Science and Technology Policy, Organization, and Trends, Korea Federation of Science and Technology, December 2006.

Li, J., Du, D., and **Hwang, I.**, "A Differential Transform Based Computational Method for Switched Linear Quadratic Optimal Control," 46th IEEE Conference on Decision on Control, New Orleans, LA, 2007.

Du, D., Li, J., and **Hwang, I.**, "A Computational Method for Optimal Control of Hybrid Systems using Differential Transformation," 46th IEEE Conference on Decision and Control, New Orleans, LA, 2007.

Hwang, I., "Hybrid Estimation and Information Inference and its Application to Large-scale Networked Systems," Department of Aerospace Engineering, Ohio State University, Columbus, OH, May 2007.

Seah, C.-E., and **Hwang, I.**, "A Hybrid Estimation Algorithm for Terminal Aircraft Tracking," AIAA Guidance, Navigation, and Control Conference, Hilton Head, SC, August 2007.

Du, D., and **Hwang, I.**, "A Computational Approach to Solving Optimal Control Problems Using Differential Transformation," AACC American Control Conference, New York, NY, July 2007.

Hwang, I., "An Plane Matching Algorithm for Accurate UAV Navigation Using Laser Range Finders in GPS-Latent Urban Environments," UKC Aerospace Science and Technology Symposium, Washington D.C., August 2007

Hwang, I., and Goppert, J., "Information Inference and Control of Complex Networked Systems: Application to Aerospace Systems," ATAIN Conference, September 2007.

Hwang, I., "Hybrid Estimation and Intent Based Probabilistic Conflict Detection for the Next Generation Air Transportation System (NextGen)," Dept. of Aerospace & Mechanical Engineering, University of Notre Dame, Notre Dame, IN, November 2007.

MARIO A. ROTEA
1990
Professor

Degrees

Electronic Engineering Degree, Universidad Nacional de Rosario, Argentina, 1983
M.S.E.E., University of Minnesota, Electrical Engineering, 1988
Ph.D., University of Minnesota, Control Science & Dynamical Systems, 1990

Interests

Algorithms for estimation and control under uncertainty
Algorithms for large-scale optimization and on-line optimization
Modeling, optimization, and control of mechanical and aerospace systems

Awards and Major Appointments

NSF Young Investigator Award
Center for Satellite Engineering, Co-Director

Propulsion

Faculty & Staff Member

W. E. Anderson, Associate Professor, Ph.D., Pennsylvania State University, 1996, chemical propulsion and design methodologies

J. Gore, (by courtesy), Vincent P. Reilly Professor in Mechanical Engineering; Ph.D, Pennsylvania State University, 1986; combustion, turbulent reacting flows and pollutant reduction, radiation heat transfer, biomedical heat transfer and fluid flows

S. D. Heister, Professor, Ph.D., UCLA, 1988, rocket propulsion& liquid propellant injection systems

I. Hrbud, Assistant Professor; Ph.D., Auburn University, 1997; electric propulsion, space power, advanced in-space propulsion

N. Key, (by courtesy), Assistant Professor of Mechanical Engineering, Ph.D., Purdue Univ., 2007, aerothermal aspects of turbomachinery, axial and radial compressor performance, experimental methods in fluid mechanics

C. L. Merkle, joint appointment with Mechanical Engineering, Reilly Professor of Engineering, Ph.D., Princeton Univ., 1969; computational fluid dynamics & mechanics, two phase flows, propulsion components and systems

S. Meyer, Senior Engineer, MSAE, Purdue Univ., 1991

T. Pourpoint, Senior Engineer, Ph.D., Purdue 2005

L. Qiao, Assistant Professor, Ph.D. Univ. of Michigan, 2007; combustion and propulsion

WILLIAM E. ANDERSON
2001
Associate Professor

Degrees

B. S., Arizona State Univ., Chemistry, 1979
M. S., Univ. of Arizona, Chemical Engineering, 1984
Ph.D., The Pennsylvania State University, Mechanical Engineering, 1996

Interests

Combustor design
Combustion stability
Atomization
Combined cycle propulsion

Sponsored Research Summaries

Rocket Combustor Performance and Heat Transfer – The *a priori* analysis of rocket combustor performance and heat transfer are difficult because the extreme environments of the combustor make direct measurements and prediction difficult. As computational resources allow, CFD models of the reacting flow beginning to be used as part of the design process. Before these models can be used, however, they must be validated with high-quality data obtained at realistic conditions. These projects emphasize point measurements of heat flux in representative high-pressure rocket combustors using full-scale injector elements. This work is sponsored by the NASA Constellation Universities Institute Project.

Combustion Instability – Combustion instability is a particularly difficult problem for rocket engines, where highly compact energy release couples with lightly damped combustion chamber acoustic modes. This effort focuses on the development of a methodology that integrates subscale experimentation, high-fidelity simulations, and engineering analysis to produce substantiated *a priori* predictions of fullscale engine combustion instability. The key elements of the iterative approach include subscale experiments, high-fidelity models, and engineering level analysis, with the low-order analysis obtaining stationary solutions to the reacting periodic flowfield and testing combustion response models, the high-fidelity simulations providing fine detail of the physics, and the experiment providing enhanced physical understanding and to validate the analysis and simulation. The final outcome is a 'validated' combustion response submodel appropriate for fullscale design analysis. This approach has been applied to combustor types based on oxidizer-rich staged-combustion engines, and its application to liquid oxygen-liquid methane pressure-fed engines is underway. This work is being funded by NASA and the Air Force.

Publications

Corpening, J., **Heister, S. D.**, and **Anderson, W. E.**, "On the Thermal Decomposition of Hydrogen Peroxide, Part II: Modeling Results," *Journal of Propulsion and Power*, Vol. 22, No. 5, 2006, pp. 996-1005.

Anderson, W. E., Ryan, H. M, and Santoro, R. J., "Impact Wave-Based Model of Impinging Jet Atomization," *Atomization and Sprays*, Vol. 16, No. 7, 2006, pp. 791-805.

Miller, K. J., Sisco, J. C., Nugent, N. N., and **Anderson, W. E.**, "Combustion Instability with a Single Element Swirl Injector," *Journal of Propulsion and Power*, Vol. 23, No. 5, September–October 2007, pp. 1102-1112.

Pourpoint, T. L., and **Anderson, W. E.**, "Hypergolic Reaction Mechanisms of Catalytically Promoted Fuels with Rocket Grade Hydrogen Peroxide," *Combustion Science and Technology*, Vol. 179, No. 10, October 2007, pp. 2107–2133.

Conference Proceedings, Presentations, Invited Lectures

Smith, R., Nugent, N., Xia, G., Sankaran, V., **Anderson, W. E.**, and **Merkle, C.**, "Experimental and Computational Investigation of Combustor Acoustics and Instabilities, Part I: Longitudinal Modes," AIAA Paper 2005-537, 44th AIAA Aerospace Sciences Meeting and Exhibit, Reno, NV, Jan. 9-12, 2006.

Sisco, J., Smith, R., Sankaran, V., and **Anderson, W. E.** , "Examination of Mode Shapes in an Unstable Model Rocket Combustor," AIAA Paper 2006-4525, 42nd AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, Sacramento, CA, July 10-12, 2006.

Gujarathi, A., Li, D., **Anderson, W. E.**, and Sankaran, V., "CFD Modeling of a Ducted Rocket Combined with a Fuel-Rich Primary Thruster," AIAA Paper 2006-4577, 42nd AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, Sacramento, CA, July 10-12, 2006.

Jung, H., Wennerberg, J., Schuff, R., **Anderson, W. E.**, and **Merkle, C.**, "Study of Simulated Fuel Flows in a High Aspect Ratio Cooling Channel," AIAA Paper 2006-4708, 42nd AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, Sacramento, CA, July 10-12, 2006.

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Yu, Y., Sisco, J., **Anderson, W. E.**, and Sankaran, V., "Examination of Spatial Mode Shapes and Resonant Frequencies Using Linearized Euler Equations," AIAA Paper 2007-3999, 37th AIAA Fluid Dynamics Conference and Exhibit, Miami, FL, June 25-28, 2007.

Nugent, N., Helderman, D., Boopalan, A., and **Anderson, W. E.**, "Breakdown Voltage Determination for Gaseous and Cryogenic Propellants," AIAA Paper 2007-5440, 43rd AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, Cincinnati, OH, July 8-11, 2007.

Portillo, J., Sisco, J., Yu, Y., **Anderson, W. E.**, and Sankaran, V., "Application of a Generalized Instability Model to a Longitudinal Mode Combustion Instability," AIAA Paper 2007-5651, 43rd AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, Cincinnati, OH, July 8-11, 2007.

Schuff, R., Jung, H., **Merkle, C.**, and **Anderson, W. E.**, "Experimental Investigation of Asymmetric Heating in a High Aspect Ratio Cooling Channel with Supercritical Nitrogen," AIAA Paper 2007-5564, 43rd AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, Cincinnati, OH, July 8-11, 2007.

Droppers, L., Schuff, R., and **Anderson, W. E.**, "Heat Transfer in a Multi-Element Gaseous Hydrogen Liquid Oxygen Combustor," AIAA Paper 2007-5550, 43rd AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, Cincinnati, OH, July 8-11, 2007.

Smith, R., **Merkle, C.**, and **Anderson, W. E.**, "Computational Modeling of Instabilities in a Single Element Rocket Combustor Using a Response Function," AIAA Paper 2007-5564, 43rd AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, Cincinnati, OH, July 8-11, 2007.

Sisco, J., Portillo, J., Yu, Y., and **Anderson, W. E.**, "Non-Linear Characteristics of Longitudinal Instabilities in a Model Rocket Combustor," AIAA Paper 2007-5570, 43rd AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, Cincinnati, OH, July 8-11, 2007.

Heister, S. D., Fleeter, S., Son, S., **Anderson, W.**, **Hrbud, I.**, **Merkle, C.**, **Key, N.** & **Qiao, L.**, "Propulsion Educational and Research Programs at Purdue University," AIAA Paper 2007-5149, 43rd AIAA Joint Propulsion Conference, Cincinnati, OH, July 2007.

JAY P. GORE
2006 (by courtesy)
Vincent P. Reilly Professor in Mechanical Engineering

Degrees

Ph.D., Penn State, Mechanical Engineering, 1986
M.S., Penn State, Mechanical Engineering1982
B.E., University of Poona, India, Mech., 1978

Interests

Combustion, Turbulent reacting flows and pollutant reduction
Radiation Heat Transfer
Biomedical heat transfer and fluid flows

Other Information

Dr. Jay P. Gore is the interim Director of the Energy Center in Discovery Park and the Associate Dean of Engineering for Research and Entrepreneurship in the College of Engineering. He is also the Vincent P. Reilly Professor in Mechanical Engineering. He served as a Research Fellow in Aerospace Engineering at the University of Michigan and as an Assistant Professor of Mechanical Engineering at the University of Maryland prior to joining Purdue as an Associate Professor. Dr. Gore received early promotions to the rank of Professor of Mechanical Engineering and to the Chair Professorship. Jay is a past Chairman of the Central States Section of the International Combustion Institute and the ASME K11 Committee on Heat Transfer in Fire and Combustion. He has served as an Associate Editor of the ASME Journal of Heat Transfer. He was the U.S. Editor of the 28th International Combustion Symposium. Dr. Gore currently serves as an Associate Editor of the AIAA Journal. He has received the Best Paper in Heat Transfer Literature Award from ASME and a Presidential Young Investigator Award. He has also received Faculty Fellowships from the Japanese Ministry of Education and the U. S. Department of Energy.

Jay's research is in the area of combustion and radiation heat transfer with applications to pollutant reduction, efficiency enhancements, fire safety, and improved fundamental understanding. He has received over $10M in research funding and is currently serving as the PI for grants over $1M in gas turbine combustion and radiation heat transfer applications. He is applying infrared radiation sensing knowledge to a wide range of problems including Bio Heat Transfer, Food Science, and Optical Biopsy in collaboration with a large group of multidisciplinary scientists and physicians. He has authored or coauthored over 100 archival papers, 4 book chapters, and 175 conference papers. Jay has developed/revised 2 courses (Combustion and Advanced Combustion) at Purdue University and three courses in heat transfer and thermodynamics at the University of Maryland.

STEPHEN D. HEISTER
1990
Professor

Degrees

B.S.E., The University of Michigan, Aerospace Engineering, 1981
M.S.E., The University of Michigan, Aerospace Engineering, 1983
Ph.D., University of California at Los Angeles, Aerospace Engineering, 1988

Interests

Rocket propulsion
Liquid propellant injection systems
Two-phase and capillary flows

Sponsored Research Summaries

1. **Atomization modeling** — Under **AFOSR** sponsorship, a number of atomization models have been developed to study the unsteady evolution of liquid jets and droplets. These simulations utilize boundary element methods to provide high-resolution of very large surface distortions and atomization processes. In fact, a number of the models can carry out calculations beyond atomization events. Currently, we are developing a more comprehensive model to treat the entire spray formed by a high-speed injection process. This model incorporates detailed drop dynamics including collisions and secondary atomization of droplets in the spray. Current models track upwards of 2,000,000 droplets simultaneously in a parallel-processing approach.

2. **Rocket Combustion Experiments** — This effort involves the use of the Purdue University Rocket Propulsion and Power Lab (PURPPL); a facility housed at the Maurice Zucrow Labs. Lab scale motors have been fired to assess basic combustion phenomena in hybrid rockets. Over 100 firings of a hydrogen peroxide/polyethylene propellant combination have been conducted during the past four years. Due to the high level of interest in the clean burning, safe handling aspects of hydrogen peroxide, numerous other opportunities are being investigated for potential application in the PURPPL facility. These efforts are heavily coupled with Professor Rusek's present research group.

3. **Diesel Engine Injector Modeling** — This project, funded by **Cummins Engine Company**, **NSF**, and **ARO** is aimed at developing computational tools for use in simulating internal flows in diesel injector passageways. Due to the high injection pressures, cavitation is a crucial feature, which must be incorporated in the modeling. To this end, we have developed a new cavitation treatment capable of addressing hydrodynamic nonequilibrium effects in a fully viscous calculation. Two-dimensional simulations have been compared to experimental measurements from Professor Collicott's research group with favorable results. A full 3-D model has recently been developed making use of advanced parallel processing schemes in a LINUX computing environment. The model shows complex unsteady flow behavior under cavitating conditions. Presently, a turbulence model is being incorporated in the 2-D codes.

Publications

Park, H., and **Heister, S. D.**, "A Numerical Study of Primary Instability on Viscous High-Speed Jets," *Computers and Fluids*, Vol. 35, 2006, pp. 1033-1045.

Corpening, J. H., **Heister, S. D.**, and **Anderson, W.A.**, "Thermal Decomposition of Hydrogen Peroxide, Part 2: Modeling Studies," *Journal of Propulsion & Power*, Vol. 22, No. 5, September-October, 2006, pp. 996-1005.

Park, H., and **Heister, S. D.**, "Nonlinear Simulation of Free Surfaces and Atomization in Pressure Swirl Atomizers," *Physics of Fluids*, Vol. 18, May 2006052103, 11 pages.

Weinstock, V. D., and **Heister, S. D.**, "Modeling Oil Flows in Engine Sumps: Drop Dynamics and Wall Impact Simulation," *International Journal of Gas Turbine Research*, Vol. 128, 2006, pp. 163-172.

Park, H., Yoon, S. S., and **Heister, S. D.**, "On the Nonlinear Stability of a Swirling Liquid Jet," *International Journal of Multiphase Flow*, Vol. 32, No. 9, September 2006, pp. 1100-1109.

Corpening, J. H., Palmer, R. K., **Heister, S. D.**, and Rusek, J. J., "Combustion of Advanced Non-Toxic Hybrid Propellants," *International Journal of Alternative Propulsion*, Vol. 1, No. 2/3, 2007, pp. 154-173.

Macdonald, M., Canino, J. V., and **Heister, S. D.**, "Nonlinear Response of Plain-Orifice Injectors to Nonacoustic Pressure Oscillations," *AIAA Journal of Propulsion & Power*, Vol. 23, No. 6, 2007, pp. 1204-1213.

Heister, S. D., "Hydrogen Peroxide, Hydroxyl Ammonium Nitrate, and Other Storable Oxidizers," with E.J. Wernimont, Chapter 11, *Fundamentals of Hybrid Rocket Combustion and Propulsion*, *AIAA Progress in Astronautics and Aeronautics*, Vol. 218, pp. 457-488, 2007.

Conference Proceedings, Presentations, Invited Lectures

Zakharov, S. I., Richardson, R., and **Heister, S. D.**, "Hydrodynamic Modeling of Swirl Injectors with Multiple Rows of Tangential Channels," AIAA Paper 2006-5202, 42nd AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit, Sacramento, CA, 9-12 July 2006.

Tsohas, J., Canino, J., and **Heister, S. D.**, "Dynamic Response of Coaxial Rocket Injectors," AIAA Paper 2006-4707, 42nd AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit, Sacramento, CA, 9-12 July 2006.

Shimo, M., **Heister, S.**, **Gore, J.**, and **Meyer, S.**, "Experimental DDT Studies in Cyclic Pulse Detonation Engines," AIAA Paper 2006-4308, 42nd AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit, Sacramento, CA, 9-12 July 2006.

MacDonald, M., and **Heister, S. D.**, "Nonlinear Response Functions for Drilled Orifice Injectors," AIAA Paper 2006-4706, 42nd AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit, Sacramento, CA, 9-12 July 2006.

Kim, B., and **Heister, S. D.,** "Numerical Modeling of Hydrodynamic Instability of Swirl Coaxial Injectors in a Recessed Region," AIAA-2006-4720, 42nd AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit, Sacramento, CA, 9-12 July 2006.

Tsohas, J., Droppers, L. J., and **Heister, S. D.**, "Sounding Rocket Technology Demonstration for Small Satellite Launch Vehicle Project," 4th AIAA Responsive Space Conference, Los Angeles, CA, 2006.

Ismailov, M., and **Heister, S. D.**, "On the Linear Stability of Compound Capillary Jets," ILASS Americas, 20th Annual Conference on Liquid Atomization and Spray Systems, Chicago, IL, May 2007.

Canino, J. V. and **Heister, S. D.**, "On the Contributions of Orifice Hydrodynamic Instabilities to Primary Atomization," ILASS Americas, 20th Annual Conference on Liquid Atomization and Spray Systems, Chicago, IL, May 2007.

Moss, J., **Heister, S. D.**, and Linke, K., "Experimental Program to Assess Erosive Burning in Segmented Solid Rocket Motors," AIAA Paper 2007-5782, 43rd AIAA Joint Propulsion Conference, Cincinnati, OH, July 2007.

Rodkey, S. C., **Heister, S. D.**, and **Collicott, S. H.**, "Physics of Gas Turbine Engine Bearing Chambers," AIAA Paper 2007-5033, 43rd AIAA Joint Propulsion Conference, Cincinnati, OH, July 2007.

Matsutomi, Y., Hein, C., Lian, C., **Meyer, S.**, **Merkle, C. L.**, and **Heister, S. D.**, "Facility Development of Wave Rotor Combustion Rig," AIAA Paper 2007-5052, 43rd AIAA Joint Propulsion Conference, Cincinnati, OH, July 2007.

Ventura, M., Wernimont, E., **Heister, S. D.**, and Yuan, S., "Rocket Grade Hydrogen Peroxide for use in Propulsion and Power Devices – Historical Discussion of Hazards," AIAA Paper 2007-5468, 43rd AIAA Joint Propulsion Conference, Cincinnati, OH, July 2007.

Richardson, R. R., Park, H., Canino, J., and **Heister, S. D.**, "Modeling the Nonlinear Dynamic Response of a Swirl Injector," AIAA Paper 2007-5454, 43rd AIAA Joint Propulsion Conference, Cincinnati, Ohio, July 2007.

Otterstatter, M. R., **Heister, S. D.**, and Dambach, E. M., "Design of an Altitude-testing Facility for Lab-scale Propulsion Devices," AIAA Paper 2007-5323, 43rd AIAA Joint Propulsion Conference, Cincinnati, OH, July 2007.

Shimo, M., and **Heister, S. D.**, "Performance Characterization and Schlieren Visualization of Flame Acceleration in Valveless Pulsed Detonation Combustors," AIAA Paper 2007-5077, 43rd AIAA Joint Propulsion Conference, Cincinnati, OH, July 2007.

Tsohas, J., Canino, J. V., and **Heister, S. D.**, "Computational Modeling of Rocket Injector Internal Flows," AIAA Paper 2007-5571, 43rd AIAA Joint Propulsion Conference, Cincinnati, OH, July 2007.

Heister, S. D., Fleeter, S., Son, S., **Anderson, W.**, **Hrbud, I.**, **Merkle, C.**, **Key, N.** & **Qiao, L.**, "Propulsion Educational and Research Programs at Purdue University," AIAA Paper 2007-5149, 43rd AIAA Joint Propulsion Conference, Cincinnati, OH, July 2007.

Tsohas, J., Droppers, L. J., Case, E. G., Dambach, E. M., and **Heister, S. D.**, "Progress in Technology Demonstration for a Small Hybrid Launch Vehicle," AIAA Paper RS5-2007-5004, AIAA 5th Responsive Space Conference, 2007.

IVANA HRBUD
2003
Assistant Professor

Degrees

M.S. (Diplom Ingineur), Stuttgart Univ., Germany, Aerospace Engineering, 1993
Ph.D, Auburn University, Aerospace Engineering, 1997

Interests

Electric and Advanced Space Propulsion
Power Systems
Nuclear/Electric Propulsion Spacecraft Concepts

Research Summaries

1. RF Plasma Thruster Experiments – To ease the impact of severe constraints on power, mass, volume and lifetime of small-satellite propulsion system, the RF plasma thruster concept considers capacitive RF discharge between co-axial electrodes. Operating conditions of this concept are dictated by mass flow rate, electrode separation, RF frequency and power input. To investigate this concept's propulsive capability and plasma characteristics, two laboratory-scale test articles have been designed and built. Both devices have been operated with various propellants in DC and RF power modes. A torsional thrust stand was designed, which is currently undergoing calibration and validation.
2. RF Plasma Thruster Modeling – A preliminary effort involved an analytical study incorporating generalized 1-d flow theory and plasma dynamics. The goal of this study is to assess the thruster's propulsive characteristics as a function of mass flow rate, electrode separation, RF frequency and power input.
3. Coil Geometries for Inductively Coupled Plasmas – The main objective of this research is to explore new geometries for a pulsed inductive plasma accelerator by which it can take advantage of innovative powertrain concepts and propellant injection. In general, inductively-coupled thrusters are appealing for high-power electric propulsion applications due to the electrodeless nature of the acceleration process. In addition, this concept operates with a wide variety of propellants, and provides variable specific impulse by varying propellant flow rate into the coupling area. A preliminary study involves Faraday's Law to calculate induced azimuthal electric field for a given geometry and current waveform. Then an RLC circuit analysis is conducted to assess the behavior of the system.

Publications

Hrbud, I. A., "Alternate Direct-Drive Electric Propulsion System," *Journal of Propulsion and Power*, Vol. 23, No. 4, July/August 2007, pp. 845-853.

Conference Proceedings, Presentations, Invited Lectures

Corpening, J., and **Hrbud, I**., "Analytical and Experimental Determination of Magnetic Field Strength in Various Current Carrying Coil Geometries," *Space Technology and Applications International Forum (STAIF),* Albuquerque, NM, February 2006.

Corpening, J., and **Hrbud, I**., "Preliminary Design and Analysis of the Purdue University Pulsed Inductive Thruster of PuPIT," *42nd AIAA Joint Propulsion Conference*, Sacramento, CA, July 2006.

Corpening, J., **Hrbud, I. A.**, and **Merkle, C**., "Computational Analysis of a Pulsed Inductive Thruster System," AIAA Paper 2007-5286, 43rd AIAA Joint Propulsion Conference, Cincinnati, OH, July 2007.

Hrbud, I. A., Kemp, G., and Bush, C., "Experimental Characterization of a Low-Power RF Plasma Thruster," 43rd AIAA Joint Propulsion Conference, Cincinnati, OH, July 2007.

Stein, W., **Hrbud, I. A.**, **Alexeenko, A.**, and Bondar, E. K., "Performance Modeling of a RF Coaxial Plasma Thruster," 43rd AIAA Joint Propulsion Conference, Cincinnati, OH, July 2007.

Heister, S. D., Fleeter, S., Son, S., **Anderson, W.**, **Hrbud, I.**, **Merkle, C.**, **Key, N.** & **Qiao, L.**, "Propulsion Educational and Research Programs at Purdue University," AIAA Paper 2007-5149, 43rd AIAA Joint Propulsion Conference, Cincinnati, OH, July 2007.

Hrbud, I. A., Kemp, E. G., Yan, A. H., Gedrimas, J. G., "Review of RF Plasma Thruster Development," IEPC Paper 2007-309, 30th International Electric Propulsion Conference, Florence, Italy, September 2007.

NICOLE KEY
(by courtesy) 2007
Assistant Professor of Mechanical Engineering

Degrees

B. S., Purdue University, Aeronautics and Astronautics, 2000
M. S., Purdue University, Mechanical Engineering, 2002
Ph.D., Purdue University, Mechanical Engineering, 2007

Interests

Aerothermal aspects of turbomachinery
Axial and radial compressor performance
Experimental methods in fluid mechanics

Research Areas

Fluid mechanics and propulsion

Conference Proceedings, Presentations, Invited Lectures

Heister, S. D., Fleeter, S., Son, S., **Anderson, W.**, **Hrbud, I.**, **Merkle, C.**, **Key, N.** & **Qiao, L.**, "Propulsion Educational and Research Programs at Purdue University," AIAA Paper 2007-5149, 43rd AIAA Joint Propulsion Conference, Cincinnati, OH, July 2007.

CHARLES L. MERKLE
2003
Reilly Professor of Engineering

Degrees

B.S., Case Institute of Technology, Engineering Science, 1962
M.S., Rensselaer Polytechnic Institute, Mechanical Engineering, 1966
Ph.D., Princeton University, Aerospace & Mechanical Sciences, 1969

Interests

Computational fluid dynamics and mechanics
Two phase flows
Propulsion components and systems

Publications

Xia, G., Li, D., and **Merkle, C. L.**, "Effects of a Needle on Shrouded Hartmann-Sprenger Tube Flows," *AIAA Journal*, Vol. 45, No. 5, May 2007, pp. 1028-1035.

Xia, G., Li, D., and **Merkle, C. L.**, "Consistent Properties Reconstruction on Adaptive Cartesian Meshes for Complex Fluids Computations," *Journal of Computational Physics*, Vol. 225, No. 1, July 2007, pp. 1175-1197.

Conference Proceedings, Presentations, Invited Lectures

Marshall, W., Pal, S., Woodward, R., Santoro, R. J., Smith, R., Xia, G., Sankaran, V., and **Merkle, C. L.**, "Experimental and Computational Investigation of Combustor Acoustics and Instabilities, Part II: Transverse Modes," AIAA Paper 2006-538, 44th AIAA Aerospace Sciences Meeting and Exhibit, Reno, NV, 9-12 January 2006.

Smith, R., Nugent, N., Sisco, J., Xia, G., **Anderson, W.**, Sankaran, V., and **Merkle, C. L.**, "Experimental and Computational Investigation of Combustor Acoustics and Instabilities, Part I: Longitudinal Modes," AIAA Paper 2006-537, 44th AIAA Aerospace Sciences Meeting and Exhibit, 9-12, January, 2006, Reno NV.

Xia, G., Sankaran, V., Li, D., and **Merkle, C. L.**, "Modeling of Turbulent Mixing Layer Dynamics in Ultra-High Pressure Flows," AIAA Paper 2006-3729, 36th AIAA Fluid Dynamics Conference and Exhibit, San Francisco CA, June 5-8, 2006.

Laster, M. L., Jordan, J. L., **Merkle, C. L.**, and Zeng, X., "Remarks on the Design of Hypersonic High Reynolds Number Nozzles with Energy Addition," AIAA Paper 2006-2957, 25th AIAA Aerodynamic Measurement Technology and Ground Testing Conference, San Francisco, CA, June 5-8, 2006.

Li, D., Zeng, X., **Merkle, C. L.**, Felderman, E. J., and Sheeley, J. M., "Coupled Fluid-Dynamic Electromagnetic Modeling of Arc Heaters," AIAA Paper 2006-3768, 36th AIAA Fluid Dynamics Conference and Exhibit, San Francisco, CA, June 5-8, 2006.

Xia, G., Li, D., and **Merkle, C. L.**, "Cartesian Adaptive Properties Interpolation for Computations of Complex Fluids," AIAA Paper 2006-1293, 44th AIAA Aerospace Sciences Meeting and Exhibit, Reno, NV, Jan. 9-12, 2006.

Merkle, C. L., Li, D, and Sankaran, V., "Multi-Disciplinary Computational Analysis in Propulsion," AIAA Paper 2006-4374, 42nd AIAA/ASME/SAE/ASEE Joint Propulsion Conference, Sacramento, CA, July 10-12, 2006.

Voytovych, D.M., **Merkle, C. L.**, Lucht, R.. P., Hulka, J. R., and Jones, G. W., "Modeling of Transient Flow Mixing of Streams Injected into a Mixing Chamber," AIAA Paper 2006-4531, 42nd AIAA/ASME/SAE/ASEE Joint Propulsion Conference, Sacramento, CA, July 10-12, 2006.

Tseng, C. C., Kulatilaka, W. D., Robinson, G. A., **Merkle, C. L.**, and Lucht, R.. P., "Laser, Imaging of Transient Mixing in Simulated Rocket Chambers," AIAA Paper 2006-4530, 42nd AIAA/ASME/SAE/ASEE Joint Propulsion Conference, Sacramento, CA, July 10-12, 2006.

Wennerberg, J. C., Jung, H., Schuff, R., **Anderson, W.E.**, and **Merkle, C. L.**, "Study of Simulated Fuel Flows in High Aspect Ratio Cooling Channels," AIAA Paper 2006-4708, 42nd AIAA/ASME/SAE/ASEE Joint Propulsion Conference, Sacramento, CA, July 10-12, 2006.

Merkle, C. L., Li, D., and Sankaran, V., "Multi-Disciplinary Computational Analysis in Propulsion," AIAA Paper 2006-4575, 42nd AIAA/ASME/SAE/ASEE Joint Propulsion Conference, Sacramento, CA, July 10-12, 2006.

Rooney, D, Moeller, T., Keefer, D., Rhodes, R., **Merkle, C. L.**, "Experimental and Computer Studies of a Pulsed Plasma Accelerator," AIAA Paper 2007-5225, 43rd AIAA/ASME/SAE/ASEE Joint Propulsion Conference, Cincinnati, OH, July 8-11, 2007.

Smith, R., Xia, G., **Anderson, W.**, **Merkle, C. L.**, and Sankaran, V., "Computational Modeling of Instabilities in a Single-Element Rocket Combustor using a Response Function," AIAA Paper 2007-5564, 43rd AIAA/ASME/SAE/ASEE Joint Propulsion Conference, Cincinnati, OH, July 8-11, 2007.

Voytovych, D., **Merkle, C. L.**, Lucht, R., and Tseng, C., "Analysis of Transient Flow Mixing of Streams Injected into a Chamber with a Cavity," AIAA Paper 2007-5566, 43rd AIAA/ASME/SAE/ASEE Joint Propulsion Conference, Cincinnati, OH, July 8-11, 2007.

Kilchyk, V., **Merkle, C. L.**, and Nalim, R., "Effect of Channel Rotation on Premixed Turbulent Combustion in a Wave Rotor Combustor," AIAA Paper 2007-5053, 43rd AIAA/ASME/SAE/ASEE Joint Propulsion Conference, Cincinnati, OH, July 8-11, 2007.

Li, D., **Merkle, C.**, Scott, M., Keefer, D., Moeller, T, and Rhodes, R., "A Hyperbolic Algorithm for Numerical Solutions of Coupled Plama/EM Fields Including Both Real and Displacement Currents," AIAA Paper 2007-5745, 43rd AIAA/ASME/SAE/ASEE Joint Propulsion Conference, Cincinnati, OH, July 8-11, 2007.

Li, D., Corpening, J., **Hrbud, I.**, and **Merkle, C. L.**, "Computational Analysis of a Pulsed Inductive Thruster," AIAA Paper 2007-5286, 43rd AIAA/ASME/SAE/ASEE Joint Propulsion Conference, Cincinnati, OH, July 8-11, 2007.

Matsutomi, Y., Hein, C., Lian, C., **Meyer, S.**, **Merkle, C.**, and **Heister, S.**, "Facility Development for Testing of Wave Rotor Combustion Rig," AIAA Paper 2007-5052, AIAA/ASME/SAE/ASEE Joint Propulsion Conference, Cincinnati, OH, July 8-11, 2007

Tucker, P., Menon, S., **Merkle, C. L.**, Oefelein, J., and Yang V., "An Approach to Improved Credibility of CFD Calculations for Rocket Injector Design," AIAA Paper 2007-5572, 43rd AIAA/ASME/SAE/ASEE Joint Propulsion Conference, Cincinnati, OH, July 8-11, 2007.

Tseng, C., Kulatilaka, W., Robinson, G., **Meyer, S.**, **Merkle, C. L.**, and Lucht, R., "Laser Imaging of Transient Injection and Mixing in a Simulated Rocket Chamber," AIAA Paper 2007-5589, 43rd AIAA/ASME/SAE/ASEE Joint Propulsion Conference, Cincinnati, OH, July 8-11, 2007.

Heister, S. D., Fleeter, S., Son, S., **Anderson, W.**, **Hrbud, I.**, **Merkle, C.**, **Key, N.** & **Qiao, L.**, "Propulsion Educational and Research Programs at Purdue University," AIAA Paper 2007-5149, 43rd AIAA Joint Propulsion Conference, Cincinnati, OH, July 2007.

Jung, H., **Merkle, C. L.**, Schuff, R., and **Anderson, W.**, "Detailed Flowfield Predictions of Heat Transfer to Supercritical Fluids in High Aspect Ratio Cooling Channels," AIAA Paper 2007-5548, AIAA/ASME/SAE/ASEE Joint Propulsion Conference, Cincinnati, OH, July 8-11, 2007.

Schuff, R., Jung, H., **Merkle, C. L.**, and **Anderson, W.**, "Experimental Investigation of Asymmetric Heating in a High Aspect Ratio Cooling Channel with Supercritical Nitrogen," AIAA Paper 2007-5546, AIAA/ASME/SAE/ASEE Joint Propulsion Conference, Cincinnati, OH, July 8-11, 2007.

SCOTT MEYER
2001
Sr. Engineer

Degrees

B.S.A.A.E., Purdue University, School of Aeronautics & Astronautics, 1990
M.S.A.A.E., Purdue University, School of Aeronautics & Astronautics, 1992

Other Information

Scott Meyer is a Senior Propulsion Engineer at Purdue University for the Departments of Mechanical Engineering and Aeronautics and Astronautics. He joined the Purdue staff in 2001 to direct propulsion testing operations and to develop the test facilities for the Indiana Propulsion and Power Center of Excellence.

From 1998 to 2001, Mr. Meyer worked at Beal Aerospace in Frisco, Texas as a senior propulsion engineer. In this role, he defined test programs to support the development of the BA2-C launch vehicle stages and rocket engines. He wrote test plans and coordinated test planning with the engine test facilities including mechanical and fluid system interfaces and instrumentation and control requirements. He directed the procurement, manufacture, and assembly activities for the construction of rocket engines and wrote engine assembly and catalyst preparation procedures. He directed testing operations, wrote test procedures, supervised the installation of test hardware, defined requirements for and performed system calibrations, and performed rocket engine tests. Following testing he wrote test and analysis reports and was responsible for the validation and analysis of test data including engine and stage performance and data reduction methodologies.

From 1993 to 1998 Mr. Meyer worked at Arnold Engineering Development Center in Tullahoma, Tennessee as a project engineer in the Propulsion Wind Tunnel Facility. There he directed multi-million dollar propulsion integration wind tunnel tests for contractors on the F-22 and F/A-18 fighter aircraft and the X-33 SSTO launch vehicle. As such his responsibilities included providing instrumentation specifications and hardware design requirements, managing testing operations, and performing project cost estimation and fiscal management.

Mr. Meyer is a co-patent holder for a hybrid rocket engine ignition device.

Conference Proceedings, Presentations, Invited Lectures

Matsutomi, Y., Hein, C., Lian, C., **Meyer, S.**, **Merkle, C. L.**, and **Heister, S. D.**, "Facility Development of Wave Rotor Combustion Rig," AIAA Paper 2007-5052, 43rd AIAA Joint Propulsion Conference, Cincinnati, OH, July 2007.

Tseng, C., Kulatilaka, W., Robinson, G., **Meyer, S.**, **Merkle, C.**, and Lucht, R., "Laser Imaging of Transient Injection and Mixing in a Simulated Rocket Chamber," AIAA Paper 2007-5589, 43rd AIAA/ASME/SAE/ASEE Joint Propulsion Conference, Cincinnati, OH, July 8-11, 2007.

TIMOTHÉE POURPOINT
2006
Sr. Engineer

Degrees

B.S., ESTACA University, Paris, France, Mechanical Engineering, July 2000
M.S., University of Alabama in Huntsville, Mechanical & Aerospace Engineering, Dec. 2000
Ph.D., Purdue University, Aeronautical & Astronautical Engineering, Dec. 2005

Interests

Aerospace propulsion systems
Rocket engine combustors
Liquid propellant injection systems
Hypergolic propellants
High pressure and hydrogen storage systems

Research Areas

Professor Timothée L. Pourpoint's PhD work was focused on gaining a fundamental understanding of the physical and chemical processes leading to the hypergolic ignition of a catalytically promoted fuel with rocket grade hydrogen peroxide. As he was completing his PhD requirements, he led the development of the Integrated Gas Turbine Combustion Facility at the Maurice Zucrow High Pressure Laboratory. Over the last five years, he has been involved with the design, operation, and upgrade of several high pressure systems used in the aerospace and automotive industries including many rocket engine testing programs. He has published several papers on the development and use of test facilities. His research interests relate to propellant storage and combustion. In a current project, Dr. Pourpoint is developing safe and efficient ways to use high-pressure hydrogen in vehicles through a combination of gas and solid-state storage approaches. Associated with faculty members in the Mechanical Engineering department at Purdue University, Pourpoint and his team focus their research on the use of metal hydrides and cryo-sorbents materials for hydrogen storage. High-purity hydrogen is provided by a bulk hydrogen storage facility designed by Pourpoint and implemented under his supervision at Purdue's Maurice J. Zucrow Laboratories. Another major research effort for Dr. Pourpoint and his students is part of a recently awarded Multiple University Research Initiative aimed at enhancing knowledge in fundamental processes relative to spray formation and combustion of gelled hypergolic propellants. His part in a research team of eleven faculty (eight from Purdue University, two from the University of Massachusetts Amherst, and one from Iowa State University) is dedicated to fundamental experiments and analyses to determine the effects gels have on vaporization, ignition, flame spreading, and chemical kinetics.

Publications

Pourpoint, T.L., Anderson, W.E., "Hypergolic Reaction Mechanisms of Catalytically Promoted Fuels with Rocket Grade Hydrogen Peroxide," *Combustion Science and Technology*, Vol. 179, No. 10, pp. 2107-2133, October 2007.

Conference Proceedings, Presentations, Invited Lectures

Pourpoint, T.L., Meyer, S.E., Ehresman, C.M., "Propulsion Test Facilities at the Purdue University Maurice J. Zucrow Laboratories," AIAA 2008-5333, 43rd AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit, Cincinnati, OH, July 8-11, 2007.

Lucas, K., Tseng, C., Pourpoint, T.L., Lucht, R., Anderson, W.E., "Imaging Flashing Injection of Acetone at Jet Engine Augmentor Conditions," AIAA 2007-1182, 45th AIAA Aerospace Sciences Meeting & Exhibit, Reno, NV, January 8-11, 2007.

LI QIAO
2007
Assistant Professor

Degrees

B.S., Tsinghua University, Engineering Mechanics, 1999
M.S., Tsinghua University, Engineering Mechanics, 2001
Ph.D., University of Michigan, Aerospace Engineering, 2007

Interests

Ignition and combustion of alternative and surrogate jet fuels
Plasma-assisted ignition and combustion for scramjet applications
Coal gasification and oxy-coal combustion
Microgravity combustion phenomena
Experimental fluid dynamics and optical diagnostics

Publications

Qiao, L., Gu, Y., Dahm, W. J. A., Oran, E. S., Faeth, G. M., "A Study of the Effects of diluents on Near-Limit H_2-Air Flames in Microgravity at Normal and Reduced Pressures," *Combustion and Flame*, 151(1):196-208, 2007.

Qiao, L., Gu, Y., Dahm, W. J. A., Oran, E. S., Faeth, G. M., "Near-Limit Laminar Burning Velocities of Microgravity Premixed Hydrogen Flames with Various Chemically Passive Fire Suppressants," *Proceedings of the Combustion Institute*, Vol. 31: 2701-2709, 2007.

Conference Proceedings, Presentations, Invited Lectures

Heister, S., Fleeter, S., Son, S., **Anderson, W., Hrbud, I., Merkle, C., Key, N.,** and **Qiao, L.,** "Propulsion Education and Research Programs at Purdue University," AIAA 43 rd Joint Propulsion Conference, Cincinnati, OH, July 11-14, 2007.

Qiao, L., Gu, Y., Dahm, W. J. A., Oran, E. S., and Faeth, G. M., "Laminar Burning Velocity Measurements of Stoichiometric $CH_4/O_2/N_2$/Diluent Mixtures in Free-Fall Experiments," 5th US Combustion Meeting, San Diego, CA, March 24-27, 2007.

Qiao, L., Gu, Y., Dahm, W. J. A., Oran, E. S., and Faeth, G. M., "Effects of Diluents on Near-Limit H_2-Air Flames in Microgravity at Normal and Reduced Pressures", University of Michigan Engineering Graduate Symposium, Ann Arbor, MI, Nov 3, 2006.

Qiao, L., Gu, Y., Dahm, W. J. A., Oran, E. S., and Faeth, G. M., "Near-Limit Laminar Burning Velocities of Microgravity Premixed Hydrogen Flames with Various Chemically Passive Fire Suppressants," 31st International Symposium on Combustion, Heidelberg, Germany, Aug 6-11, 2006.

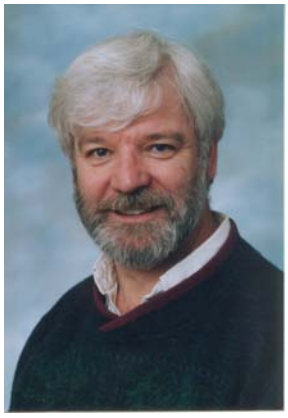
Qiao, L., Gu, Y., Dahm, W. J. A., Oran, E. S., and Faeth, G. M., "Chemically Passive Suppression of Laminar Premixed Hydrogen Flames at Microgravity," 44th AIAA Aerospace Sciences Meeting and Exhibit, AIAA-2006-741, Reno, NV, Jan 9-12, 2006.

Structure and Materials

Faculty Members

W. Chen, joint appointment in MSE, Professor, Ph.D., California Institute of Technology, 1995, mechanical response of solids and structures under extreme conditions, microstructural effects on mechanical behavior, fatigue behavior of engineering materials, experimental solid and structural mechanics

W. A. Crossley, Associate Professor, Ph.D., Arizona State, 1995, optimal design methods, genetic algorithms and aerospace applications, aircraft and conceptual design, composite and smart structure design



J. F. Doyle, Professor, Ph.D., Illinois, 1977, structural dynamics, experimental mechanics, inverse problems, wave propagation

T. N. Farris, Professor and Head, Ph.D., Northwestern, 1986, tribology, manufacturing processes, fatigue and fracture

A. F. Grandt, Jr., Professor, Ph.D., Illinois, 1971, damage-tolerant structures and materials, fatigue and fracture, and aging aircraft

P. K. Imbrie,(by courtesy), Associate Professor of Engineering Education, Ph.D., Texas A&M, 2000, educational research, solid mechanics, experimental mechanics, and nonlinear materials characterization

H. Kim, Assistant Professor, Ph.D., University of California-Santa Barbara, 1998, composites, impact, stability, and adhesive joining

R. B. Pipes, joint appointment in Chem. Engrg. and MSE, John L. Bray Distinguished Professor of Engineering; Ph.D., Univ. of Texas, 1972, application of nanotechnology to engineering disciplines including aerospace, composite materials and polymer science and engineering

C. T. Sun, Neil A. Armstrong Distinguished Professor; Ph.D., Northwestern, 1967, composites, fracture and fatigue, and structural dynamics, smart materials and structures

Terrence A. Weisshaar, Professor, Ph.D., Stanford, 1971, aircraft structural mechanics, aeroelasticity, integrated design

WEINONG WAYNE CHEN
2005
Professor

Degrees

B.S., Beijing University of Aeronautics and Astronautics, Beijing China, Aircraft Structure Design, 1982
M.S., Beijing University of Aeronautics and Astronautics, Aircraft System Engineering, Beijing China, 1985
Ph.D., California Institute of Technology, Aeronautics, minor in Materials Science, 1995

Interests

Experimental Solid and Structural Mechanics
Mechanical Response of Solids at High Strain Rates
Fatigue Behavior of Engineering Materials
Microstructural Effects on Mechanical Behavior
Dynamic Response of Advanced Materials

Awards and Major Appointments

Fellow, American Society of Mechanical Engineers, 2005
University Faculty Scholar, Purdue University, 2005

Research Areas

Dr. Chen's research activities mainly involve the development of novel dynamic material characterization techniques and the determination of dynamic responses of engineering materials at high loading rates. He built dynamic material characterization laboratories at California Institute of Technology, University of Arizona, and Purdue University. He also assisted the development of such laboratories at Sandia National Laboratories in Albuquerque, NM and Livermore, CA; Army Research Laboratory in Aberdeen Proving Ground, MD; U.S. Army Waterway Experiment Station in Vicksburg, MS; National Institute of Standard and Technology in Gaithersburg MD; and a number of university and industrial laboratories. The techniques he developed are focused on ensuring valid testing conditions during dynamic experiments to obtain accurate material properties at high rates of loading. These techniques, summarized in over 15 journal articles, have been well accepted in the research community. Two of top five, four of top ten “most cited papers of Experimental Mechanics” are from Dr. Chen's group.

Using the novel techniques, Dr. Chen and his students have obtained accurate and reliable material behavior at high rates for soft rubbers, glassy polymers, polymeric foams, gelatins, glass/epoxy composites, soy-bean based clay nanocomposites, biological tissues (muscles, skins, bones), shape memory alloys, high-strength steels, geomaterial, masonry materials, textile materials, and armor ceramics. For each class of the materials under dynamic tension, compression, or multiaxial compression, at various temperatures, his group examined the valid dynamic testing conditions to obtain valid experimental results. Microstructural characterization was carried on some of the materials. Based on the experimental results and microstructural observations, material constitutive models were developed to describe the recorded material behavior. Over forty journal articles have been published based on the results from these research programs.

The research accomplishments demonstrate that Dr. Chen has established himself with unique contributions in the field of experimental solid mechanics. He has developed an independent and well funded research program investigating the dynamic mechanical behavior of materials and the necessary experimental techniques, and has established a national and international reputation in his field.

Publications

Luo, H., **Chen, W.**, and Rajendran, A. M., "Dynamic Compressive Response of Damaged and Interlocked SiC-N Ceramics," *Journal of the American Ceramic Society,* Vol. 89, No. 1, 2006, pp. 266-273.

Song, B., **Chen, W.**, Liu, Z., and Erhan, S. Z., "Dynamic Compressive Mechanical Behavior of New Soybean Oil-Based Polymeric Materials," *Journal of Applied Polymer Materials*, Vol. 99, 2006, pp. 2759-2770.

Cheng, M., and **Chen, W.**, "Modeling Transverse Behavior of Kevlar KM2 Single Fibers with Deformation-Induced Damage," *International Journal of Damage Mechanics,* Vol. 15, No. 2, 2006, pp. 121-132.

Chen, W., and Song, B., "Dynamic Compression Testing on Polymeric Foams," *Journal of Materials and Manufacturing, SAE 2005 Transactions*, Feb. 2006, pp. 720-728.

Song, B., Forrestal, M. J., and **Chen, W.**, "Dynamic and Quasi-static Compactions Waves in an Epoxy Foam," *Experimental Mechanics*, Vol. 46, 2006, pp. 127-136.

Song, B., **Chen, W.**, Liu, Z., and Erhan, S. Z., "Dynamic Compressive Mechanical Behavior of New Soybean Oil-Based Polymeric Nanocomposites," *International Journal of Plasticity*, Vol. 22, No. 8, 2006, pp. 1393-1568.

Weerasooriya, T., Moy, P., Casem, D., Cheng, M., and **Chen, W.**, "A Four Point Bending Load Technique for Determination of Dynamic Fracture Toughness for Ceramics," *Journal of the American Ceramic Society*, Vol. 89, No. 3, 2006, 990-995.

Song, B., and **Chen, W.**, "Energy for Specimen Deformation in a Split Hopkinson Pressure Bar Experiment," *Experimental Mechanics*, Vol. 46, 2006, pp. 407-410.

Chen, W., and Song, B., "Temperature Dependence of a NiTi Shape Memory Alloy's Superelastic Behavior at a High Strain Rate," *Journal of Mechanics of Materials and Structures*, Vol. 1, No. 2, 2006, pp. 339-356. Forrestal, M. J., Wright, T. W., and **Chen, W.**, "The Effect of Radial Inertia on Brittle Samples During the Split Hopkinson Pressure Bar Test," *International Journal of Impact Engineering,* Vol. 34, 2007, pp. 405-411.

Syn, C. J. and **Chen, W.**, "Split Hopkinson Bars for Dynamic Structural Testing," Chapter 10, pp. 371-386, in *Advanced Ultrasonic Methods for Material and Structure Inspection*, Ed. T. Kundu, Pub. ISTE, London, U.K. and Newport Beach, CA, USA (book chapter), 2007.

Song, B., Ge, Y., **Chen, W.**, and Weerasooriya, T., "Radial Inertia Effects in Kolsky Bar Testing of Extra-Soft Specimens," *Experimental Mechanics*, Vol. 47, 2007, pp. 659-670.

Chen, W., Rajendran, A.M., Song, B. and Xie, N., "Dynamic Fracture of Ceramics in Armor Applications," *Journal of the American Ceramic Society*, Vol. 90, No. 4, 2007, pp. 1005-1018.

Song, B., Ge, Y., **Chen, W.**, and Weerasooriya, T., "Dynamic and Quasi-static Compressive Response of A Porcine Muscle," *Journal of Biomechanics*, Vol. 40, 2007, pp. 2999-3005.

Song, B., **Chen, W.**, and Lu, W.-Y., "Compressive Mechanical Response of A Low-Density Epoxy Foam at Various Strain Rates," *Journal of Materials Science*, Vol. 42, 2007, pp. 7502-7507.

Song, B., **Chen, W.**, Antoun, B. R., and Frew, D. J., "Determination of Early Stress for Ductile Specimens at High Strain Rates by Using An SHPB," *Experimental Mechanics*, Vol. 47, 2007, pp. 671-680.

Sarva, S. S., Deschanel, S., Boyce, M. C., and **Chen, W.**, "Stress-Strain Behavior of a Polyurea and a Polyurethane from Low to High Strain Rates," *Polymer*, Vol. 48, 2007, pp. 2208-2213.

Nie, X., **Chen, W.**, Sun, X., and Templeton, D. W., "Dynamic Failure of Borosilicate glass under Compression/Shear Loading: Experiments," *Journal of the American Ceramic Society*, Vol. 90, No. 8, 2007, pp. 2556-2562.

Song, B., **Chen, W.**, and Lu, W.-Y., "Mechanical Characterization at Intermediate Strain Rates for Rate Effects on An Epoxy Syntactic Foam," *International Journal of Mechanical Sciences*, Vol. 49, 2007, pp. 1336-1343.

Conference Proceedings, Presentations, Invited Lectures

Luo, H., and **Chen, W.**, "Damage modes correlated to the dynamic response of SiC-N," in *Advances in Ceramic Armor II*, Ceramic Engineering and Science Proceedings, Vol. 27, No. 7, Dec. 2006, pp. 59-68.

Moy, P., Weerasooriya, T., Juliano, T. F. , VanLandingham, M. R., and **Chen, W.**, "Dynamic Response of an Alternative Tissue Stimulant, Physically Associating Gels (PAG)," Paper 285, Proceedings of 2006 Annual Society for Experimental Mechanics Conference, St. Louis, Missouri, USA, June 4-7, 2006.

Lu, W-Y., Jin, H., Lee, S., Gwinn, K., **Chen, W.**, and Song, B., "Dynamic Loading of LIGA Structures," Paper 46, Proceedings of 2006 Annual Society for Experimental Mechanics Conference, St. Louis, Missouri, USA, June 4-7, 2006.

Song, B., **Chen, W.**, and Weerasooriya, T., 2006, "Experimental Investigation of Radial Inertia Effects in Hopkinson Bar Testing of Extra-soft Materials," Paper 64, Proceedings of 2006 Annual Society for Experimental Mechanics Conference, St. Louis, Missouri, USA, June 4-7, 2006.

Song, B., **Chen, W.**, Antoun, B. R., and Frew, D. J., "Determination of Early Flow Stress in Ductile Specimens Using SHPB," Paper 87, Proceedings of 2006 Annual Society for Experimental Mechanics Conference, St. Louis, Missouri, USA, June 4-7, 2006.

Weerasooriya, T., Moy, P., Casem, D., Cheng, M., and **Chen, W.**, "Fracture Toughness of PMMA as a Function of Loading Rate," Paper 327, Proceedings of 2006 Annual Society for Experimental Mechanics Conference, St. Louis, Missouri, USA, June 4-7, 2006.

Ge, Y., **Chen, W.**, and Weerasooriya, T., "Radial Inertia Effects on Dynamic Response of Soft Biological Tissues," Paper 441, Proceedings of 2006 Annual Society for Experimental Mechanics Conference, St. Louis, Missouri, USA, June 4-7, 2006.

Chen, W., "Recent Developments in the Experimental Techniques for High-rate Responses of Metals," Plasticity 2006 The Twelfth International Symposium on Plasticity and Its Current Applications, Halifax, Nova Scotia, Canada, July 17-22 2006.

Lu, W.-Y., Gwinn, K. W., Korellis J. S., and **Chen W.**, "High Strain-Rate Testing for Characterization of Shuttle Ablator Materials," 23rd Aerospace Testing Seminar, Manhattan Beach, CA, October 10-12, 2006.

Chen, W., and Song, B., "Dynamic Compressive Response of Polymeric Nanocomposites," in *Advances in Computational & Experimental Engineering and Sciences*, Proceedings of International Conference on Computational & Experimental Engineering and Sciences, Miami, FL, January 3-8, 2007.

Chen, W., and Nie, X., "Dynamic Failure of a Borosilicate Glass under Biaxial Loading," 31st International Cocoa Beach Conference & Exposition on Advanced Ceramics & Composites, Daytona Beach, FL, January 21-26, 2007.

Weerasooriya, T., Moy, P., and **Chen, W.**, "Measurement of Initiation Fracture Toughness as a Function of Loading Rate in Brittle Materials," 2007 TMS Annual Meeting and Exhibition, Orlando, FL, February 25-March 1, 2007.

Chen, W., and Song, B., "Dynamic Characterization of Shape-Memory Alloys," (Invited paper) 2007 TMS Annual Meeting and Exhibition, Orlando, FL, February 25-March 1, 2007.

Song, B., and **Chen, W.**, "Dynamic Yield Stress Obtained with a Split Hopkinson Bar," 2007 TMS Annual Meeting and Exhibition, Orlando, FL, February 25-March 1, 2007.

Sarva, S., Deschanel, S., Boyce, M., and **Chen, W.**, "Large Deformation Rate-dependent Stress-strain Behavior of Polyurea and Polyurethane," Proceedings of the American Chemical Society, 233rd National Meeting and Exposition, Chicago, IL, March 25-29, 2007.

Chen, W., Rajendran, A. M., and Luo, H., "Hopkinson Bar Techniques for Characterizing Armor Ceramics," 17th U.S. Army Symposium on Solid Mechanics, Baltimore, MD, April 3-5, 2007.

Song, B., **Chen, W.**, Ge, Y., and Weerasooriya, T., "Dynamic Compressive Response of Biological Tissues," 17th U.S. Army Symposium on Solid Mechanics, Baltimore, MD, April 3-5, 2007.

Chen, W., Song, B., Liu, Z., and Erhan, S., "Dynamic Compressive Response of Polymeric Nanocomposites," 17th U.S. Army Symposium on Solid Mechanics, Baltimore, MD, April 3-5, 2007.

Frew, D. J., Forrestal, M. J., and **Chen, W.**, "Shock Testing Electrical Components with a Hopkinson Pressure Bar," Proceedings of 2007 Annual Society for Experimental Mechanics Conference, Springfield, Massachusetts, USA, June 3-7, 2007.

Song, B., **Chen, W.**, and Luk, V., "Strain Rate and Stress State Effects on the Dynamic Compressive Response of a Fine Sand," Proceedings of 2007 Annual Society for Experimental Mechanics Conference, Springfield, MA, USA, June 3-7, 2007.

Rhorer, R., Chin, J., **Chen, W.**, Song, B., and Nie, X., "Aging Effects on Dynamic Tensile Response of a Zylon Fiber," Proceedings of 2007 Annual Society for Experimental Mechanics Conference, Springfield, MA, USA, June 3-7, 2007.

Song, B., **Chen, W.**, Ge, Y., and Weerasooriya, T., "Dynamic Compressive Behavior of Porcine Muscle," Paper No. 074, Proceedings of 2007 Annual Society for Experimental Mechanics Conference, Springfield, MA, USA, June 3-7, 2007.

Song, B., Antoun, B. R., and **Chen, W.**, "Dynamic High-temperature Response of a 304L Steel," Paper No. 076, Proceedings of 2007 Annual Society for Experimental Mechanics Conference, Springfield, MA, USA, June 3-7, 2007.

Nie, X., **Chen, W.**, Sun, X., and Templeton, D., "Dynamic Failure of Glass under Combined Compression/Shear Load," ASME Summer Meeting, McMat07, Austin, TX, June 3-7, 2007.

Weerasooriya, T., Moy, P., Casem, D., Syn, C., and **Chen, W.**, "Measurement of Initiation Fracture Toughness as a Function of Loading Rate in Brittle Materials," ASME Summer Meeting, McMat07, Austin, TX, June 3-7, 2007.

Chen, W., and Song, B., "Effects of Nanoclay Load and Loading Rate on the Compressive Response of Compressive Nanaocomposites," ASME Summer Meeting, McMat07, Austin, TX, June 3-7, 2007.

Song, B., Ge, Y., **Chen, W.**, and Weerasooriya, T., "Dynamic Compressive Response of Biological Tissues," ASME Summer Meeting, McMat07, Austin, TX, June 3-7, 2007.

Lu, W.-Y., Jin, H., Gwinn, K., **Chen, W.**, and Song, B. "Validation of LIGA Structure Deformation Under Impact Loading," 9th U.S. National Congress on Computational Mechanics (USNCCM IX), San Francisco, CA, July 23-26, 2007.

Nie, X., and **Chen, W.**, "Dynamic Fracture of a Transparent Armor under Combined Compression/Shear Load," International Symposium on Interactions of the Effects of Munitions with Structures, Orlando, FL, September 18-21, 2007.

Chen, W., "High-rate Compressive Response of Soft Biological Tissues," University of Nebraska, Lincoln, NE, September 23, 2007.

Frew, D. J., Song, B., and **Chen, W.**, "Shock Response of Micromachined Accelerometers," ASME 2006 International Mechanical Engineering Congress and Exposition, Chicago, IL, November 5-10, 2007.

Grupido, C., Song, B., Syn, C. J., and **Chen, W.**, "Characterization of Polymeric Foams with a Modified Kolsky Bar," ASME 2006 International Mechanical Engineering Congress and Exposition, Chicago, IL, November 5-10, 2007.

Lu, W.-Y., Song, B., and **Chen, W.**, "Response of LIGA Structures to Impact Loading," ASME 2006 International Mechanical Engineering Congress and Exposition, Chicago, IL, November 5-10, 2007.

Song, B., Ge, Y., **Chen, W.**, and Weerasooriya, T., "Characterization of Soft Biological Tissues under Dynamic Compression," ASME 2006 International Mechanical Engineering Congress and Exposition, Chicago, IL, November 5-10, 2007.

Nie, X., **Chen, W.**, Sun, X. and Templeton, D., "Impact Fracture and Fragmentation of a Transparent Armor under Combined Compression/Shear Load," ASME International Mechanical Engineering Congress & Exhibition, Seattle, WA, November 11-15, 2007.

Chen, W., "Dynamic Compressive Response of a Fine Sand," Symposium on Discrete and Continuum Modeling and Experiments on Granular Materials, Powders, and Solids, ASME International Mechanical Engineering Congress & Exposition, Seattle, WA, November 11-15, 2007.

WILLIAM A. CROSSLEY
1995
Associate Professor

Degrees

B.S.E. University of Michigan, Aerospace Engineering, 1990
M. S. Arizona State University, Aerospace Engineering, 1992
Ph.D. Arizona State University, Aerospace Engineering, 1995

Interests

Optimization
Rotorcraft and aircraft design
Structure design

Research Areas

Professor Crossley's major research interests are in the area of design methodologies and optimization, with emphasis on techniques like the GA that will allow optimization-like methods to be applied in the conceptual design phase, which traditionally has been dominated by qualitative or subjective decision making. Significant contributions have been made in applications to discrete actuator placement, topology design, and satellite constellation design.

Sponsored Research Summaries

Topology Design of Rotor Blades for Aerodynamic and Structural Concerns. This computational research effort strives to develop a rotor blade design strategy with the potential to improve the aerodynamic, structural, and dynamic performance of advanced rotorcraft. This work investigates the Genetic Algorithm (GA) as a means to combine aerodynamic and structural concerns for topology design of rotor blades. Inverse airfoil design and optimal airfoil design are receiving much attention in both industry and academia; the same holds true for structural optimization. The combination of the two concerns for topology design has not been fully addressed. A multi-disciplinary approach combining structural and aerodynamic concerns for optimal topology design of rotor blades provides potential benefit to the rotorcraft design process. The aerodynamic optimization portion of this research was cited in the technical research highlights of the NASA Ames Research Center, Rotor Aeromechanics Branch for 1999. Contributions in the structural portion of the research have demonstrated capabilities for discrete (on/off) topology; most notably handing connectivity issues and performing design of sections under combinations of bending and torsion that several authors had previously claimed were not possible.

Genetic Algorithm Issues for Optimal Smart Actuator Placement. This research is investigating approaches for smart actuator placement to provide aircraft maneuverability without requiring hinged flaps or other control surfaces. The effort supports many of the goals of the Multidisciplinary Design Optimization focus efforts in NASA's Aircraft Morphing program. Computational studies are being conducted to allow comparison and selection of appropriate techniques for posing and solving an actuator placement problem. The work began with a geometrically simple wing model, but the approaches identified during this research have been applied to complete aircraft configurations. The problem statement and algorithm application are being used at NASA Langley by researchers working on the Aircraft Morphing

Program. Research in this area has been cited twice as technical highlights for the NASA Langley Multidisciplinary Optimization Branch; once in 1998 and again in 1999.

Improved Satellite Constellation Design and Optimization. Improving satellite constellation design is of great interest to any users of satellite communication (e.g. cellular phones, television), location (e.g. global positioning system) and/or observation (e.g. weather). Many of today's satellite constellation designs rely on the "Walker Constellations," a series of designs developed in 1970, which have rarely been improved upon. These constellations make use of symmetric constellations with circular orbits. Using the genetic algorithm to search the constellation design space has begun to yield constellation designs not previously envisioned but with performance equal to or greater than comparable Walker or "streets of coverage" constellations. Research is ongoing for sparse coverage constellations, constellation build-up problems, multiobjective constellation concerns and elliptic orbit constellations. The Aerospace Corporation performs satellite constellation design for its US Air Force customers using the design techniques developed as part of this research. In one of these studies, a multiobjective GA approach was able to generate constellation designs that outperformed constellations that had been under development for several months. The GA was able to do this in a matter of days.

Development of a Genetic Algorithm for Conceptual Design of Aircraft. Air vehicle conceptual design appears to be a promising area for application of the genetic algorithm as an approach to help automate part of the design process. Because the GA-based approach to conceptual design helps to reduce the number of qualitative decisions needed from the design team, this appears to have great potential for application to aircraft design. Work has been extensively conducted for helicopters, some additional work has been conducted for high-speed VTOL rotorcraft (e.g. tilt-rotor and tilt-wing aircraft), and work is currently underway for fixed-wing aircraft. The Systems Analysis Branch at NASA Langley Research Center supports this research.

Methods to Assess Commercial Aircraft Technologies. Increasing competition in the commercial aircraft industry requires that airframe manufacturers be judicious with technology research and development efforts. Currently, technology development strategies for commercial aircraft appear to be lacking; this research presents a methodology to assess new technologies in terms of both cost and performance. This methodology encompasses technologies that can be applied to the aircraft design and technologies that improve the development, manufacturing, and testing of the aircraft. This differs from past studies that focused upon a small number of performance-based technologies. The method is divided into two phases. The first phase evaluates technologies based on cost measures alone. The second phase redesigns an aircraft with new technologies, assesses the relative importance of performance-based technologies, and recognizes technology interactions using Taguchi's Design of Experiments. For a wide-body transport aircraft example, the methodology identifies promising technologies for further study. Recommendations and conclusions about the methodology are made based on the results. This work was done in collaboration with the Configuration Engineering and Analysis group at Boeing Commercial Aircraft.

Response Surface Methods as Approximation Models for Optimization. Approximation techniques, particularly the use of response surfaces (RS), have achieved wide popularity in engineering design optimization, especially for problems with computationally expensive analyses. The chief aims of using RS is to lower the cost of optimization and to smooth out the problem (e.g., for analyses solved iteratively, with a convergence tolerance). In one part of this

research effort, an investigation of RS methods to minimize drag of a turbofan nacelle is being pursued in conjunction with engineers at Allison Advanced Development Company. This approach can improve the nacelle design practices at AADC by providing a formalized optimization framework for this CFD-based design exercise. The use of RS raises practical questions about the solution accuracy and computational expense. In particular, building response surfaces may involve a prohibitively large number of high-fidelity function evaluations, depending on problem dimensionality. In another part of this research effort, a computational study to address questions of expense and accuracy was undertaken with researchers in the Multidisciplinary Optimization Branch at NASA Langley Research Center. Important observations about the impact of constructing and using response surfaces for moderately high-dimensional problems were made. NASA researchers are using the RS models constructed during this portion of the research to further investigate techniques to manage approximation models in engineering optimization.

Publications

Nusawardhana, A., Zak, S. H., and **Crossley, W. A.**, "Nonlinear Synergetic Optimal Controllers," *Journal of Guidance, Control, and Dynamics*, Vol. 30, No. 4, July-Aug. 2007, pp. 1134-1147.

Mane, M., and **Crossley, W. A.**, Nusawardhana, A., "System of Systems Inspired Aircraft Sizing and Airline Resource Allocation via Decomposition," *Journal of Aircraft*, Vol. 44, No. 4, July-Aug. 2007, pp. 1222-1235.

Namgoong, H., **Crossley, W. A.**, Lyrintzis, A. S., "Aerodynamic Optimization of a Morphing Airfoil using Energy as an Objective," *AIAA Journal*, Vol. 45, No. 9, 2007, pp. 2113-2124.

Hassan, R. A., and **Crossley, W. A.**, "Approach to Discrete Optimization Under Uncertainty: The Population-Based Sampling Genetic Algorithm," *AIAA Journal*, Vol. 45, No. 11, 2007, pp. 2799-2809.

Conference Proceedings, Presentations, Invited Lectures

Namgoong, H., **Crossley, W.**, and Lyrintzis, A., "Aerodynamic Optimization of a Morphing Airfoil Using Energy as an Objective," AIAA Paper 2006-1324, AIAA 44th Aerospace Sciences Meeting, Reno, NV, Jan. 9-12. 2006.

Nusawardhana, and **Crossley, W.**, "NeuroDynamic Programming Approaches for Problems of Combined System- Design and Its Operational Management," AIAA Paper 2006-1914, 2nd AIAA Multidisciplinary Design Optimization Specialist Conference, Newport, RI, May 1-4, 2006.

Namgoong, H., **Crossley, W.**, and **Lyrintizis, A.**, "Morphing Airfoil Design for Minimum Aerodynamic Drag and Actuation Energy Including Aerodynamic Work," AIAA Paper 2006-2041, 14th AIAA/ASME/AHS Adaptive Structures Conference, Newport, RI, May 1-4, 2006.

Skillen, M., and **Crossley, W.**, "Developing Morphing Wing Weight Predictors with Emphasis on the Actuating Mechanism," AIAA Paper 2006-2042, 14th AIAA/ASME/AHS Adaptive Structures Conference, Newport, RI, May 1-4, 2006.

Crossley, W. A., and **DeLaurentis, D. A.**, "Methods for Designing, Planning and Operating Systems of Systems," proceedings of an AFOSR-sponsored workshop, June 2006.

Crossley, W. A., "Systems of Systems: A perspective on the academic research agenda," invited presentation and panelist, Academic Forum, 16th INCOSE Annual International Symposium, Orlando, FL, July 10, 2006.

Nusawardhana and **Crossley, W.**, "On Synergetic Extremal Control for Aerospace Applications," AIAA Paper 2006-6359, AIAA Guidance, Navigation, and Control Conference and Exhibit, Keystone, CO, Aug. 21-24, 2006.

Frommer, J., and **Crossley, W.**, "Building Surrogate Models for Capability-Based Evaluation: Comparing Morphing and Fixed Geometry Aircraft in a Fleet Context," AIAA Paper 2006-7700, 6th AIAA Aviation Technology, Integration and Operations Conference (ATIO), Wichita, KS, Sep. 25-27, 2006.

Skillen, M., and **Crossley, W.**, "Modeling and Optimization for Morphing Wing Concept Generation," NASA/CR-2007-214860, Mar. 2007.

Nusawardhana, and **Crossley, W.**, "A Theoretical Framework of Vehicle Design for Multi-Modal Dynamic System-of-Systems," AIAA Paper 2007-2944, AIAA Infotech@Aerospace 2007 Conference and Exhibit, Rohnert Park, CA, May 7-10, 2007.

Crossley, W. A., "System-of-Systems Inspired Optimization Problems: Experiments in Formulation and Solution," Research Consortium for Multidisciplinary System Design: Second Annual Workshop, Stanford, CA, July 12, 2007.

Mane, M. and **Crossley, W.**, "Probabilistic Approach for Selection of Maintenance Facilities for Air Taxi Operations," AIAA-2007-7786, 7th AIAA Aviation Technology, Integration and Operations Conference, Belfast, Northern Ireland, UK, Sep. 18-20, 2007.

Mane, M. and **Crossley, W.**, "An Approach to Predict Impact of Demand Acceptance on Air Taxi Operations," AIAA Paper 2007- 7787, 7th AIAA Aviation Technology, Integration and Operations Conference, Belfast, Northern Ireland, UK, Sep. 18-20, 2007.

Crossley, W. A., "Systems of Systems Inspired Optimization Problems: Updates and Recent Progress," invited presentation to the Math and Computational Technologies group, Boeing Phantom Works, Bellevue, WA, Nov. 8, 2007.

Frommer, J., and **Crossley, W.**, "Aircraft Sizing and Allocation as a System-Of-Systems Problem via Surrogates and Multiobjective Design," INFORMS Annual Meeting, Seattle, WA, Nov. 4-7, 2007.

Mane, M., and **Crossley, W.**, "Allocation of Variable Resources as a System of Systems Problem," INFORMS Annual Meeting, Seattle, WA, Nov. 4-7, 2007.

Skillen, M., and **Crossley, W.**, "Modeling and Optimization for Morphing Wing Concept Generation, Part I: Morphing Wing Modeling and Structural Sizing Techniques," NASA/CR-2007-214902, Dec. 2007.

Skillen, M., and **Crossley, W.**, "Modeling and Optimization for Morphing Wing Concept Generation, Part II: Morphing Aircraft Sizing Via Multi-Level Optimization," NASA/CR-2007-214903, Dec. 2007.

JAMES F. DOYLE
1977
Professor

Degrees

Dipl. Eng., Dublin Institute of Technology, Ireland, 1972
M.Sc., University of Saskatchewan, Canada, 1974
Ph.D., University of Illinois, 1977

Interests

Structural dynamics
Experimental Mechanics
Inverse Problems
Wave propagation

Research Areas

Wave Motion in Structures

Because of their size and low stiffness, large space structures are susceptible to wave motions due to transients. New, spectrally formulated, elements are being developed that are suitable for dynamic problems and have the following advantages:

Single elements can extend from joint to joint thus giving a remarkable reduction in the size of the system to be solved (with no loss of resolution).

Inverse problems can be solved conveniently, thus making it useful for experimental systems identification studies.

Experimentally characterized substructures (such as joints) may be easily incorporated in the modeling.

Spectral elements have already been developed for rods, beams and shafts, and their implementation in a general 3-D structural analysis computer program accomplished.

Impact and Damage of Structures

A very important aspect of structural performance is the ability to withstand impact and minimize the amount of damage caused. Impact had two effects on damage: (1) Generation if new damage near the impact site or at a stress concentrator. (2) Increased damage at pre-existing flaws caused by the propagated energy. Current investigations involve wave interactions with delamination flaws. This has direct application to damage in composite materials. Other aspects of the problem include:

FORCE IDENTIFICATION: from measurements made on the structure being able to determine the impact of force history.

REMOTE SENSING: from analysis of the reflected and transmitted waves being able to locate flaws and estimate their size.

LOCAL/GLOBAL ANALYSIS: separate the global structural dynamics from the local behavior near the flaw, thus leading to computational efficiencies. A novel layered spectral element has been developed for use with composite materials.

Whole Field Image Characterization

An alternative to strain gages and accelerometers in dynamic measurements is to use ultra-high speed photography coupled with such methods as photoelasticity; and moiré. The question being investigated is: Under what circumstances is a single (or a limited number) of photographs capable of completely characterizing the wave information? This touches on some fundamental aspects of transform theory coupled with measurement theory. The payoff is that photographs combined with digital imaging techniques offer unique possibilities for recording and post-processing the data. This is essentially an experimental problem because experimental data is always incomplete, so questions of quality of the data, the amount of data, etc. must be confronted, as well as the following aspects: (1) High-Speed photography and photoelasticity (2) Digital imaging techniques (3) 2-D Fast Fourier Transforms.

Publications

Meacham, E. M. and **Doyle, J. F.**, "An Inverse Method for Nonlinear Problems using Image Data," *Measurement Science & Technology*, Vol. 18, 2007, pp. 2800-2808.

Conference Proceedings, Presentations, Invited Lectures

Doyle, J. F., "Identification in Nonlinear Structural Dynamics," keynote address, Proceedings of the Ninth International Conference on Recent Advances in Structural Dynamics, ISVR, Southampton, July 2006.

THOMAS N. FARRIS
1986
Professor and Head

Degrees

B. S., Rice University, Mechanical Engineering, cum laude, 1982
M. S., Northwestern University, Theoretical and Applied Mechanics, 1984
Ph.D., Northwestern University, Theoretical and Applied Mechanics, 1986

Interests

Tribology
Manufacturing processes
Fatigue and fracture

Awards and Major Appointments

General Chair of 42nd AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, Seattle WA, April 2001

Research Areas

In tribology, a major research effort is underway in the experimental and analytical characterization of fretting fatigue. The experimental work uses a unique fixture design that allows independent control of the applied clamping and tangential forces. Analytical work combines boundary and finite element analysis of the effect of forces, microslip, and geometry on subsurface stresses. Multiaxial fatigue theories are used to correlate these stresses with experimentally observed crack nucleation and fracture mechanics is used to predict growth of these cracks. The calculations have been used to predict the effect of fretting on multi-site damage nucleation and growth in the aging aircraft problem. The approach is being used to address fretting fatigue in jet engines as part of the Air Force High Cycle Fatigue initiative. Recent effort includes the capability to perform fretting fatigue experiments at high temperatures.

Manufacturing process research includes experimental and analytical work on grinding, turning, and super finishing of hardened steels and ceramics for precision components. The focus is on understanding the mechanics of the material removal process so that the effect of process parameters on component performance can be predicted. To this end, deformation induced during the controlled static and sliding microindentation is being studied. An example of the results of this research is a recently established relationship between grinding temperatures and near surface residual stress and microstructure of the ground component. A model of free abrasive machining that predicts statistical properties of the load/particle relationship has been developed. The model can be used to predict finished surface roughness. A new effort in the area of form generation in centerless grinding is underway. The use of high pressure fracture to produce smooth defect free ceramic surfaces is also being pursued.

Additional work in the area of manufacturing processes is directed at modeling of the heat treatment process. A commercial finite element package has been adapted to predict the microstructure, deformation, and stress induced by quenching and tempering of steel structures. The model includes the effects of latent heat and volumetric strains induced by phase changes.

Industrial collaborators are providing requisite material properties as a function of temperature as well as assistance with experimental validation of the modeling.

Publications

Bartha, B. B., Nicholas, T., and **Farris, T. N.**, "Modeling of Geometry Effects in Fretting Fatigue," *Tribology International,* Special Issue for 4th International Symposium on Fretting Fatigue, Vol. 39, No. 10, 2006, pp. 1131-1141.

Murthy, H., Gao, G., and **Farris, T. N.**, "Fretting Fatigue of Single Crystal Nickel at 600°C," *Tribology International,* Special Issue for 4th International Symposium on Fretting Fatigue, Vol. 39, No. 10, 2006, pp. 1227-1240.

Matlik, J. F., **Farris, T. N.**, Haake, F.K., Swanson, G.R., Duke, G.C., "High-Frequency, High-Temperature Fretting-Fatigue Experiments," *Wear,* Vol. 261, Nos. 11-12, 2006, pp. 1367-1382.

Conference Proceedings, Presentations, Invited Lectures and Reports

Farris, T. N., "Fretting Fatigue of Aerospace Structures," Rice University, February 2006.

Kumari, S., and **Farris, T. N.**, "Statistical Analysis of Effect of Surface Profile on Fretting Fatigue Life for Ti-6Al-4V," AIAA Paper 2006-1729, 47th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, Newport, RI, May 2006.

Farris, T. N., "Fretting Fatigue of Aerospace Structures," Iowa State University, March 2007.

Sreeram, S., Garcia, D. B., Gean, M. C., Murthy, H., and **Farris, T. N.**, "Fretting Fatigue Testing of Laser Shock Peened Ti-6Al-4V," Proc of the 5th Int Sym on Fretting Fatigue, Montreal, April 2007.

Kumari, S. and **Farris, T. N.**, "Statistical Study of Ti-6Al-4V with Contact Surface Profile and Friction Variation," Proc. of the 5th Int Sym on Fretting Fatigue, (Keynote Paper) Montreal, April 2007.

Sundaram, N. and **Farris, T. N.**, "Mechanics of Doubly-Connected Contacts," ASME Applied Mechanics and Materials Conference, Austin, June 2007.

ALTEN F. GRANDT, JR.
1979
Raisbeck Engineering Distinguished Professor for Engineering and Technology Integration

Degrees

B. S., University of Illinois at Urbana-Champaign, General Engineering, 1968
M. S., University of Illinois at Urbana-Champaign, Theoretical and Applied Mechanics, 1969
Ph.D., University of Illinois at Urbana-Champaign, Theoretical and Applied Mechanics, 1971

Interests

Damage-tolerant structures and materials
Fatigue and fracture
Aging aircraft
Nondestructive inspection

Research Areas

General technical interests deal with assuring the safe operation of aerospace and other complex structures through damage tolerance analyses and nondestructive inspection. Particular emphasis is on basic research to predict critical and subcritical crack growth under static and cyclic loads (i.e. fracture and fatigue). The influence of corrosion on structural integrity is also of interest. This research may be characterized by several overlapping categories.

Aging aircraft research is aimed at determining and/or extending the remaining life of structures that have seen extended periods of service, and focuses on determining the effect of multiple site damage on residual strength, and on evaluating the influence of corrosion on fatigue life.

Evaluation of new materials and manufacturing processes includes characterization of new materials in simple coupon or mechanical joint scenarios, analysis of fatigue resistant fastening systems, and evaluation of damage tolerant aspects of unitized construction. Research in this category also includes development of devices to monitor the severity of aircraft loading and has led to one patent.

Crack growth research is directed at predicting crack formation by fretting, corrosion, or cyclic loading, and as well as characterization of fatigue crack growth under complex variable amplitude and/or elevated temperature load histories.

Stress intensity factor analyses are aimed at obtaining solutions to evaluate complex two- and three-dimensional crack configurations common to aerospace structures (e.g. cracked fastener holes, dovetail joints, etc.).

Publications

Park, C. Y., and **Grandt, Jr., A. F.**, "A Proposed Test Protocol for Generic Mechanical Joints," *Journal of Engineering Failure Analysis*, Vol. 13, No. 1, January 2006, pp. 136-154.

Park, C. Y., **Grandt, Jr., A. F.**, and Suh, J. J., "Stress Intensity Factors for Surface Cracks at Countersunk Holes," *Journal of Engineering Fracture Mechanics,* Vol. 73, No. 13, 2006, pp. 1878-1898.

Park, C. Y., and **Grandt, A. F., Jr.,** "Effect of Load Transfer on the Fatigue Cracking Behavior at a Countersunk Fastener Holes," *International Journal of Fatigue*, Vol. 29, 2007, pp. 146-157.

Garcia, D. B., **Grandt, A. F., Jr.**, Bartha, B. B., and Golden, P. J., "Threshold Fatigue Measurements and Fractographic Examination of Fretting Induced Cracks in Ti-17," *Journal of Engineering Failure Analysis*, Vol. 14, No. 4, June 2007, pp. 529-540.

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Conference Proceedings, Presentations, Invited Lectures

Chan, K., Harter, J., **Grandt, Jr., A. F.**, Kim, J. and Honeycutt, K., "Enhanced Crack Growth Methodology and Analyses for Unitized Structures," 9th Joint FAA/DoD/NASA Conference on Aging Aircraft, Atlanta, GA, 6-9 March 2006.

Grandt, Jr., A. F., and Suh, J., "Stress Intensity Factors for Non-Symmetric Cracks at Countersunk Fastener Holes," 9th Joint FAA/DoD/NASA Conference on Aging Aircraft, Atlanta, GA, 6-9 March 2006 (16 pages).

Grandt, Jr., A. F., "A Modern Re-Examination of Lessons from the Classic Fatigue Novel: No Highway," Fatigue 2006, 9th International Fatigue Congress, Atlanta, GA, May 2006, (8 pages).

Grandt, Jr., A. F., "Application of Polymer Models For Three-Dimensional Fatigue Crack Growth Studies," Fatigue 2006, 9th International Fatigue Congress, Atlanta, GA, 14-19 May 2006, (12 pages).

Grandt, Jr., A. F., "Lessons Learned from Aerospace Failures," Keynote Lecture, Second International Conference on Engineering Failure Analysis, Toronto, Canada, 12-15 September 2006 (abstract only).

Grandt, Jr., A. F., "Fundamentals of Damage Tolerance and Nondestructive Inspection," 24 hours of lecture, Purdue University Engineering Professional Education, NASA AERO Institute in Palmdale, CA, 10-13 July 2006.

Grandt, Jr., A. F., "Fundamentals of Damage Tolerance Analysis and Applications," 30 hours of lecture, Advanced Technology Training, South Melbourne, Australia, 26-30 June 2006.

Grandt, Jr., A. F., "Fundamentals of Damage Tolerance Analysis and Applications," 30 hours of lecture, Advanced Technology Training, Wellington, New Zealand, 19-23 June 2006.

Grandt, Jr., A. F., "Fundamentals of Damage Tolerance Analysis and Applications," 30 hours of lecture, Advanced Technology Training, South Melbourne, Australia, 4-8 June 2007.

Grandt, Jr., A. F., "Fundamentals of Damage Tolerance and Nondestructive Inspection," 24 hours of lecture, Purdue University Engineering Professional Education, Aviation Technology Center, Indianapolis, IN, 8-10 May 2007.

PETER K. IMBRIE
(by courtesy)
Associate Professor of Engineering Education

Degrees

B.S.A.E., Texas A&M University, May 1980
M.S.A.E., Texas A&M University, May 1985
Ph.D., Texas A & M University, August 2000

Interests

Solid mechanics
Experimental mechanics
Nonlinear materials characterization
Microstructural evaluation of materials
Mechanics of composites
Engineering materials
Constitutive modeling
Experiment and instrument design
Educational research

Research Areas

Current research interests include, educational research, solid mechanics, experimental mechanics, nonlinear materials characterization, microstructural evaluation of materials, and experiment and instrument design. He has been involved with various research projects sponsored by NSF, NASA, and AFOSR, ranging from education related issues to traditional research topics in the areas of elevated temperature constitutive modeling of monolithic super alloys and environmental effects on titanium based metal matrix composites.

HYONNY KIM
2001
Assistant Professor

Degrees

B. S., University of California, Santa Barbara, Mechanical Engineering, 1993
M. S., Stanford University, Mechanical Engineering, 1994
Ph.D., University of California, Santa Barbara, Mechanical Engineering, 1998

Interests

Composites
Impact
Stability
Adhesive Joining

Research Areas

Adhesive Joining

Current research projects in adhesive joining are focused on (i) buckling stability driven disbonding of bonded composite structures, and (ii) developing nonlinear analysis techniques to predict failure in lap joints.

There exists features in high-performance structures of bonded composite construction that are of minimum gage thickness, or that rely on adhesive bonds to maintain structural stability. When these features develop partial disbonds, they become susceptible to buckling if compressive and/or shear loads are applied. Henceforth they are critical safety concerns, particularly if additional disbonding ensues. Conditions for which buckling initiates, and for which further disbond growth can occur are being investigated. Theoretical models have been developed to predict buckling initiation and the threshold for disbond growth. These models identify which are the critical parameters governing these phenomena. Sub-element level experiments of partially-disbonded splice-jointed sandwich panels are being used to validate the capabilities of these models, and to observe the interplay between buckling and disbond growth. This research addresses important safety issues related to the tolerance of bonded composite airframes to disbonds, particularly if these disbonds are not easily detected by pre-flight ground checks or basic maintenance inspections.

Theoretical models predicting the complex nonlinear behavior, and ultimately failure, of adhesively bonded joints are being developed. In order to predict failure, these models incorporate the highly nonlinear constitutive behavior of adhesives. A current focus is to understand the phenomena of plastic strain localization which develops in a highly concentrated zone at the outer overlap-ends of a bonded joint, near the interface between the adhesive and the adherend. These zones are where fracture initiates, and cracks propagating inwards from these zones ultimately result in failure of the joint.

Impact Simulation

A research project is underway investigating the numerical simulation of high-velocity hailstone impacts on composite structures. Hail ice ingestion in aero-engines is a realistic concern for engines having composite, as well as metallic, fan blades. A key component of this project is the material response of the ice projectile during the impact event: the ice transitions between an elastic-like solid into a fluid-like powder. A material model that accounts for various parameters, principally strain rate and hydrostatic pressure, on the rupture of ice projectiles is being developed based on available experimental data.

Publications

Kim, H., Park, M., and Hsieh, K., "Fatigue Fracture of Embedded Copper Conductors in Multifunctional Composite Structures," *Composites Science and Technology*, Vol. 66, Nos. 7-8, 2006, pp. 1010-1021.

Kim, H., "Closed Form Solution for Strain Energy Release Rate Distribution in Debonded One-Edge Free Postbuckled Composite Flanged Joints," *Composites Science and Technology*, Special issue in honor of Professor C.T. Sun, Vol. 66, No. 14, 2006, pp. 2456-2464.

Park, M., Cola, B. A., Siegmund, T., Xu, J., Maschmann, M. R., Fisher, T. S., and **Kim, H.**, "Effects of a Carbon Nanotube Layer on Electrical Contact Resistance Between Copper Substrates," *Nanotechnology*, Vol. 17, No. 9, 2006, pp. 2294-2303.

Conference Proceedings, Presentations, Invited Lectures

Zalamea, L., **Kim, H.**, and **Pipes, R. B**., "Intershell Coupling in Multiwalled Carbon Nanotubes," *Proceedings of MNT for Aerosapce Applications,* CANEUS2006, 2006.

R. BYRON PIPES
1972
John L. Bray Distinguished Professor of Engineering

Degrees

B. S., Louisiana Polytechnic Institute, 1964
M. S., Princeton University, 1969
Ph.D., University of Texas at Arlington, 1972

Interests

Application of Nanotechnology to engineering disciplines including:
Aerospace
Composite materials and polymer science
Engineering

Research Areas

Dr. Pipes is a distinguished researcher, currently working on the application of nanotechnology to engineering disciplines including aerospace, composite materials and polymer science and engineering. He has active programs in the study of the advanced manufacturing science for composite materials. He is also engaged in the development of Internet-based collaborative research wherein scientific instruments are shared by research groups located in academic, corporate and government scientific centers worldwide.

Publications

Cano, C. I., Weiser, E. S., Kyu, T., and **Pipes, R. B.**, "Polyimide Foams from Powder: Experimental Analysis of Competitive Diffusion Phenomena," *Polymer*, Vol. 46, No. 22, 2005, pp. 9296-9303.

Chang, T. E., Jensen, L. R., Kisliuk, A., **Pipes, R. B.**, Pyrz, R., and Sokolov A. P., "Microscopic Mechanism of Reinforcement in Single-Wall Carbon Nanotube / Polypropylene Nanocomposite," *Polymer*, Vol. 46, 2005, pp 439-444.

Pipes, R. B., Hubert, Salvetat, J.-P., and Zalamea, L., **"**Flexural Deflection as a Measure of van der Waals Interaction Forces in the CNT Array,**"** *Composites Science and Technology,* Vol. 66, No. 9, 2006, pp. 1125-1131.

Coffin, D. W., Carlsson, L. A., and **Pipes, R. B.**, "On the Separation of Carbon Nanotubes," *Composites Science and Technology*, Vol. 66, No. 9, 2006, pp. 1132-1140.

Salvetat, J-P, Bhattacharyya, S., and **Pipes, R. B.**, "Progress on Mechanics of Carbon Nanotubes and Derived Materials," *Journal of Nanoscience and Nanotechnology*, Vol. 6, No. 7, 2006, pp. 1857-1882.

Pipes, R. B., and Zalamea, L., "Energetics of Imperfectly Bonded Carbon Nanotube Arrays in Flexure," *Composites Science and Technology*, Vol. 66, No. 15, 2006, pp. 2844-2854.

Zalamea, L., and **Pipes, R. B.**, "Harmonic Oscillators of Carbon Nanotube Arrays," *Nanoscience and Nanotechnology*, Vol. 6, No. 4, 2006, pp. 1177-1181.

Zalamea, L., **Kim, H.**, and **Pipes, R. B.**, "Stress Transfer in Multiwalled Carbon Nanotubes," *Composites Science and Technology*, Vol. 67, No. 15, 2007, pp. 3425-3433.

Cano, C.I., Kyu, T., and **Pipes, R. B.**, "Modeling Particle Inflation from Poly(amic acid) Powdered Precursors (Part I): Preliminary Stages Leading to Bubble Growth," *Polymer Engineering & Science*, Vol. 47, No. 5, 2007, pp. 560-571.

Cano, C.I., Clark, M. I., Kyu, T., and **Pipes, R. B.**, "Modeling Particle Inflation from Poly(amic acid) Powdered Precursors (Part II): Morphological Development During Bubble Growth," *Polymer Engineering & Science*, Vol. 47, No. 5, 2007, pp. 572-581.

C.-T. SUN
1968
Neil A. Armstrong Distinguished Professor of Aeronautical & Astronautical Engineering

Degrees

B. S., National Taiwan University, Taiwan, Civil Engineering, 1962
M. S., Northwestern University, Theoretical & Applied Mechanics, 1965
Ph.D., Northwestern University, 1967

Interests

Composites
Fracture and Fatigue
Structural Dynamics
Smart Materials and Structures
Nano-structured Materials

Research Areas

Current research interests include the following areas:

Composite Materials and Structures – Advanced fiber composites have gained wide applications in aircraft and aerospace structures. Our research programs cover a broad spectrum in mechanics and design of various composite materials and structures. Research topics include developing methods for testing and modeling high strain rate and fracture behavior of polymeric composites, unconventional modeling of heterogeneous solids, exploring the use of nano particles in reinforcing composites, developing self-assembly methods for processing nanocomposites, improving methods for joining composite structures using adhesives, and developing multifunctional composite materials and structures.

Fracture Mechanics – Fracture mechanics is an important tool in analyzing failure in materials and structures. Our current research focuses on fracture of highly ductile metals and cohesive zone fracture modeling. We have successfully demonstrated that the crack tip opening angle (CTOA) as a crack growth criterion is independent of specimen size and can be used for predicting fracture failure in ductile materials. The CTOA approach is being investigated for use in predicting failure in metallic structures with widespread damage. Our effort in the subject of cohesive zone models is centered on the cohesive law: its physical meaning and conditions it must satisfy.

Smart Materials – The use of piezoelectric materials as actuators and sensors in adaptive structures demands these materials to perform under increasingly high electrical and mechanical loads. Durability and reliability of actuators have become important issues. Our current research aims at solving a number of fundamental problems involving cracks in piezoceramics subjected to combined electrical and mechanical loads.

Nanomaterials – Many nanostructured materials possess highly desired physical and mechanical properties and offer tremendous potentials in many applications. Our research is concentrated on developing multiscale modeling techniques for nanomaterials and their composites and on the use of molecular mechanics to study the behavior of nanomaterials including nanocomposites.

Publications

Sun, C.-T., and Jin, Z.-H., "Modeling of Composite Fracture Using Cohesive and Bridging Models," *Composites Science and Technology*, Vol. 66, No. 10, 2006, pp. 1297-1302.

Huang, G. L., and **Sun, C.-T.**, "The Dynamic Behaviour of a Piezoelectric Actuator Bonded to an Anisotropic Elastic Medium," *International Journal of Solids and Structures*, Vol. 43, 2006, pp. 1291-1307.

Jin, Z.-H., and **Sun, C.-T.**, "A Comparison of Cohesive Zone Modeling and Classical Fracture Mechanics Based on Near Tip Stress Field," *International Journal of Solids and Structures*, Vol. 43, 2006, pp. 1047-1060.

Subramaniyan, A. K., and **Sun, C.-T.**, "Enhancing Compressive Strength of Unidirectional Polymeric Composites Using Nanoclay," *Composites Part A,* Vol.37, 2006, pp. 2257–2268.

Zhang, H. and **Sun, C.-T.**, "A Multiscale Mechanics Approach for Modeling Textured Polycrystalline Thin Films with Nano Thickness," *International Journal of Mechanical Sciences,*Vol. 48, 2006, pp. 899-906.

Cho, J., Joshi, M. S., and **Sun, C.-T.**, "Effect of Inclusion Size on Mechanical Properties of Polymeric Composites with Micro and Nano Particles," *Composites Science & Technology,* Vol. 66, 2006, pp.1941-1952.

Huang, G. L., and **Sun, C.-T.**, "A Continuum Model with Microstructures for Wave Propagation in Ultra Thin Films," *International Journal of Solids and Structures*, Vol. 43, Nos. 22-23, 2006, pp. 7014-7027.

Huang, G. L., and **Sun, C.-T.**, "Modeling Heterostructures of Nano-Phononic Crystals by Continuum Model with Microstructures," *Applied Physics Letter,* Vol. 88, 2006, pp. 261908-1-3.

Sun, C.-T., *Mechanics of Aircraft Structures*, John Wiley & Sons, New York, NY, 1998. Second Edition, 2007.

Sun, C.-T., and Huang, G. L., "Modeling Heterogeneous Media with Microstructures of Different Scales, *"Journal of Applied Mechanics*, Vol. 74, 2007, pp. 203-209.

Jin, Z.-H., and **Sun, C.-T.**, "Integral Representation of Energy Release Rate in Graded Materials," *Journal of Applied Mechanics*, Vol. 74, No. 5, 2007, pp. 1046-1048.

Bing, Q., and **Sun, C.-T.**, "Effect of Compressive Transverse Normal Stress on Mode II Fracture Toughness in Polymeric Composites," *International Journal of Fracture*, Vol.145, No. 2, 2007, pp. 89-97.

Adnan, A., **Sun, C.-T.**, and Mahfuz, H., "A Molecular Dynamics Simulation Study to Investigate the Effect of Filler Size on Elastic Properties of Polymer Nanocomposites," *Composites Science and Technology*, Vol. 67, No. 3-4, 2007, pp. 348-356.

Subramaniyan, A. K., and **Sun, C.-T.**, **"**Toughening Polymeric Composites Using Nanoclay: Crack Tip Scale Effects on Fracture Toughness," *Composites Part A,* Vol.38, 2007, pp. 34-43.

Fang, D., Jiang, Y, Li, S., and **Sun, C.-T.**, "Interaction between Domain Switching and Crack Propagation in Poled $BaTiO_3$ Single Crystal Under Mechanical Loading," *Acta Materialia*, Vol. 55, 2007, pp. 5758-5767.

Huang, G. L., and **Sun, C. T.**, "Continuum Modeling of Solids with Micro/Nanostructures," *Philosophical Magazine*, Vol. 87, No. 24, 2007, pp. 3689-3707.

Conference Proceedings, Presentations, Invited Lectures

Sun, C.-T., "Challenges in Manufacturing and Continuum Modeling of Nanocomposites," National Chiaotung University, Hsin-chu, Taiwan, March 15, 2006.

Jin, Z.-H., and **Sun, C.-T.**, "Integral Representation of Energy Release Rate in Functionally graded Materials," 15th US National Congress on Theoretical and Applied Mechanics, University of Colorado, Boulder, CO, June 25-30, 2006.

Huang, G. L., and **Sun, C.-T.**, "A Continuum Model with Microstructures for Wave Propagation in Ultra Thin Films," 15th US National Congress on Theoretical and Applied Mechanics, University of Colorado, Boulder, CO, June 25-30, 2006.

Sun, C.-T., and Yang, Z., "Significance of K-dominance in Delamination Cracking in Composite Laminates," 16th European Conference on Fracture, Alexandropolis, Greece, July 3-7, 2006.

Sun, C.-T., "Size Effects in Composite Materials," keynote at the International Conference on Aerospace Materials, 2006 Beijing International Materials Week, Beijing, China, June 25-30, 2006.

Sun, C.-T., "Old and New Issues in Solid Mechanics," Beijing Institute of Technology, Beijing, China, June 27, 2006.

Kothari, R., and **Sun, C.-T.**, "Design of Heat Dissipating Systems for Multifunctional Structures," 21st Technical Conference, American Society for Composites, Dearborn, MI, September 17-20, 2006.

Dong, Z., and **Sun, C.-T.**, "Experimental and Numerical Investigation of the Ballistic Performance of Kevlar Fabric/Silica Nano-Particle Composites," 21st Technical Conference, American Society for Composites, Dearborn, MI, September 17-20, 2006.

Sun, C.-T., "What is Multiscale Modeling in Composites," 21st Technical Conference, American Society for Composites, Dearborn, MI, September 17-20, 2006.

Uddin, M. F., and **Sun, C.-T.**, "New Processing Method for High Particle Loading Silica/Alumina/Epoxy Hybrid Nanocomposites," 12th US-Japan Conference on Composite Materials, Dearborn, MI, September 20-22, 2006.

Sun, C.-T., "Fracture and Durability of Ferroelectric Materials," plenary lecture at 17th International Conference on Adaptive Structures and Technologies, National Taiwan University, Taipei, Taiwan, October 17-19, 2006.

Sun, C.-T., "Novel Design, Testing, and Modeling Methods for Advanced Materials," Chung Cheng University, Chiayi, Taiwan, October 20, 2006.

Subramaniyan, A. K., and **Sun, C.-T.**, "Engineering Molecular Statics for Molecular Simulation Including Temperature Effects," (presentation only) ASME International Mechanical Engineering Congress & Exposition, Chicago, IL, November 5-10, 2006.

Sun, C.-T., and Bing, Q., "Characterizing Mode II Fracture Toughness in Polymeric Composites Using Off-Axis Specimens," 48th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, Honolulu, HI, April 23-27, 2007.

Tsai, J.-L., and **Sun, C.-T.**, "Multi-displacement Continuum Model for Discrete Systems," (presentation only) ASME Applied Mechanics and Materials Conference (McMat 2007), University of Texas at Austin, Austin, TX, June 3-7, 2007.

Sun, C.-T., and Huang, G. L., "Continuum Modeling of Mode I Crack in Media with Micro Structures," (presentation only) ASME Applied Mechanics and Materials Conference (McMat 2007), University of Texas at Austin, Austin, TX, June 3-7, 2007.

Bing, Q., and **Sun, C.-T.**, "Effect of Transverse Normal Stress on Mode II Fracture Toughness in Fiber Composites," Sixteenth International Conference on Composite Materials (ICCM 16), Kyoto, Japan, July 9-13, 2007.

Uddin, M. F., and **Sun, C.-T.**, "Compressive Strength of Unidirectional GFRP Composite with Silica Nanoparticle-Enhanced Epoxy," 22st Technical Conference, American Society for Composites, Seattle, WA, September 17-19, 2007.

Sun, C.-T., "Novel Design, Testing, and Modeling Methods for Advanced Materials," Chung Cheng University, Chiayi, Taiwan, October 20, 2006.

Subramaniyan, A. K., and **Sun, C.-T.**, "Modeling Piezoelectric Behavior of Quartz Using Molecular Simulations," (presentation only) ASME International Mechanical Engineering Congress & Exposition, Seattle, WA, November 11-15 2007.

Qian, H., and **Sun, C.-T.**, "Brittle Fracture Beyond Stress Intensity Factors," (presentation only) ASME International Mechanical Engineering Congress & Exposition, Seattle, WA, November 11 – 15 2007.

Sun, C.-T., "Behavior and Modeling of Nanocomposites," State University of New York at Stony Brook, NY, November 30, 2007.

TERRENCE A.WEISSHAAR
1980
Professor

Degrees

B. S., Northwestern University, Mechanical Engineering, (highest distinction), 1965
M. S., Massachusetts Institute of Technology, Aeronautics & Astronautics, 1966
Ph.D., Stanford University, Aeronautics & Astronautics, 1971

Interests

Aircraft structural mechanics
Aeroelasticity
Integrated Design

Research Areas

Primary research areas include optimization of structural concepts for smart aeroelastic structures and efficient multidisciplinary design. Currently, two primary areas are of interest:

- *Aeroelastic tailoring and active flexible wings.* This includes using conventional articulated surfaces such as ailerons and leading edge devices for roll control, as well as using smart materials to change the camber of advanced wing concepts for aircraft control. Objectives also include aeroelastic design for reduced drag and optimization of smart wing flutter suppression systems for micro-air vehicles. We are also developing innovative techniques with advanced composite structure design to find optimal designs and reduce time to develop new concepts.
- *Design methodology – developing new methods and algorithms to improve the ability of a design team to generate innovative, creative concepts for aerospace vehicles.* This includes examining how the external aerodynamic and internal structural topology of lifting surfaces can be addressed simultaneously in the design process. This also includes introducing manufacturing concerns and decisions early in the design process and creating, through the early use of finite element models, more feed-forward/feed-back paths.

  We have been examining how to use new modeling software to generate and present accurate, useful information to designers by displaying load paths and theoretically optimal designs. This leads to an improved conceptual design process for airplane structures that begins with a few participants and quickly proceeds to a high level with diverse technical groups represented. We are involved in the creation of an object-oriented system, using Adaptive Modeling Language (AML), to provide a natural, integrated, virtual environment for modeling, linking and simulating the aircraft design process from its earliest conceptual phase into preliminary design. When completed, this system will allow an integrated product team access to a virtual environment that scientifically simulates the iterative, collaborative process required to design an airplane in a short amount of time.

Publications

Weisshaar, T. A., and Duke, D. K., "Induced Drag Reduction using Aeroelastic Tailoring with Adaptive Control Surfaces," *Journal of Aircraft*, Vol. 43, No. 1, 2006, pp. 157-164.

Taylor, R. M., **Weisshaar, T. A.**, and Sarukhanov, V., "Structural Design Process Improvement using Evolutionary Finite Element Methods," *Journal of Aircraft*, Vol. 43, No. 1, 2006, pp. 172-181.

Conference Proceedings, Presentations, Invited Lectures

Weisshaar, T. A., "Changing Shape and Shaping Change in Aeronautical Structures," RPI Distinguished Lecture Series, Rensselaer Polytechnic Institute, Troy, NY, April 2006.

Weisshaar, T. A., "Shaping the Change and Changing the Shape of Aeronautical Structures and Materials," SDM Keynote Lecture, 47th AIAA Structural Dynamics and Materials Conference, Structural Dynamics and Materials Lecture, Newport, RI, May 2006.

Weisshaar, T. A. and Sanders, B., "Morphing Wing Technology," NATO RTO conference on Advanced Flight Concepts, Vilnius, Lithuania, October 2006.

Ivanco, T. G., Scott, R. C., Love, M. H., Zink, S., **Weisshaar, T. A.**, "Validation of the Lockheed Martin Morphing Concept with Wind Tunnel Testing," 48th AIAA/ASME/ ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, Waikiki, HI, April 2007.

Bowman, J., Sanders, B., Cannon, J., Kudva, J., Joshi, S., **Weisshaar, T. A.**, "Development of Next Generation Morphing Aircraft Structures," 48th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, Waikiki, HI, April 2007.

Weisshaar, T. A., "Future Flight Structures," *AFOSR Flight Structures Workshop*, Arlington, VA, 15-16 October 2007.

Adjunct Faculty

D.L. Filmer, Adjunct Professor of Aeronautics & Astronautics, Ph.D., Univ. of Wisconsin, 1961, satellite design, ground station design for acquisition of satellite data

J. J. Rusek, Adjunct Assistant Professor, Ph.D., Case Western Reserve, 1983, experimental energy conversion and rocket propulsion

DAVID L. FILMER
2002
Adjunct Professor

Degrees

A.B., Youngstown University (Biology) 1954
M.S., University of Wisconsin (Bacteriology) 1958
Ph.D., University of Wisconsin (Biochemistry, Biophysics) 1961
Postdoctoral Studies, Brookhaven National Lab, 1961-65

Research Areas

- Digital signal processing
- Nonlinear dynamics and chaotic systems
- CubeSat design
- Software design for acquisition of satellite data
- LabView software applications

JOHN J. RUSEK
1998
Adjunct Assistant Professor

Degrees

B. S., Case Western Reserve University, Chemical Engineering, 1976
M. S., Case Western Reserve University, Chemical Engineering, 1981
Ph.D., Case Western Reserve University, Chemical Engineering, 1983

Interests

Energy Conversion
Chemical and Physical Propulsion
Power Generation

Awards and Major Appointments

- Who's Who in the World
- Who's Who in America

Research Areas

Current research is directed towards obtaining a fundamental understanding of hydrogen peroxide decomposition via heterogeneous and homogeneous catalysis for use in rocket propulsion and power generation. Major focus concerns the synthesis, characterization, and testing of these novel catalysts in rocket propulsion, turbine, and fuel cell applications. Areas of interest include the experimental and analytical understanding of catalytic reaction kinetics and thermodynamics.

Another major research direction is the fundamental understanding of aerospace materials, specifically in the safe containment of exotic propellant ingredients. International collaboration with government, academic and industrial research centers is playing an important part in this research.

Conference Proceedings, Presentations, Invited Lectures

Luo, N., Miley, G. H., Mather, J., Burton, R., Hawkins, G., Byrd, E., Holcomb, F., **Rusek, J.**, "A KW-class $NABH_4/H_2O_2$ Fuel Cell for Air Independent Propulsion," Proceedings of the 4th International ASME Conference on Fuel Cell Science, Engineering and Technology, FUELCELL2006, Irvine, CA, June 19-21, 2006.

Luo, N., Miley, G. H., Mather, J., Buron, R., **Rusek, J.**, Holcomb, F., "A 500-W Direct Peroxide Fuel Cell for Space Power Systems," 5th International Energy Conversion Engineering Conference, St. Louis, MO, June 25-28, 2007, pp. 456-463.

ACTIVE RESEARCH PROJECTS

July 2006 to June 2008

RESEARCH AND OTHER SCHOLARLY ACTIVITIES

Between July 1, 2006 and June 30, 2007, approximately $7.1 million; and July 1, 2007 and June 30, 2008 approximately $7.5 million in external research expenditures were realized in the areas of Aerodynamics, Aerospace Systems, Astrodynamics and Space Applications, Dynamics and Controls, Propulsion, and Structures and Materials. This represents a growth has doubled over the last six years. Several faculty members were recognized for research as is detailed in the "Faculty Highlights" section. The research expenditure for the 2006-2008 years was attributed to the following sources.

SOURCE OF SPONSORED RESEARCH FOR 2006-2008		
Source	**2006-2007 Percentage of Total**	**2007-08 Percentage of Total**
Department of Defense	29.71	31.48
Department of Education	1.91	2.63
Department of Energy	3.34	2.41
Department of Labor	0.07	0.17
FAA	0.04	1.24
NASA	24.54	25.82
National Science Foundation	4.52	3.30
Industry	29.89	30.52
Indiana 21st Century R & D	4.63	0.69
Other	0.76	1.74
Total	100.0%	100.0%

SPONSORED RESEARCH PROJECTS ACTIVE DURING THE PERIOD JULY 1, 2006 to JUNE 30, 2007					
Staff Name	**Staff Role**	**Title**	**Sponsor**	**Grant Dates**	**Total**
Alexeenko, Alina	**PI**	Java Parallel Computing for Heat Transfer and Fluid Dynamics	**Sun Microsystems Academic Excellence Grant**	03/30/2007	42,295
Anderson, William	**CO-PI**	University Technology Center in High Mach Propulsion	**Allison Advanced Development Company**	1/1/2003– 12/31/2008–	75,000
	CO-PI	Optimization of Manufacturable high Pressure Metal Hydride Storage Systems - Phase 1	**General Motors Corp**	4/1/2007– 1/31/2009–	76,500
	PI	DES-Based Combustion Response Models for Hydrocarbon Engines	**IN Space, LLC**	9/18/2006– 6/30/2007–	56,000
	PI	Development of A Combustion Response Model for Advanced Afterburners, Part II	**IN Space, LLC**	1/1/2006– 8/31/2006–	17,500
	PI	Development of A Combustion Response Model for Advanced Afterburners, Part II	**IN Space, LLC**	8/31/2006– 12/15/2006–	13,006
	PI	Innovative Ignition System for Non-Toxic Storable Propellants, Phase 2 - Experimental	**IN Space, LLC**	9/28/2004– 9/27/2006–	45,000
	PI	Third-Generation Reusable Launch Vehicle Technology ... Z 6892 07	**University of Maryland**	8/19/2006– 9/30/2007–	118,800
	PI	Combustion Instability Experiments	**IN Space, LLC**	11/1/2006– 5/31/2008–	58,648
Blaisdell, Gregory	**CO-PI**	Supersonic Business Jet Applications	**Rolls-Royce Corporation**	8/14/2006– 7/31/2008–	293,053
	CO-PI	Supersonic Business Jet Applications	**Rolls-Royce Corporation**	8/14/2006– 7/31/2008–	39,446.47
Chen, Weinong	**CO-PI**	Integrated Lightweight C4ISR Electronics Shelter Support	**ARINC**	6/30/2006– 8/27/2007–	144,177
	PI	Dynamic Compressive Behavior of Clayey Sand	**Sandia National Laboratories**	12/13/2006– 9/30/2007–	46,900
	PI	Dynamic Fracture of Structural Materials	**Sandia National Laboratories**	12/6/2006– 9/30/2007–	29,912
	PI	High Temperature Metal Testing and High Rate Foam Testing	**Sandia National Laboratories**	7/1/2006– 9/30/2006–	6,804
	PI	Ceramics of Vehicle and Transparent Armor Under Compression and Compression Shear	**Army Research Office**	7/1/2005– 6/30/2007–	120,000
	PI	Impact Response of Brain Tissues	**Army Research Office**	6/1/2007– 2/29/2008–	33,500
	PI	Sandia National	**Sandia National Laboratories**	3/19/2007– 1/31/2008–	10,050
	PI	Amendment 1 - Dynamic Behavior of Porous Ceramics	**Sandia National Laboratories**	12/1/2005– 9/30/2007–	12,060
	PI	Dynamic Material and Structural Testing	**Sandia National Laboratories**	4/15/2006– 9/30/2008–	13,400
	PI	Dynamic Behavior of Porous Ceramics	**Sandia National Laboratories**	12/1/2005– 9/30/2007–	6,700

	PI	Honda	**University of Washington**	12/1/2006–2/28/2007–	10,050
Collicott, Steven	**CO-PI**	Modeling of A Rolls-Royce Turbine Within A Naval Combat Survivability Testbed	**Rolls-Royce, Inc.**	8/15/2006–2/28/2007–	14,874
	PI	Researching the More-electric Engine and Business Jet	**Rolls-Royce, Inc.**	3/1/2007–12/31/2007–	66,250
Crossley, William	**CO-PI**	Supersonic Business Jet Applications	**Rolls-Royce Corporation**	8/14/2006–7/31/2008–	293,053
	CO-PI	Supersonic Business Jet Applications	**Rolls-Royce Corporation**	8/14/2006–7/31/2008–	39,446.47
	PI	Air Taxi Operations As A System-of System Problem	**Cessna Aircraft Company**	9/1/2006–8/31/2007–	91,712
	PI	Genetic Algorithm Approaches for Sizing, Shape and Topology Optimization	**NextGen Aeronautics, Inc**	8/28/2006–5/30/2008–	18,000
DeLaurentis, Daniel	**CO-PI**	Constellation Concept of Ground Operations Study	**United Space Alliance LLC**	6/30/2006–10/5/2006–	11,550
	PI	Automotive Intelligence in Swarm Environment	**Honda**	10/1/2006–9/30/2007–	50,000
	PI	Technology Roadmapping Support for Ducommun Technologies	**Ducommun Technologies**	8/21/2006–8/20/2007–	70,000
Farris, Thomas	**PI**	Fretting Fatigue of Turbine Materials for Propulsion System Prognosis	**General Electric Aircraft Engines**	9/7/2006–3/31/2007–	50,700
	PI	National Defense Science and Engineering Graduate (NDSEG) Fellowship	**American Society For Engineering Educ.**	8/1/2006–7/31/2007–	27,936
	PI	Mechanics of Blade Disk/Contracts	**General Electric Aircraft Engines**	4/22/2002–11/30/2007–	16,500
	PI	Fretting Fatigue Life Models for Ti-6AI-4V and Ti-811	**United Technologies Pratt & Whitney**	9/1/2006–12/31/2007–	60,000
Garrison, James	**PI**	An Error analysis of GNSS-R Derived Roughness Corrections to Salinity Retrievals From Passive Microwave Radiometry	**NASA**	9/1/2006–8/31/2007–	24,000
	PI	Investigation of Transient Ionospheric Perturbations Observed in The GPS Signal	**NASA**	9/15/2004–9/14/2007–	24,000
Grandt, Alten, Jr.	**CO-PI**	Novel Binder for IM-Compliant Solid Rocket Motors	**IN Space, LLC**	9/1/2006–3/11/2007–	13,731
	PI	Fuselage Panel Fatigue Crack Growth and Residual Strength Test Program Supplement	**Alcoa Inc.**	10/1/2006–5/31/2007–	32,437
	PI	Fuselage Panel Fatigue Crack Growth and Residual Strength Test Program - Supplement	**Alcoa Inc.**	9/19/2005–5/31/2008–	17,441
Heister, Stephen D.	**CO-PI**	Purdue University Wave Rotor Combustion Rig Test Facility Design	**IN Univ. Purdue Univ. at Indianapolis**	3/1/2006–2/28/2007–	45,000
	CO-PI	Third-Generation Reusable Launch Vehicle Technology ... Z 6892 07	**University of Maryland**	8/19/2006–9/30/2007–	42,900
	CO-PI	Wave Rotor Combustion Rig Testing	**Rolls-Royce Corp - Libertyworks**	1/1/2007–12/31/2008–	185,858

	PI	Novel Binder for IM-Compliant Solid Rocket Motors	**IN Space, LLC**	9/1/2006–3/11/2007–	32,039
	PI	Supersonic Business Jet Applications	**Rolls-Royce Corporation**	8/14/2006–7/31/2008–	334,924
	PI	Valveless Pulse Detonation Engine Performance/ Design Study	**Rolls-Royce Corp - Libertyworks**	9/5/2006–12/31/2006–	20,000
	PI	University Technology Center in High Mach Propulsion	**Allison Advanced Development Company**	1/1/2003–12/31/2008–	75,000
	PI	Supersonic Business Jet Applications	**Rolls-Royce Corporation**	8/14/2006–7/31/2008–	45,081.68
	PI	Modeling Liquid Rocket Engine Atomization and Swirl/Coaxial Injectors - Amendment 4	**Air Force Office of Scientific Research**	2/1/2003–2/28/2008–	107,631
	PI	Advanced Passive infra-Red Signature Reduction Research with Application to Suppression Systems for Aircraft	**NAVSEA/NSWC Crane**	4/2/2007–6/19/2009–	338,400
	PI	Propulsion Activities	**Composite Tech Development Inc.**	6/15/2007–12/31/2075	1,000
Howell, Kathleen	**PI**	Encore and End-of-Life Options for The Cassini Spacecraft	**Jet Propulsion Laboratory**	4/17/2006–2/28/2007	20,438
	PI	Strategies for Trajectory Design and Mission analysis: Multiple Three-Body and Four-Body Systems Including Sun-Earth-Moon	**NASA**	9/1/2004–8/31/2007–	55,000
Hwang, Inseok	**PI**	Windy Toy Company	**Flying High LLC**	4/20/2007–6/1/2007–	2,000
Kim, Hyonny	**CO-PI**	Integrated Sensor Is Structure (ISIS)	**Northrop Grumman Corporation**	5/18/2006–5/30/2007–	50,000
	CO-PI	Workshop On Tools for Nano Engineering	**Army Research Office**	8/14/2006–2/13/2007–	11,756
	PI	Damage Tolerance and Durability of Composite Structures and Joints	**Federal Aviation Administration**	9/1/2006–8/31/2007–	25,670
Longuski, James	**CO-PI**	Encore and End-of-Life Options for The Cassini Spacecraft	**Jet Propulsion Laboratory**	4/17/2006–2/28/2007–	20,437
Lyrintzis, Anastasios	**CO-PI**	Supersonic Business Jet Applications	**Rolls-Royce Corporation**	8/14/2006–7/31/2008–	293,053
	CO-PI	Supersonic Business Jet Applications	**Rolls-Royce Corporation**	8/14/2006–7/31/2008–	39,446.47
Merkle, Charles	**CO-PI**	Supersonic Business Jet Applications	**Rolls-Royce Corporation**	8/14/2006–7/31/2008–	146,526
	CO-PI	Third-Generation Reusable Launch Vehicle Technology ... Z 6892 07	**University of Maryland**	8/19/2006–9/30/2007–	46,200
	CO-PI	Supersonic Business Jet Applications	**Rolls-Royce Corporation**	8/14/2006–7/31/2008–	19,723
	CO-PI	Advanced Passive Infra-Red Signature Reduction Research with Application to Suppression Systems for Aircraft	**NAVSEA/NSWC Crane**	4/2/2007–6/19/2009–	112,800
	PI	Design Support for Small Cryogenic Turbopump	**University Of Alabama Huntsville**	8/7/2006–9/30/2007–	75,000

Meyer, Scott	**CO-PI**	Supersonic Business Jet Applications	**Rolls-Royce Corporation**	8/14/2006–7/31/2008–	146,526
	CO-PI	Supersonic Business Jet Applications	**Rolls-Royce Corporation**	8/14/2006–7/31/2008–	19,723.23
	CO-PI	Advanced Passive Infra-Red Signature Reduction Research with Application to Suppression Systems for Aircraft	**NAVSEA/NSWC Crane**	4/2/2007–6/19/2009–	112,800
	PI	KT Engineering CEV Igniter Testing	**KT Engineering**	5/8/2006–4/27/2007–	67,118
	PI	Purdue University Wave Rotor Combustion Rig Test Facility Design	**IN Univ. Purdue Univ. at Indianapolis**	3/1/2006–2/28/2007–	22,500
	PI	Regen Duct Testing	**Sierra Engineering Inc.**	8/7/2006–12/20/2006–	17,500
	PI	Wave Rotor Combustion Rig Testing	**Rolls-Royce Corp - Libertyworks**	1/1/2007–12/31/2008–	92,929.25
	PI	KT Engineering CEV Igniter Testing	**KT Engineering**	5/8/2006–9/30/2007–	15,330
	PI	Triax Test Program	**Sierra Engineering, Inc.**	1/23/2007–6/4/2008–	52,109
	PI	Advanced Fuel Thruster Testing With 98% Hydrogen Peroxide	**ERC, Inc..**	3/12/2007–12/31/2007–	10,430
	PI	LOX-Hydrocarbon Swirl Injector Testing for IN Space LLC	**IN Space, LLC**	4/1/2007–12/31/2007–	21,500
Pipes, R. Byron	**CO-PI**	Integrated Lightweight C4ISR Electronics Shelter Support	**ARINC**	6/30/2006–8/27/2007–	110,905
	PI	Workshop On Tools for Nano Engineering	**Army Research Office**	8/14/2006–2/13/2007–	4,408
Pourpoint, Timothee L.	**PI**	Activation of High Pressure Metal Hydride	**General Motors Corp**	1/2/2007–4/30/2007–	108,982
	PI	Optimization of Manufacturable High Pressure Metal Hydride Storage Systems - Phase 1	**General Motors Corp**	4/1/2007–1/31/2009–	229,500
	PI	GM High Pressure Metal Hydride Cost Extension	**General Motors Acceptance Corp Financing**	1/1/2006–8/31/2007–	81,015
Rotea, Mario A.	**CO-PI**	A Noninvasive Sensor / Control for Health Monitoring and Extended Life of Aircraft Generation Systems	**P. C. Krause And Associates, Inc.**	8/1/2006–5/31/2007–	10,500
	PI	Security of Large-Scale Systems	**P. C. Krause And Associates, Inc.**	7/19/2006–7/18/2007–	37,309
	PI	Safety of Nighttime Construction Activities	**National Science Foundation**	1/10/2005–1/31/2007–	7,131
Schneider, Steven P.	**CO-PI**	Third-Generation Reusable Launch Vehicle Technology ... Z 6892 07	**University of Maryland**	8/19/2006–9/30/2007–	49,500
	PI	Collaborative Research: Crossflow-Induced Boundary-Layer Transition On Reentry Vehicles	**Sandia National Laboratories**	10/1/2006–9/30/2009–	48,000
	PI	Request for AFOSR FY06 Supplemental Funds to Support The Falcon and Fresh-FX	**Air Force Office of Scientific Research**	9/1/2006–11/30/2006–	40,000

	PI	Towards Mechanism-Based Models for Laminar- Turbulent Transition On Blunt Reentry Vehicles: Request for FY06 Supplemental Funds	**NASA**	3/28/2006– 3/31/2008–	80,000
	PI	Towards Mechanism-Based Models for Laminar- Turbulent Transition On Blunt Reentry Vehicles	**NASA**	3/28/2006– 3/31/2008–	60,000
	PI	Towards High-Reynolds-Number Quiet Flow in Hypersonic Wind Tunnels	**Air Force Office of Scientific Research**	3/1/2006– 11/30/2007–	120,000
	PI	Towards Mechanism-Based Models for Laminar-Turbulent Transition On A Representative Airbreathing Forebody: Mach-6 Quiet-Tunnel Experiments	**NASA**	3/1/2007– 2/28/2010–	100,000
	PI	Amendment 3 - Request for AFOSR FY07 Supplemental funds to support a stability and transition analysis for reentry (STAR)	**Air Force Office of Scientific Research**	3/1/2006– 11/30/2008–	140,000
	PI	Request for AFOSR Supplemental Funds to Support the FALCON Program	**Air Force Office of Scientific Research**	3/1/2006– 11/30/2008–	63,000
Sullivan, John P.	**CO-PI**	Security of Large-Scale Systems	**P. C. Krause and Associates, Inc.**	7/19/2006– 7/18/2007–	37,309
	CO-PI	Supersonic Business Jet Applications	**Rolls-Royce Corporation**	8/14/2006– 7/31/2008–	293,053
	CO-PI	Supersonic Business Jet Applications	**Rolls-Royce Corporation**	8/14/2006– 7/31/2008–	39,446.47
	CO-PI	Midwest Coalition for Comprehensive Design Education	**National Science Foundation**	9/1/2006– 8/31/2009–	25,000
	PI	Integrated Sensor Is Structure (ISIS)	**Northrop Grumman Corporation**	5/18/2006– 5/30/2007–	100,000
	PI	Indiana Advanced Manufacturing Education Collaborative	**Ivy Tech State College Jane Harper**	11/1/2006– 10/31/2009–	125,000
	PI	KSM Project	**Katz, Sapper & Miller**	4/1/2007– 6/30/2007–	7,500
Sun, Chin-Teh	**CO-PI**	Damage Tolerance and Durability of Composite Structures and Joints	**Federal Aviation Administration**	9/1/2006– 8/31/2007–	24,915
	PI	High Energy Laser Vulnerability Assessment and Modeling Program (HELV AMP)	**Ball Aerospace & Technologies Corp**	7/5/2006– 12/29/2006–	40,211
	PI	Modeling of Nanocomposites	**Tuskegee University**	9/1/2003– 8/31/2007–	40,000
	PI	Development of Toughened and Multifunctional Nanocomposites for Ship Structures	**Office of Naval Research**	4/1/2005– 3/31/2007–	38,000
	PI	Development of Flexible Extremities Protection Utilizing Shear Thickening Fluid/Fabric Composites	**Tuskegee University**	11/18/2004– 5/17/2007–	70,000

	PI	Development of Toughened and Multifunctional Nanocomposites for Ship Structures	**Office of Naval Research**	4/1/2005–12/31/2008–	12,000
	PI	Development of Nanoparticle-Enhanced Multifunctional Composites for Ship Structures	**Office of Naval Research**	4/1/2005–12/31/2008–	40,000
Weisshaar, Terrence A.	**PI**	Future Directions for Structural Mechanics- Fundamental Research Issues	**Air Force Office of Scientific Research**	12/1/2006–7/31/2007–	35,500

SPONSORED RESEARCH PROJECTS ACTIVE DURING THE PERIOD JULY 1, 2007 to JUNE 30, 2008					
Staff Name	**Staff Role**	**Title**	**Sponsor**	**Grant Dates**	**Total**
Alexeenko, Alina	**PI**	Verification of DSMC Source Modeling	**Veeco**	2/1/2008–02/28/09	69,546
	CO-PI	Center for Prediction of Reliability, Integrity and Survivability of Microsystems	**Department of Energy**	04/15/08 – 04/15/09	56,918
Anderson, William	**CO-PI**	Spray & Combustion of Gelled Hypergolic Propellants	**Army Research Office**	6/1/2008–5/31/2011	78,125
	CO-PI	UTC in High Mach Propulsion Year 6	**Allison Advanced Development Company**	1/1/2003–12/31/2008	75,000
	PI	Advanced Measurement Techniques for High Pressure Rocket Combustors Amendment 3	**NASA**	8/1/2004–7/31/2007	3,675
	PI	Advanced Propulsion Systems Testing for Optimized Designs	**NASA**	8/1/2006–7/31/2009	30,000
	PI	Combustion Instability Experiments	**IN Space, LLC**	11/1/2006–5/31/2008	12,000
	PI	Hot Fire Testing	**Sierra Engineering Inc.**	6/1/2007–5/31/2009	100,000
	PI	Modeling and Simulation of Combustion Instability	**IN Space, LLC**	11/15/2007–10/31/2009	150,000
	PI	Plume Diagnostics For Combustion Stability	**Sierra Engineering Inc.**	6/1/2007–5/31/2009	136,000
	PI	Space X Grant Grad Student	**Space Exploration Technologies Corp**	9/1/2007–12/31/2075	18,000
	PI	Studies and Support of Project Constellation Amend A	**University Of Maryland**	10/1/2007–9/30/2008	422,346
Blaisdell, Gregory	**PI**	Heat Transfer Computation for Space Shuttle Applications	**Lyndon B. Johnson Space Center**	6/1/2006–5/31/2009	44,861
Caldwell, Barrett	**CO-PI**	Architecture Analysis for Constellation Program Lunar C31 Concepts	**Jet Propulsion Laboratory**	12/14/2007–9/30/2008	68,000
Chen, Weinong	**CO-PI**	Development & Testing of Innovative Health Management Tools for Damage Detection, Evaluation & Repair of the CH-35K Composite Rotor Blades & Structure	**CACI International Inc.**	9/19/2007–4/15/2009	67,500
	CO-PI	Development and Testing of Innovative Health Management Tools for Damage Detection, Evaluation, and Repair of the CH-53K Composite Rotor Blades & Stru	**CACI International Inc.**	9/19/2007–4/15/2009	16,500
	CO-PI	Integrated Lightweight C4ISR Electronics Shelter Support	**Aeronautical Radio, Inc. - ARINC**	6/30/2006–6/12/2008	120,390
	CO-PI	PRISM: Center for Prediction of Reliability, Integrity and Survivability of Microsystems	**Energy, U.S. Department Of**	4/15/2008–4/14/2009	100,500

	PI	Ceramics of Vehicle and Transparent Armor Under Compression and Compression Shear	**Army Research Office**	7/1/2005–6/30/2008	130,000
	PI	Development and Evaluation of Novel MEMS Digital Accelerometers	**Defense Threat Reduction Agency**	1/2/2008–3/31/2009	143,493
	PI	Dynamic Compressive Behavior of Dry and Clayey Sand and Dynamic Fracture of High-Strength Steel	**Sandia National Laboratories**	12/13/2006–8/29/2008	67,000
	PI	Dynamic Deformation and Failure Behavior of Biological Tissues	**Army Research Laboratory**	1/1/2007–12/31/2011	120,600
	PI	Dynamic Interfacial Behavior in Through-thickness Stitched Polymer Composites	**Army Research Office**	9/15/2007–10/31/2008	33,500
	PI	Dynamic Material and Structural Testing	**Sandia National Laboratories**	4/15/2006–9/30/2008	13,400
	PI	High Temperature Metal Testing and High Rate Foam Testing	**Sandia National Laboratories**	4/15/2006–9/30/2008	13,400
	PI	High-Rate Constitutive Behavior of Armor Ceramics and Polymers	**Defense Advanced Res Projects Agency**	2/13/2008–8/12/2009	134,000
	PI	High-Rate Strength of High-Performance Fibers	**Army Research Office**	6/15/2008–2/14/2009	26,794
	PI	high-speed X-ray Diagnostic System for Trajectory Stability Characterization in Penetration Experiments	**Air Force Office Of Scientific Research**	5/15/2008–5/14/2009	136,894
	PI	Mechanical Properties Measurements and Blast Loading Experiments on Brains for Model Calibration and Validation.	**Massachusetts Institute Of Technology**	9/1/2007–8/31/2008	44,806
Collicott, Steven	**CO-PI**	Development of Fatigue Loading and Design Methodology for High-Mast Lighting Poles	**National Academy Of Sciences**	5/2/2008–5/1/2011	40,000
	PI	Purdue Aero-Electrical Systems Research	**Rolls-Royce Corporation**	1/1/2008–12/31/2008	38,200
Corless, Martin	**PI**	An investigation of Vehicle Dynamics and Stability for NextGeneration Passive Safety Systems Activation and Control	**Ford Motor Company**	4/1/2008–5/15/2009	40,000
Crossley, William	**PI**	Advanced Multidisciplinary Optimization Techniques for Efficient Subsonic Aircraft Design Amendment 1	**Massachusetts Institute Of Technology**	8/1/2007–7/31/2009	50,000
	PI	Advanced Multidisciplinary Optimization Techniques for Efficient Subsonic Aircraft Design	**Massachusetts Institute Of Technology**	8/1/2007–7/31/2009	50,000
	PI	Genetic Algorithm Approaches for Sizing, Shape and Topology Optimization	**NextGen Aeronautics, Inc.**	8/28/2006–5/30/2008	18,000
	PI	Innovative Reconfigurable Wing Designs for Future Short Take-Off and Landing Aircraft	**NextGen Aeronautics, Inc.**	8/1/2007–9/16/2008	12,000
	PI	System-of-Systems Approach for Assessing New Technologies in NGATS - Sup. 3	**Glenn Research Center**	10/1/2007–9/30/2009	272,099

	PI	System-of-Systems Approach for Assessing New Technologies in NGATS	**Glenn Research Center**	10/1/2007–9/30/2009	131,107
	PI	Systems-of-Systems Approaches for Business Aviation	**Cessna Aircraft Company**	10/1/2007–9/30/2008	82,148
DeLaurentis, Daniel	**CO-PI**	Development & Testing of Innovative Health Management Tools for Damage Detection, Evaluation & Repair of the CH-35K Composite Rotor Blades & Stru	**CACI International Inc.**	9/19/2007–4/15/2009	67,500
	CO-PI	Development and Testing of Innovative Health Management Tools for Damage Detection, Evaluation, and Repair of the CH-53K Composite Rotor Blades & Stru	**CACI International Inc.**	9/19/2007–4/15/2009	16,500
	CO-PI	System-of-Systems Approach for Assessing New Technologies in NGATS	**Glenn Research Center**	10/1/2007–9/30/2009	131,107
	PI	Architecture Analysis for Constellation Program Lunar C31 Concepts	**Jet Propulsion Laboratory**	12/14/2007–9/30/2008	102,000
	PI	Dependency Analysis and New Concepts for Metroplex Operations Amendment 1	**George Mason University**	8/24/2007–9/30/2009	90,000
	PI	Dependency Analysis and New Concepts for Metroplex Operations	**George Mason University**	8/24/2007–9/30/2009	105,000
	PI	Network Restructuring Scenarios for ATO Forecasts	**Federal Aviation Administration**	5/1/2007–7/15/2008	50,000
	PI	Research on Defense Acquisition Management for System-of-Systems	**Naval Postgraduate School**	12/20/2007–12/19/2008	101,750
	PI	System-of-Systems Engineering: A New Systems Analysis for Integrated Design	**NASA**	8/1/2006–7/31/2008	30,000
Farris, Thomas	**PI**	ASEE/SMART/DOD Fellowship for A. Schleuter	**American Society For Engineering Education**	8/1/2007–7/31/2008	4,022
	PI	Fretting Fatigue of Turbine Materials for Propulsion System Prognosis	**General Electric Aircraft Engines**	8/25/2004–3/31/2009	50,000
	PI	Gear Prognosis	**VEXTEC Corporation**	9/1/2007–6/30/2008	21,000
	PI	Mechanics of Blade Disk/Contracts	**General Electric Aircraft Engines**	4/22/2002–11/30/2007	28,500
Garrison, James L	**PI**	An Error Analysis of GNSS-R Derived Roughness Corrections to Salinity Retrievals from Passive Microwave Radiometry - Supp. 1	**NASA**	9/1/2007–8/31/2010	30,000
	PI	An Error Analysis of GNSS-R Derived Roughness Corrections to Salinity Retrievals from Passive Microwave Radiometry	**NASA**	9/1/2007–8/31/2010	24,000
Grandt, Alten	**PI**	Assignment Agreement as Visiting Professor with US Air Force Academy with accompanying IPA	**Air Force Academy**	7/6/2007–5/30/2008	149,963
Heister, Stephen	**CO-PI**	Studies and Support of Project Constellation	**University Of Maryland**	10/1/2007–9/30/2008	78,778

	PI	Evaluation of the Effects of +100 Additive Package on the Thermal Stability of Cold Flow Bio Aviation Kerosene	**Baere Aerospace Consulting Inc.**	9/1/2007–6/30/2008	7,399
	PI	Spray & Combustion of Gelled Hypergolic Propellants	**Army Research Office**	6/1/2008–5/31/2011	104,167
	PI	Study of Cavitation/Vaporization In Liquid Rocket Thruster Injectors	**Air Force Office Of Scientific Research**	3/15/2008–11/30/2008	58,656
	PI	UTC in High Mach Propulsion Year 6	**Allison Advanced Development Company**	1/1/2003–12/31/2008	75,000
Howell, Kathleen	**PI**	Design and Analysis in Support of Mission Architectures in NASA's Vision for Space Exploration In	**NASA**	5/24/2006–5/23/2009	45,000
	PI	Mission Design Architectures for Lunar Relay Satellite Systems	**NASA**	8/1/2007–7/31/2009	30,000
Hwang, Inseok	**PI**	CAREER: Real-Time Hybrid Estimation and Control for Networked Embedded Hybrid Systems	**National Science Foundation**	5/1/2008–4/30/2009	80,000
Longuski, James	**PI**	A Dual-Use Ballute for Aerocapture and Descent During Planetary Missions	**NASA**	8/1/2005–7/31/2008	30,000
Lyrintzis, Anastasios	**CO-PI**	Heat Transfer Computation for Space Shuttle Applications	**Lyndon B. Johnson Space Center**	6/1/2006–5/31/2009	44,861
	PI	Fellowship Program In Aeronautics And Astronautics – Action #1	**Education, U.S. Department Of**	8/14/2006–8/13/2008	170,508
Merkle, Charles	**CO-PI**	Spray & Combustion of Gelled Hypergolic Propellants	**Army Research Office**	6/1/2008–5/31/2011	26,042
	CO-PI	Studies and Support of Project Constellation	**University Of Maryland**	10/1/2007–9/30/2008	52,518
Meyer, Scott	**PI**	Advanced Injector Designs for Hydrocarbon Liquid Rocket Engine Components	**Sierra Engineering Inc.**	10/15/2007–8/15/2008	29,000
	PI	Regulator Panel Test	**IN Space, LLC**	3/1/2008–7/31/2008	5,000
	PI	Spark Ignition Testing	**Sierra Engineering Inc.**	8/1/2007–9/30/2007	7,500
	PI	Wear-In Development/ Life Testing of GK 82% Gas Generator	**General Kinetics, LLC**	9/1/2007–3/31/2008	27,933
Pipes, R. Byron	**CO-PI**	Integrated Lightweight C4ISR Electronics Shelter Support	**Aeronautical Radio, Inc. - ARINC**	6/30/2006–6/12/2008	90,141
Pourpoint, Timothée	**PI**	Catalyst Bed 90% H2O2	**Sandia National Laboratories**	9/6/2007–9/30/2007	14,237
	PI	Heat Transfer Characterization of Metal Organic Frameworks for Cryo-adsorption of Hydrogen Gas	**General Motors Corp**	3/17/2008–3/16/2009	75,437
Rotea, Mario	**CO-PI**	A Noninvasive Sensor / Control Suite For Health Monitoring And Extended Life Of Aircraft Generation Systems	**P. C. Krause And Associates, Inc.**	8/1/2006–9/30/2007	4,500
Schneider, Steven	**CO-PI**	Studies and Support of Project Constellation	**University Of Maryland**	10/1/2007–9/30/2008	74,401
	PI	Collaborative Research: Crossflow-Induced Boundary-Layer Transition on Re-Entry Vehicles Revision 3	**Sandia National Laboratories**	10/1/2006–9/30/2009	48,000

	PI	Measurements of the Mechanisms of Laminar-Turbulent Transition of the Mach-6 Quiet Tunnel	**Air Force Office Of Scientific Research**	3/1/2006–11/30/2008	120,000
	PI	Quantitative Global Heat Transfer in a Mach-6 Quiet Tunnel	**NASA**	1/1/2008–12/31/2010	54,415
	PI	Towards High-Reynolds-Number Quiet Flow in Hypersonic Wind Tunnels: FY07 Supplemental Funds to Support X-51 Tripping Experiments	**Air Force Office Of Scientific Research**	3/1/2006–11/30/2008	67,000
	PI	Towards Mechanism-Based Models for Laminar-Turbulent Transition on a Representative Airbreathing Forebody - Sup. 1	**NASA**	3/1/2007–2/28/2010	100,000
	PI	Towards Mechanism-Based Models For Laminar-Turbulent Transition on a Representative Airbreathing Forebody - Supplement 2	**NASA**	3/1/2007–2/28/2010	100,000
Sullivan, John	**CO-PI**	GOALI: Micro/Meso Scale Characterization of Interface Phenomena in Environmentally Clean Machining	**National Science Foundation**	9/1/2007–8/31/2009	30,000
	CO-PI	Innovative Reconfigurable Wing Designs For Future Short Take-Off And Landing Aircraft	**NextGen Aeronautics, Inc.**	8/1/2007–9/16/2008	12,000
	CO-PI	Quantitative Global Heat Transfer in a Mach-6 Quiet Tunnel	**NASA**	1/1/2008–12/31/2010	163,244
	PI	PLM Membership-Siemens PLM Software	**Boeing Company, The**	5/13/2004–12/31/2075	15,000
	PI	Product Lifecycle Management (PLM) Center of Excellence Membership	**Boeing Company, The**	5/13/2004–12/31/2075	50,000
	PI	Product Lifecycle Management Center of Excellence (PLM)	**Boeing Company, The**	5/13/2004–12/31/2075	100,000
Sun, Chin-Teh	**CO-PI**	Damage Tolerance of Composite Structure	**Federal Aviation Administration**	8/17/2007–5/31/2009	32,500
	CO-PI	Damage Tolerance of Composite Structures	**Federal Aviation Administration**	9/1/2004–5/31/2009	32,500
	CO-PI	Development & Testing of Innovative Health Management Tools for Damage Detection, Evaluation & Repair of the CH-35K Composite Rotor Blades & Structure	**CACI International Inc.**	9/19/2007–4/15/2009	135,000
	CO-PI	Development and Testing of Innovative Health Management Tools for Damage Detection, Evaluation, and Repair of the CH-53K Composite Rotor Blades & Stru	**CACI International Inc.**	9/19/2007–4/15/2009	33,000
	PI	Development of Flexible Extremities Protection	**Tuskegee University**	11/18/2004–5/17/2009	70,000
	PI	Development Of Multifunctional Nanocomposites For Ship Structures	**Office Of Naval Research**	4/1/2005–12/31/2008	6,625
	PI	Development of Toughened and Multifunctional Nanocomposites for Ship Structures	**Office Of Naval Research**	4/1/2005–12/31/2008	135,255

Weisshaar, Terrence	**CO-PI**	Innovative Reconfigurable Wing Designs For Future Short Take-Off And Landing Aircraft	**NextGen Aeronautics, Inc.**	8/1/2007–9/16/2008	6,000
	PI	Future Directions for Structural Mechanics-Fundamental Research Issues	**Air Force Office Of Scientific Research**	12/1/2006–8/31/2008	49,808

GRADUATE THESES

July 2006 to June 2008

MASTER'S THESES

Student/ ***Major Professor***	**Thesis Title**	**Degree** **Date Granted**
Delgado, Jorge *I. Hrbud*	"Design and Validation of a Test Facility for Coaxial Radio Frequency Plasma Thrusters"	M.S. August 2006
Joshi, Manasi *B. Pipes*	"Effect of Temperature on Mode I Fracture Toughness of Certain Polymeric Foams"	M.S. August 2006
MacDonald, Megan *S. Heister*	"on the Nonlinear Dynamic Response of Plain Orifice Atomizers/Injectors"	M.S. August 2006
Manning, Robert *S. Collicott*	"Gas Bubble Stability in a Sphere Layer"	M.S. August 2006
Oliver, A. Brandon *G. Blaisdell* *A. Lyrintzis*	"Validation of High-Speed Turbulent Boundary Layer and Shock-Boundary Layer Interaction Computations with the OVERFLOW Code"	M.S. August 2006
Saheba, Ruchir *M. Rotea*	"Real-Time Thermal Observer for Electric Machines"	M.S. August 2006
Smith, Randolph *C. Merkle*	"Computational Modeling of High Frequency Combustion Instability in a Single-Element Liquid Rocket Engine"	M.S. August 2006
Wennerberg, Jason *W. Anderson*	"An Experiment to Study the Effects of Aspect Ratio on Rocket Thrust Chamber Cooling Channel Performance"	M.S. August 2006
Haberlen, Philip *W. Anderson*	"Supercritical Fuel Film Cooling in a RP-1/Gox Staged Combustion Rocket"	M.S.E. December 2006
Heckler, Gregory *J. Garrison*	"Implementation and Testing of an Unaided Method for the Acquisition of Weak GPS C/A Code Signals"	M.S. December 2006
Juliano, Thomas *S. Schneider*	"Nozzle Modifications for Quiet Flow to High Reynolds Number in the Boeing/AFOSR Mach-6"	M.S. December 2006
Khoo, Teng Thuan *H. Kim*	"Effect of Bondline Thickness on Mixed-Mode Fracture of Adhesive Joints"	M.S. December 2006
Nakaima, Daniel K. *C. T. Sun*	"Ductile Fracture of Polycarbonate"	M.S. December 2006

Nightingale, Jay M. *H. Kim*	"Experimental Correlation Between Instrinsic Material Properties and the Failure of Composite Laminates under Ice Impact"	M.S.E. December 2006
Ozimek, Martin *K. C. Howell*	"A Low Thrust Transfer Strategy to Earth-Moon Colinear Libration Point Orbits"	M.S. December 2006
Childress, Karla *C. Merkle*	"Supersonic Analysis of Plume Characteristics for Asymmetric Nozzles"	M.S. December 2006
Grinham, Matthew J. *A. F. Grandt, Jr.*	"Parametric Study of Damager Containment Features in Integral Structures for Optimum Crack Retardation"	M.S. December 2006
Karni, Etan *J. Sullivan*	"Experimental Characterization of Opposed Oscillating Wings for a Hovering MAV"	M.S. December 2006
Rodkey, Samuel C. *S. Heister*	"Dynamics of Bearing Chamber Air and Oil Flows in Gas Turbine Engines"	M.S. December 2006
Sindiy, Oleg *D. DeLaurentis*	"A System-of-Systems Framework for Improved Decision Support in Space Exploration"	M.S. December 2006
Byron, Jennifer *K. C. Howell*	"Maneuver Costs to Transfers Between Halo and Halo-Like Orbits in the Circular Restricted Three-Body Problem"	M.S. August 2007
Droppers, Lloyd *W. Anderson*	"Study of Heat Transfer in a Gaseous Hydrogen Liquid Oxygen Multi-Element Combustor"	M.S. August 2007
Gujarathi, Amit *C. Merkle*	"Analysis of an Axisymmetric Rocket Based Combined Cycle Engine"	M.S.E. August 2007
Jaron, Jacqueline *S. Collicott*	"Static Two-Phase Solutions in Laterally-Compressed Circular Cylinders in Zero Gravity"	M.S.E. August 2007
Pinheiro, Jacob R. *J. Sullivan*	"Aerodynamic Characteristics and Dynamic Modeling of a Lenticular Airship"	M.S.E. August 2007
Schuff, Reuben *W. Anderson*	"Experimental Investigation of Asymmetric Heating in a High Aspect Ratio Cooling Channel"	M.S. August 2007
Wilson, Gregory S. *A. F. Grandt, Jr.*	"Improving Fatigue Crack Growth Performance of Structural Components through Consideration of Residual Stress in Design and Manufacture"	M.S. August 2007
Dambach, Erik M. *S. Heister*	"Development of a Hybrid Rocket Engine for Evaluation of Altitude Compensation using Ablative Nozzle Liners"	M.S. August 2007

Davendralingam, N. *J. Doyle*	"Modeling of Flexible Structures"	M.S. August 2007
Kloeden, Richard *A. F. Grandt, Jr.*	"Modeling Crack Propagation in Modern Stiffened Fuselage Structures"	M.S. August 2007
Segura, Rodrigo *S. Schneider*	"Oscillations in a Forward-Facing Cavity Measured Using Laser-Differential Interferometry in a Hypersonic Quiet Tunnel"	M.S. August 2007
Braun, Jonathan *S. Collicott*	"Zero Gravity Two-Phase Stability Solutions of Droplets in a Bent Circular Cylinder"	M.S. May 2008
Cashbaugh, Jasmine *D. DeLaurentis*	"An Agent-Base Modeling Approach to a Study of the Effects of Network Logic and a New Aircraft Design on an Air Force Supply Network Located in the Middle East"	M.S. May 2008
Chigullapalli, Sruti *A. Alexeenko*	"High-Order Numerical Methods for the Boltzmann Transport Equations for Non-Equilibrium Gas Flows"	M.S. May 2008
Hahn, Jeeyeon *I. Hwang*	"Rule-Based Conflict Resolution for the Next Generation Air Transportation System"	M.S. May 2008
Otterstater, Matthew *S. Heister*	"Design of an Altitude Simulation Facility for Testing Ablative Nozzle Liners"	M.S. May 2008

DOCTORAL THESES

Student/ ***Major Professor***	**Thesis Title**	**Degree** **Date Granted**
Bing,Qida *C. T. Sun*	"Characterizing Compressive and Fracture Strengths of Fiber Reinforced Composites Using Off-Axis Specimens"	Ph.D. August 2006
Canino, J. V. *S. D. Heister*	"Numerical Analysis of Coaxial Swirl Injectors"	Ph.D. August 2006
Lee, J. *H. Kim*	"Prediction of Adhesive Stress and Strain Solution and Failure Criterion of Single Lap Bonded Joints"	Ph.D. August 2006
Sung, I.-K. *W. Anderson*	"Fatigue Life Prediction of Liquid Rocket Engine Combustor with Subscale Test Verification"	Ph.D. August 2006
Chandra, Budi Wijaya *A. F. Grandt, Jr.*	"Flows in Turbine Engine of Oil Sumps"	Ph.D. December 2006
Kim, Jeesoo *A. F. Grandt, Jr.*	"Characterization of Fatigue Crack Growth in Unitized Construction"	Ph.D. December 2006
Landau, Damon *J. Longuski*	"Strategies for the Sustained Human Exploration of Mars"	Ph.D. December 2006
Okutsu, Masataka *J. Longuski*	"Design of Human Missions to Mars and Robotic Missions to Jupiter"	Ph.D. December 2006
Porras Alonso, German *K. C. Howell*	"The Design of System-to-System Transfer Arcs Using Invariant Manifolds in the Multi-Body Problem"	Ph.D. December 2006
Shimo, Masayoshi *S. Heister*	"Multicyclic Detonation Initiation Studies in Valveless Pulsed Detonation Combustors"	Ph.D. December 2006
Ayoubi, Mohammad Ali *J. Longuski*	"Analytical Theory for the Motion of Spinning Rigid Bodies"	Ph.D. May 2007
Kumari, Shyama *T. Farris*	"Geometry Deviation and Load History Effect Investigation for Constant and Variable Amplitude Fretting Fatigue of Ti-6Al-4V Using Different Life Prediction Approaches and Statistical Analysis"	Ph.D. May 2007
Richardson, Renith *S. Heister*	"Linear and Nonlinear Dynamics of Swirl Injectors"	Ph.D. May 2007

Nusawardhana, A. *W. Crossley*	"Dynamic Programming Methods for Concurrent Design and Dynamic Allocation of Vehicles Embedded in a System-of-Systems"	Ph.D. August 2007
Park, Myounggu *H. Kim*	"Deformation Dependent Electrical Resistance of MWCNT Layer and MWCNT/PEO Composite Films"	Ph.D. August 2007
Sisco, James *W. Anderson*	"Measurement and Analysis of an Unstable Model Rocket Combustor"	Ph.D. August 2007
Corpening, Jeremy *C. Merkle &* *I. Hrbud*	"Computational Analysis of a Pulsed Inductive Plasma Accelerator"	Ph.D. May 2008
Frommer, Joshua *W. Crossley*	"System of Systems Design: Evaluating Aircraft in a Fleet Context Using Reliability and Non-Deterministic Approaches"	Ph.D. May 2008
Kothari, Rushabh *C. T. Sun*	"Design and Analysis of Multifunctional Structures for Embedded Electronics in Unmanned Aerial Vehicles"	Ph.D. May 2008
Lana, Carlos *M. Rotea*	"Constrained Control and State Estimation"	Ph.D. May 2008
Millard, Lindsay *K. Howell*	"Control of Spacecraft Imaging Arrays in Multi-Body Regimes"	Ph.D. May 2008
Qian, Haiyang *C.T. Sun*	"A Study of Failure in Bonded Lap Joints Using Fracture Mechanics"	Ph.D. May 2008
Raghavan, Seetha *P.K. Imbrie*	"The Development of Photo-Stimulated Luminescence Spectroscopy for 3-D Stress Measurements"	Ph.D. May 2008
Syn, Chul Jin *W. Chen*	"Dynamic Interfacial Fracture in a Glass Fiber Composite and Bi-Material (A1/Epoxy)	Ph.D. May 2008
Yam, Chit Hong *J. Longuski*	"Design of Missions to the Outer Planets and Optimization of Low-Thrust Gravity-Assist Trajectories via Reduced Parameterization"	Ph.D. May 2008

COLLOQUIUM SERIES

July 2006 to June 2008

FALL 2006
COLLOQUIUM SERIES

DATE/TIME	TOPIC	SPEAKER
September 21, 2006 3:00 p.m. GRIS 180	"NTSB—Procedures and Past Accidents"	**Scott Warren** Team Leader – Aircraft Systems Investigations National Transportation Safety Board Washington, DC
October 5, 2006 3:00 p.m. GRIS 180	"FRESH FX Flight 1 Experiment Design"	**Roger Kimmel** Air Vehicles Directorate Air Force Research Lab, WPAFB, OH
October 12, 2006 3:00 p.m. GRIS 180	"Advanced Metallic and Hybrid Structural Concepts for Future Aircraft and Associated Technology Development Opportunities"	**Dr. Markus Heinimann & Dr. Robert Bucci** Alcoa, Inc., Alcoa Technical Center Alcoa Center, PA
October 18, 2006 3:00 p.m. POTR 234-Fu Rm.	"High Strain Rate Response of Materials at Different Temperatures"	**Prof. Veli-Tapani Kuokkala** Institute of Materials Science Tampere University of Technology Tampere, Finland
October 19, 2006[§] 3:00 p.m. GRIS 180	"Skunk Works: Creating an Environment for Innovation"	**Frank Cappuccio** Exec. Vice Pres. & General Mgr. Skunk Works Lockheed Martin Aeronautics
October 27, 2006 1:30 p.m. GRIS 180	Update on 747-8 and 787 Programs	**Roy A. Eggink** Chief Engr. 747 Product Development **David N. Loffing** Airplane Config. Design. Engr. **Wayne Tygert** Loads & Dynamics Unit Chief Boeing Commercial Airplanes
November 2, 2006 3:00 p.m. GRIS 180	"Nano/Micro/Meso-Scale Rarefield Flows Driven by Temperature of Pressure Gradients"	**E. Phillip Muntz** University of Southern California Los Angeles, CA
November 9, 2006 3:00 p.m. GRIS 180	"Industrial Applications of CFD: Aerospace and Automotive—The View of a Commercial CAE Vendor"	**Dr. Evangelos Koutsavdis** Automotive Aerodynamics & Thermal Management Team ANSYS-Fluent Inc

November 16, 2006 3:00 p.m. GRIS 180	"Key Technology of Flight Control System"	**Dr. Shaoping Wang** Mechatronic Department School of Automation Science and Electrical Engineering Beihang Univ., P.R. China
November 30, 2006 3:00 p.m. GRIS 180	"from Particle Packing to Material Failure: High-Performance Multi-scale Modeling"	**Dr. Karel Matous** Research Scientist, Center for Simulation of Advanced Rockets Adjunct Assistant Professor Department of Aerospace Engineering University of Illinois at Urbana-Champaign
December 7, 2006 3:00 p.m. GRIS 180	"Launching to the Moon, Mars, and Beyond"	**Daniel L. Dumbacher** Deputy Director NASA Exploration Launch Projects Office Marshall Space Flight Center

SPRING 2007
COLLOQUIUM SERIES

DATE/TIME	TOPIC	SPEAKER
January 18, 2007 3:00 p.m. GRIS 180	"Multiple Scale Modeling of Deformation and Damage in Composite and Polycrystalline Materials"	**Dr. Somnath Ghosh** Computational Mechanics Research Lab. Department of Mechanical Engineering The Ohio State University
January 26, 2007[†] 2:00 p.m. ME 117	"Stress-induced Transformation in Polycrystalline Shape-memory Alloys"	**Dr. Kaushik Bhattacharya** Prof. of Mechanics & Materials Science California Institute of Technology
February 1, 2007 3:00 p.m. GRIS 180	"Mechanical Behavior of Polymeric Nanofibers Subject to Cold Drawing"	**Ioannis Chasiotis** Aerospace Engineering Univ. of Illinois @ Urbana-Champaign
February 7, 2007 2:30 p.m. ME 116	"Modeling Glass Strength under Static and Dynamic Loadings using Continuum Damage Mechanics and Fracture Mechanics Approach"	**Xin (Shin) Sun** Chief Scientist & Information Sciences Directorate Pacific Northwest National Laboratory
February 8, 2007 3:00 p.m. GRIS 180	"Modeling the Impact, Damage and Penetration of Silicon Carbide"	**Timothy Holmquist & Gordon Johnson** Network Computing Services Minneapolis,MN
February 22, 2007 3:00 p.m. GRIS 180	"Investigation into Windage Power Loss from a Spiral Bevel Gear using Computational and Experimental Methods"	**Kathy Simmons and Graham Johnson** University of Nottingham Rolls-Royce University Technology Center in Gas Turbine Trans. Systems
March 8, 2007 3:00 p.m. GRIS 180	"Progress Towards a MEMS-Based Monopropellant Micropropulsion System"	**Darren L. Hitt** Assoc. Prof. of Mechanical Engineering School of Engineering University of Vermont
March 28, 2007[‡] 1:00 p.m. Fowler Hall, Stewart Center	"System Engineering and the Two Cultures of Engineering"	**Michael Griffin** Administrator NASA
March 28, 2007[‡] 10:30 a.m. GRIS 166	"Intelligent Centerless Grinding: Increasing Precision and Productivity"	**Dr. Iván Gallego** Manufacturing Department Mondragon University Mondragon, Spain

March 29, 2007 3:00 p.m. GRIS 180	"Sensors, Topology, and Minimality: Turning Dumb Sensors into Smart Systems"	**Robert Ghrist** Professor Department of Mathematics Co-ordinated Science Laboratory University of Illinois @ Urbana-Champaign
March 30, 2007[†] 2:30 p.m. ME 116	"Bacterial Microfluidics—The Science and Engineering of Bacterial Flagellar Propulsion"	**Kenny Breuer** Division of Engineering Brown University
April 5, 2007 3:00 p.m. GRIS 180	"Gas-Turbine Heat Transfer: Issues, Challenges, and Opportunities"	**Tom I-P. Shih** Professor and Chair Department of Aerospace Engineering Iowa State University
April 12, 2007 3:00 p.m. GRIS 180	"Aeroscraft—the New Type of Air Vehicle"	**Igor Pasternak** CEO and President Worldwide Aeros Corporation
April 19, 2007 1:45 p.m. STEW 302	"Fly me to the Moon—A Trip Down Memory Lane"	**R. Joseph Cassady** Aerojet Chief Engineer Ares Launch Vehicle Program
April 26, 2007 3:00 p.m. GRIS 180	"Challenges and Opportunities in Solid Mechanics of Army Applications"	**Bruce LaMatinna** Chief, Solid Mechanics Branch Army Research Office
May 3, 2007 3:00 p.m. GRIS 180	"Coherent Rayleigh-Brillouin Scattering (CRBS) and Microwave Radar-REMPI Methods for a Gas and Gas Flow Diagnostics"	**Michael Shneider** Department of Mechanical & Aerospace Engineering Princeton University

FALL 2007
COLLOQUIUM SERIES

DATE/TIME	TOPIC	SPEAKER
October 5, 2007† 3:00 p.m.. PHYS 238	"Large Actuation through Electrostriction in Single Crystal Ferroelectrics"	**Guruswami Ravichandran** John E. Goode, Jr., Professor of Aeronautics and Mechanical Engineering California Institute of Technology
October 4, 2007 3:00 p.m. ME 261	"Commercial Human Spaceflight"	**John Gedmark** Executive Director Personal Spaceflight Federation
October 18, 2007 3:00 p.m. ME 261	"Tradeoffs in Safety and Security in Air Traffic Management (ATM)"	**Natasha Neogi** Assistant Professor at the University of Illinois, Urbana-Champaign Department of Aerospace Engineering
November 1, 2007 3:00 p.m. ME 261	"Rarefied Gas Dynamics and its Applications to Vacuum Technology"	**Dr. Felix Sharipov** Associate Proessor Departamento de Física Universidade Federal do Paraná Curitiba, Brazil
November 8, 2007 3:00 p.m. ME 261	"NASA's Airspace Systems Program: Enabling NextGen"	**John A. Cavolowsky** Deputy Director, NASA Airspace Systems Program
November 29, 2007 3:00 p.m. ME 261	"Nonlinear Compressibility Effects in Fluid-Structure Interaction and Their Implications on the Air-Blast Loading of Structures"	**Professor Raul Radovitzky** Aeronautics and Astronautics Massachusetts Institute of Technology

SPRING 2008
COLLOQUIUM SERIES

DATE/TIME	TOPIC	SPEAKER
January 18, 2008† 2:30 p.m. ME 256	"Cellular Force Transmission and Transduction"	**Roger Kamm** Germeshausen Professor of Mechanical and Biological Engineering and Associate Head, Department of Mechanical Engineering Massachusetts Institute of Technology
January 24, 2008 3:00 p.m. ARMS 1109	"Advanced Technologies for U.S. Military Warfighters' Protection"	**Dr. James Q. Zheng** U.S. Army Chief Scientist Project Manager – Soldier Equipment Program Executive Office – Soldier U.S. Army
February 5, 2008 3:30 p.m. ARMS 1010	"The NASA Constellation Program"	**NASA Constellation Team** **Mark Geyer** Orion Project Manager **Claudia Meyer** CUIP Manager **Jeff Rybak** CUIP Deputy Manager **Kevin Tucker** CUIP Virtual Institute Lead for Thrust Chamber Assembly **Richard Tyson** Special Assistant for Exploration Launch Office (Ares)
February 15, 2008 2:30 p.m. ARMS 1109	"Flight Experiments on Laminar Flow Control in Swept-Wing Boundary Layers (An Unlikely Journey of a Mechanician)	**William S. Saric** Aerospace Engineering Texas A & M University
February 21, 2008 3:00 p.m. ARMS 1109	"Recent Research Activities on PSP/TSP Technology with Emphasis on Hypersonic Applications	**Professor Keisuke Asai** Department of Aerospace Engineering Tohoku University Sendai, Japan
February 28, 2008 3:00 p.m. ARMS 1109	"Heterogeneities in Microelectronic Materials: Computational Models for Pores, Particles, and Cracks	**Ganesh Subbarayan** School of Mechanical Engineering Purdue University
February 29, 2008† 2:30 p.m. ME 256	"Inertial Range Dynamics in Density-Stratified Flows"	**James J. Riley** Department of Mechanical Engineering University of Washington Seattle

March 20, 2008 3:00 p.m. ARMS 1109	"Engineering Challenges in Aviation Accident Investigations"	**Thomas E. Haueter** Director Office of Aviation Safety National Transportation Safety Board
March 27, 2008 3:00 p.m. ARMS 1109	"Products Customers Want—The Engine of Your Business"	**Ronald L. Kerber** Executive Vice President Chief Technical Officer (retired) Whirpool Corporation
April 10, 2008‡ 10:00 a.m. Fowler Hall Stewart Center	"Space Policy in an Enlarged European Union"	**Sigmar Wittig** Chairman Emeritus German Aerospace Center
April 10, 2008 3:00 p.m. ARMS 1109	"Some Elastodynamic Problems of Layered Solids"	**Dr. H.Y. (Sean) Yu** Materials Research Engineer Naval Research Laboratory
April 11, 2008 2:30 p.m. ARMS 1021	"Application of MDAO and CFD at Boeing"	**Steve Sawyer** Manager, ET&R's CFD Development and Geometry Group
April 17, 2008 3:00 p.m. ARMS 1109	"Air Travel at the Edge of Chaos: Howe we got here and What to do about it"	**George L. Donahue, Ph.D.** Prof. of Systems Engineering & Operations Research Volgenau School of Information Technology & Engineering George Mason Univ**ersity**
April 24, 2008 3:00 p.m. ARMS 1109	"Inverse Methods for Estimating Heat Flux from Temperature Measurements"	**Ben Blackwell** Blackwell Consulting Corrales, NM

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* Jointly sponsored by the School of Aeronautics & Astronautics and the Student American Institute of Aeronautics and Astronautics Chapter

† Jointly sponsored by the School of Aeronautics & Astronautics and the Mechanical Engineering Dept.; Midwest Mechanics Seminar

‡ William E. Boeing Distinguished Lecture sponsored by the School of Aeronautics and Astronautics Department

§ Charles Rolls and Henry Royce Purdue Memorial Lecture

Highlights & Awards

July 2006 to June 2008

FACULTY HIGHLIGHTS

Several faculty continue their visible service as editors and on various visiting committees.

Other highlights include:

- Professor Dominick Andrisani received the School's 2007 Gustafson Outstanding Teacher Award and the 2007 Elmer F. Bruhn Excellence in Teaching Award.

- Professor John Sullivan was named to the NASA Advisory Council in 2006.
- Professor Mario Rotea was recipient of the 2006 C. T. Sun School of Aeronautics and Astronautics Research Award and named a Fellow of IEEE.
- Professor Steven Schneider received the 2007 C. T. Sun School of Aeronautics and Astronautics Research Award
- Professor Kathleen Howell and AAE Graduate Student, Lindsay Millard received the Best Paper Award at the AAS/AIAA Astrodynamics Conference

- Professors **Steven Collicott** and **James Longuski** were honored at this ceremony. To be included in the Book of Great Teachers, professors and former professors must have served on the

- Professor William Crossley received the 2006 Elmer F. Bruhn Excellence in Teaching Award and the prestigious Dean A. A. Potter Best of Engineering Award.
- Professor Art Frazho received the School's 2006 Gustafson Outstanding Teacher Award.
- Professor Dominick Andrisani received the School's 2007 Elmer F. Bruhn Excellence in Teaching and the 2007 Gustafson Outstanding Teacher Awards.
- Professor Anastasios Lyrintzis received the College of Engineering 2007 Faculty Awards of Excellence

STUDENT HIGHLIGHTS

There are several student organizations with a relationship with the School. They are the Aeronautics and Astronautics Engineering Student Advisory Council (AAESAC); American Institute of Aeronautics and Astronautics (AIAA); Students for the Exploration and Development of Space (SEDS); and Sigma Gamma Tau (SGT). SEDS coordinated the annual Spring Space Forums, the Educational Outreach Program, and each semester host a rocket launch and BBQ. AAESAC hosted "Professor Pizzas," an opportunity for students to interact one-on-one with AAE professors and visiting dignitaries; and "Aero Social Night" a program aimed to provide a social event for professors, students and staff to interact on an informal level. Several student groups continue to perform well in national design competitions, as well as participating in educational outreach programs.

The SEDS Spring Space Forum was held on April 20, 2006 which was organized by SEDS and sponsored by the Indiana Space Grant Consortium. This is an educational community-driven event geared toward generating interest in both students and the public on issues concerning space exploration. Four VIP's took part in the forum and talked about the possibility of returning to the Moon and the potential research that can be done there.

OUTREACH HIGHLIGHTS

More than 600 youngsters from three states and 104 different schools attended the 11th annual Purdue Space Day on November 11, 2006. Guest VIP Astronaut Gregory Harbaugh (BSAAE '78) met with the school students who then participated in several space-related activities. Over 160 Purdue students from 28 majors volunteered their time to run the program. The school's 12th annual Purdue Space Day took place on Saturday November 3, 2007 with Purdue astronaut alumnus, astronaut Mr. Charles D. Walker (BSAE' 71) as guest speaker. Over 400 third through eighth graders from 97 schools in three states, Illinois, Indiana, and Kentucky came to Purdue, with a strong volunteer crew of over 139 Purdue students from 36 majors. Purdue Space Day is sponsored by: the Indiana Space Grant Consortium; School of Aeronautics and Astronautics; Purdue Engineering Student Council (PESC); Daimler Chrysler, United Technologies Corp, Eli Lilly & Co., and Office Max. Purdue Space Day was created in 1996 as an educational outreach activity for students in grades 3 to 8. Participants learn about astronautics and space exploration through hands-on experiences.

Several faculty gave presentations to local schools. Many students of the School take time to interact with students in K-12 and share their excitement of space exploration. The inherent excitement of aerospace leads to these invitations and generates

Curriculum & Course Offerings

July 2006 to June 2008

CURRICULUM AND COURSE OFFERINGS

Course enrollments and summarized class enrollment statistics are listed below:

Course Enrollments
School of Aeronautics and Astronautics
2006-2007 Academic Year

A&AE Course	Most Recent Title	Cr.	Fall 2006		Spring 2007	
			Enroll-ment	Instructor	Enroll.	Instructor
203	Aeromechanics I	3	98	Garrison	68	Corless
204	Aeromechanics II	3	62	Farris	69	Chen
204L	Aeromechanics II Lab.	1	64	Doyle	68	Doyle
251	Intro. Aerosp. Design	3	79	DeLaurentis	76	DeLaurentis
301	Engrg. Systems Anal.	3	81	Frazho	39	Garrison
333	Fluid Mechanics	3	95	Lyrintzis	46	Alexeenko
333L	Fluid Mechanics Lab.	1	93	Collicott	49	Collicott
334	Aerodynamics	3	32	Schneider	90	Collicott
334L	Aerodynamics Lab.	1			57	Collicott
340	Dynamics & Vibration	3	69	Longuski	70	Howell
341	Industrial Practice III	0			6	Williams
342	Industrial Practice IV	0	6	Williams	1	Williams
352	Structural Anal. I	3	71	Sun	47	Grandt
352L	Struct. Anal. I Lab.	1	31	Doyle	44	Doyle
364	Control System Analy.	3	58	Hwang	82	Hwang
364L	Control Systems Lab.	1	72	Frazho	53	Frazho
372	Jet Propl. Power Plt.	3			92	Anderson
412	Intro. Comp. Fluid Dyn.	3	33	Blaisdell		
415	Aerodynamic Design	3	36	Sullivan		
421	Flt. Dyn. Control	3	53	Andrisani	36	Corless
439	Rocket Propulsion	3	71	Hrbud		
440	Spacecr. Attitude Dyn.	3			53	Howell
442	Industrial Practice V	0			1	Williams
450	Spacecraft Design	3	15	Weisshaar	30	Longuski
451	Aircraft Design	3	32	Andrisani	43	Crossley
453	Matr. Meth. Aerosp. Struc.	3			26	Doyle
454	Design Aerosp. Struct.	3	37	Grandt		
490A	Flight Testing				24	Andrisani
490B	Aerosp. Sys. Design	3			32	Weisshaar

A&AE Course	Most Recent Title	Cr.	Fall 2006		Spring 2007	
			Enroll.	Instructor	Enroll.	Instructor
507	Principles of Dynam.	3	28	Longuski		
511	Intro. Fluid Mech.	3	26	Blaisdell		
512	Comput. Aerodyn.	3			33	Merkle
512Q	Comput. Aerodyn.	3			6	Merkle
514	Intermediate Aerodyn.	3			29	Lyrintzis
520	Experimental Aerody.	3			11	Schneider
532	Orbit Mechanics	3	21	Howell		
535	Prop; Des. Build, Test	3			11	Anderson
538	Air Breath. Propul.	3	37	Merkle		
539	Adv. Rocket Prop.	3			36	Heister
546	Aero Struct Dyn Stab.	3	15	Doyle		
547	Exp. Stress Analy.	3			8	Doyle
550	Multidisciplinary Des. Opt.	3	53	Crossley		
550Q	Multidisciplinary Des. Opt.	3	36	Crossley		
551	Des. Theory & Methods	3			34	Crossley
552	Nondes. Eval. Struct. Matrls.	3			37	Grandt
552Q	Nondes. Eval. Struct.	3			8	Grandt
553	Elasticity Aerosp. I	3	27	Doyle		
554	Fatigue Struct. & Matrl.	3	35	Grandt		
554Q	Fatigue Struct. & Matrl.	3	28	Grandt		
555	Mechanics Comp. Matl.	3			28	Sun
555Q	Mechanics Comp. Matl.				5	Sun
558	Finite Elem Meth. in Aerospace Structures	3	36	Kim		
558Q	Finite Elem. Meth. in Aerospace Struct.	3	7	Kim		
559	Mech. of Frict. & Wear	3			10	Farris
564	System Anal. & Synth.	3	26	Corless		
565	Guidance Aerospace Veh.	3			4	Andrisani
567	Intro. Appl. Stoch. Proc.	3			42	Frazho
575	Intro. Sate. Nav. & Pos.	3	6	Garrison		
590A	Exp. Char. Of Adv. Composite Matrls.	3	2	Pipes	2	Pipes
590D	Molecular Gas Dyn.	3	7	Alexeenko		
590E	Intro. Electric Propul.	3			25	Hrbud
590F	Dyn. Behav. Matrls.	3	7	Chen		
590K	Sys. of Sys. Model. & Anal.	3			30	DeLaurentis
590M	Manuf. of Adv. Comp.	3			1	Pipes
590 N	Intro. to Labview	3	6	Filmer		
590R	Aerosp. Propulsion	3	9	Anderson		
590W	Appl. Opt. Contrl. & Est.	3			21	Hwang

A&AE Course	Most Recent Title	Cr.	Fall 2006		Spring 2007	
			Enroll.	Instructor	Enroll.	Instructor
590Z	Satellite Systems	3			1	Filmer
607	Variable Princ. of Mech.	3			11	Longuski
613	Viscous Flow Theory	3	12	Schneider		
615	Aeroacoustics	3	10	Lyrintzis		
626	Turb. & Turb. Modeling	3			24	Blaisdell
630	Stability of Free Surfaces	3	11	Heister		
632	Adv. Orbital Mech.	3	18	Howell		
654	Fracture Mechanics	3	13	Sun		
666	Nonlin. Dyn. Syst. Control	3	23	Corless		
690G	Astro. Nav. & Guidance	3			8	Garrison
698	M.S. Thesis Research	–				
699	Ph.D. Thesis Research	–				

CURRICULUM AND COURSE OFFERINGS

Course enrollments and summarized class enrollment statistics are listed below:

Course Enrollments
School of Aeronautics and Astronautics
2007-2008 Academic Year

A&AE Course	Most Recent Title	Cr.	Fall 2007		Spring 2008	
			Enroll.	Instructor	Enroll.	Instructor
203	Aeromechanics I	3	153	Howell	79	Wawrzyniak
204	Aeromechanics II	3	52	Imbrie	117	Farris
204L	Aeromechanics II Lab.	1	48	Doyle	115	Doyle
241	Industrial Practice I	0	10	Williams	2	Williams
242	Industrial Practice II	0	3	Williams		
251	Intro. Aerosp. Design	3	99	DeLaurentis	101	DeLaurentis
301	Engrg. Systems Anal.	3	96	Frazho	50	Frazho
333	Fluid Mechanics	3	82	Alexeenko	42	Alexeenko
333L	Fluid Mechanics Lab.	1	76	Sullivan	37	Sullivan
334	Aerodynamics	3	44	Collicott	74	Blaisdell
334L	Aerodynamics Lab.	1	24	Sullivan	31	Sullivan
340	Dynamics & Vibration	3	77	Longuski	42	Howell
342	Industrial Practice IV	0	2	Williams	1	Williams
352	Structural Anal. I	3	55	Weisshaar	53	Chen
352L	Struct. Anal. I Lab.	1	27	Doyle	46	Doyle
364	Control System Analy.	3	49	Hwang	60	Hwang
364L	Control Systems Lab.	1	67	Frazho	58	Frazho
372	Jet Propl. Power Plt.	3	20	Qiao	71	Qiao
412	Intro. Comp. Fluid Dyn.	3	46	Blaisdell		
418	Zero Grav. Flt. Exper.	3	7	Collicott		
421	Flt. Dyn. Control	3	73	Andrisani	32	Andrisani
439	Rocket Propulsion	3	74	Hrbud		
440	Spacecr. Attitude Dyn.	3			51	Howell
442	Industrial Practice V	0	1	Williams		
450	Spacecraft Design	3	16	Anderson	39	Longuski
451	Aircraft Design	3	31	Andrisani	27	Crossley
453	Matr. Meth. Aerosp. Struc.	3			14	Doyle
490A	Applied Aerodynamics	3			20	Williams
490B	Aerosp. System Design	3			35	Weisshaar
490F	Flight Testing	3			22	Andrisani
490R	Design Build Test				21	Sullivan
507	Principles of Dynam.	3	41	Longuski		
507Q	Principles of Dynam.	3	9	Longuski		
508	Optimiz. Aerosp. Engr	3			53	Longuski

A&AE Course	Most Recent Title	Cr.	Fall 2007		Spring 2008	
			Enroll.	Instructor	Enroll.	Instructor
508Q	Optimiz. Aerosp. Engr.	3			3	Longuski
511	Intro. Fluid Mech.	3	46	Blaisdell		
512	Comput. Aerodyn.	3			14	Merkle
514	Intermediate Aerodyn.	3			39	Lyrintzis
514Q	Intermediate Aerodyn.				6	Lyrintzis
515	Rotorcraft Aerodyn.	3	28	Lyrintzis		
515Q	Rotorcraft Aerodyn.	3	8	Lyrintzis		
518	Low-Grav. Fluid Dyn.	3			4	Collicott
519	Hyper. Aerothermo.	3	13	Schneider		
520	Experimental Aerody.	3			9	Schneider
532	Orbit Mechanics	3	27	Howell		
535	Prop; Des. Build, Test	3			17	Anderson
537	Hypersonic Propulsion	3	23	Heister		
538	Air Breath. Propul.	3	41	Merkle		
538Q	Air Breath. Propul.	3	4	Merkle		
539	Adv. Rocket Prop.	3			39	Heister
546	Aero Struct Dyn Stab.	3	39	Doyle		
550	Multidisciplinary Des. Opt.	3	60	Crossley		
550Q	Multidisciplinary Des. Opt.	3	32	Crossley		
553	Elasticity Aerosp. I	3	23	Sun		
555	Mechanics Comp. Matl.	3			28	Sun
558	Finite Elem Meth. in Aerospace Structures	3	42	Farris		
564	System Anal. & Synth.	3	33	Frazho		
567	Intro. Appl. Stoch. Proc.	3			17	Frazho
590D	Molecular Gasdyn.	3	11	Alexeenko		
590E	Intro. Electric Propul.	3			11	Hrbud
590F	Dyn. Behav. Matrls.	3	5	Chen		
590K	Sys. of Sys. Model. & Anal.	3			21	DeLaurentis
590N	Intro. to Labview	3	6	Filmer	6	Filmer

A&AE Course	Most Recent Title	Cr.	Fall 2007		Spring 2008	
			Enroll.	Instructor	Enroll.	Instructor
646	Elastic Wave Propag.	3			6	Doyle
690B	Hybrid Sys. Theory & Apps.	3			13	Hwang
690D	Sel. Topics Nonlinear Mech.				11	Doyle
698	M.S. Thesis Research	–				
699	Ph.D. Thesis Research	–				

Aerospace Engineering Requires a Multidisciplinary Curriculum

Required Introductory 251-Introduction to Aerospace Design; 203 Aeromechanics I (statics/dynamics)			
Aerodynamics	*Dynamics and Control*	*Propulsion*	*Structures and Materials*
Required Undergraduate			
333-Fluid Mechanics & Lab. 334-Aerodynamics and Lab	340-Dynamics and Vibrations 364-Controls and Lab 421-Flight Dynamics or 440-Spacecraft Att. Dynamics	372-Jet Propulsion or 439-Rocket Propulsion	204-Aeromech. II (Str of Mat.) and lab 352-Structural Analysis & Lab
Undergraduate Electives			
412-Intro to CFD 414-Compressible Aero 416-Viscous Flows 415-Aerodynamic Design	421-Flight Dynamics or 440-Spacecraft Att. Dynamics 490A-Flight Testing 490R-Control Systems Design	372-Jet Propulsion or 439-Rocket Propulsion 590C-Propulsion Design	453-Matrix Methods in Struct. 454-Structural Design
Multidisciplinary Required	301-Signals for Aero. Systems;		
Required Capstone Design	450-Spacecraft Design or 451-Aircraft Design		
Multidisciplinary Electives	490E-Introduction to Satellite Systems; 490B-Aerospace Systems Design; 490S-Satellite Design		
Undergraduate/ Graduate Electives			
511-Intro. to Fluid Mech. 512-Computational Aero 514-Intermediate Aero 515-Rotorcraft Aerodynamics 518-Low Gravity Fluid Mech. 519-Hypersonic Aero. 520-Experimental Aero. 590D-Molecular Gas Dynam 613-Viscous Flow Theory 615-Aerocoustics 624-Lam-Tur Transition 626-Turbulence	564-Systems Anal. and Control 565-Guidance and Control 567-Intro to Stochastic Proc. 590W-Estimation Theory 660-Operator Methods 666-Nonlinear Dynamics 696-Multivariable Control **Astrodynamics** 507-Basic Mechanics 508-Optimization in Aero. Eng. 532-Orbital Mechanics 575-Satellite Nav and Pos 607-Var Prin of Mechanics 632-Adv Orbital Dynamics 690G-Astro Navig. & Guidance	537-Hypersonic Propulsion 538-Air Breathing Propulsion 539-Adv. Rocket Propulsion 590E-Electrical Propulsion 590R-Aerospace Propulsion 630-Stability of Free Surfaces 637-Future Prop Concepts 690C-Combustion Stability **Aerospace Systems** 550-MDO 551-Design Th and Methods 590K-Systems of Systems 690B-Hybrid Systems	546-Struct. Dyn and Stability 547-Experimental Stress Anal. 552-NDE of Struct and Mat. 553-Elasticity in Aero. Eng 554-Fatigue in Struct. and Mat. 555-Mech. of Composite Mat. 556-Aeroelasticity 558-Finite Element Methods 559-Mech. of Friction & Wear 590F-Dynamic Behav of Mater 590M-Manufac. of Adv Compos 646-Elastic Wave Propaga 654-Fracture Mechanics 655-Adv Topics in Composites

Summarized Class Enrollment Statistics
for the 2006-2007 Academic Year

Semester	Statistic	Three-Credit Courses				One-Credit Laboratory Courses
		100, 200, 300, 400, Levels	500 Levels	600 Level	All Levels	
Fall of 2006	No. of classes offered	16	15	5	37	5
	Total Enrollment	923	394	74	1391	266
	Average number of students per class	58	26	15	38	53
Spring of 2007	No. of classes offered	18	18	5	41	5
	Total enrollment	923	18	5	41	5
	Average number of students per class	51	21	12	33	54

(does not include AAE 490 special projects, 590, 698 and 699)

Summarized Class Enrollment Statistics
for the 2007-2008 Academic Year

Semester	Statistic	Three-Credit Courses				One-Credit Laboratory Courses
		100, 200, 300, 400, Levels	500 Levels	600 Level	All Levels	
Fall of 2007	No. of classes offered	16	16	0	32	6
	Total Enrollment	974	487	0	1461	248
	Average number of students per class	61	30	0	46	41
Spring of 2008	No. of classes offered	19	16	3	37	6
	Total enrollment	957	335	19	1311	293
	Average number of students per class	50	21	10	35	49

(does not include AAE 490 special projects, 590, 698 and 699)

STAFF FOR THE 2006-2008 ACADEMIC YEARS

Administrative Assistants

Ann Broughton, Linda Flack, Terri Moore

Business Office

Craig Hamaker, Joan Jackson, Kara Munson, Angie Nobile

Clerical

Lisa Crain, Karen Johnson, Paula Kerkhove, Jennifer LaGuire

Professional

Scott Meyer, Timothée Pourpoint, Guoping Xia, Nathan Wight

Technical

Madeline Chadwell, Gerald Hahn, Michelle Kidd, Joe Kline, John Phillips, David Reagan, Robin Snodgrass, Jim Younts

Staff

Administrative Staff

Ann Broughton, Administrative Assistant

Linda Flack, Graduate Program Administrator

Terri Moore, Administrative Assistant

Business Office

Craig Hamaker, Business Office Manager

Joan Jackson, Account Clerk

Kara Munson, Account Clerk

Angela Nobile, Account Clerk

Clerical Staff

Lisa Crain, Secretary

Karen Johnson, Information Processing Systems Operator

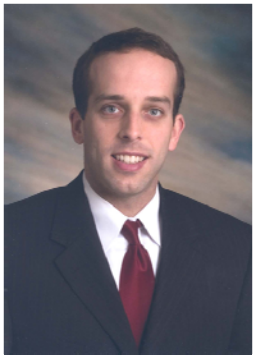
Paula Kerkhove, Secretary

Jennifer LaGuire, Secretary

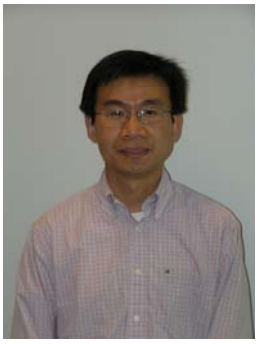
Professional Staff

Scott Meyer, Senior Engineer

Timothée Pourpoint,
Senior Research Scientist



Nathan Wight, Director of
Communications and Development



Guoping Xia,
Senior Research Scientist

Technical Staff

Madeline Chadwell,
Machine Shop Supervisor

Gerald Hahn, Machinist

Michelle Kidd, Assistant Operations
Service Coordinator

Joseph Kline,
Computer System Analyst

John Phillips, Electronics Specialist

David Reagan, Shop Technician

Robin Snodgrass, Machinist

James Younts, Machinist