Division of Engineering and Weapons

CAPT William R. Rubel, USN
Director

Aerospace Engineering Department

CDR Robert J. Niewoehner, USN
Chair

Research in the Aerospace Engineering Department covered a broad range of topics from astrophysics to practical engineering design of propellers. The publications and presentations by the department faculty reflect interest in both highly theoretical topics and very practical long time concerns to the flying community. Although the capstone courses are not explicitly listed, midshipmen and faculty advisers were aligned with research and current interests in other government agencies. Scientists and engineers from the National Air and Space Administration (NASA), the Naval Space Command, and the Center for Naval Analysis assisted in review and evaluation of midshipmen projects. This occasionally leads to follow-on research and midshipmen opportunities. By use of numerical methods and sophisticated computer graphics techniques, extensive work of interest to the Navy and Coast Guard was carried out and published concerning ship hull-superstructure interaction.

The research efforts of the aerospace engineering faculty and students have benefited the Naval Academy in three fundamental areas: (1) midshipmen have had opportunities to participate in research work at the leading edge of both aeronautical and astronautical engineering technology, (2) the Defense Department has been the beneficiary of the Academy's extensive computer and manpower resources, and (3) faculty participation in developments in the field of aerospace engineering has enhanced the learning process in the classroom, from the most fundamental courses to the sophisticated design course projects.

Support for research has come from various sources including NASA, the Naval Space Command, the Naval Research Laboratory (NRL), the U.S. Air Force Space Test Program, and the Naval Air Systems Command. Ongoing research in cooperation with other engineering departments (to be reported in the future) into composite materials is being supported by the Great Lakes Composite Consortium.

Sponsored Research Projects

Space Technology Series

Researcher: Professor Daryl G. Boden (Editor)
Sponsor: Department of Astronautics, U. S. Air Force Academy

The Space Technology Series is a series of books that focus on the process of moving from a mission need, through the systems' acquisition phase, to an operational space mission. The Department of Astronautics at the United States Air Force Academy has provided program management and editorial support for the project for the past ten years. Funding for the project has come from numerous sources, including Navy funding.

The series includes books describing all aspects of space mission design. As the number of books increases, the level of detail of the books increases (more detail on a particular topic). A goal of the series is to capture the knowledge and experience of engineers who have worked in the space business from its inception before these engineers retire.

The Aerospace Engineering Department is a partner in the program management of this project. Specific tasks include looking for funding support from Navy agencies, providing editorial support for the books, identifying potential authors to contribute to the books, and writing selected chapters.

The Abrupt Wing Stall (AWS) Project

Researcher: Professor Gabriel N. Karpouzian
Sponsor: Office of Naval Research (ONR)

Unsteady wing surface pressure on an 8% scale of an F/A 18E model was measured in Langley's Transonic Dynamic Tunnel. After experimenting with different methods, Welch's method was chosen to perform spectral analysis on the unsteady pressure data in order to uncover the salient features of the boundary layer embedded in the time histories. The analysis revealed the vortical characteristics in the boundary layer. A single distinct peak pressure spectrum is obtained, which corresponds to the existence of a single large eddy in the boundary layer, accompanied with small scale eddies representing turbulent fluctuations. Drop in the magnitude of the peak pressure spectra with increasing angle of attack is a precursor to boundary layer separation. Their coalescence at different locations on the wing surface indicates flow separation over these locations. Confirmed by oil flow visualization, it was found that boundary layer separation occurs over the mid sections of the wing, progressing from the TE to the LE as the angle of attack increases, while the boundary layer over the outer panels remains attached. This may generate a strong rolling moment (AWS) when the flow suddenly becomes asymmetric over both wings.

Text Mining Using Bibliometrics and Database Tomography

Researcher: Professor Gabriel N. Karpouzian
Sponsor: Office of Naval Research (ONR)

Database Tomography (DT) is a textual database analysis system consisting of two major components: (1) algorithms for extracting multi-word phrase frequencies and phrase proximities (physical closeness of the multi-word technical phrases) from any type of large textual database, to augment (2) interpretative capabilities of the expert human analyst. DT was used to derive technical intelligence from an Abrupt Wing Stall (AWS) database from the Science Citation Index (SCI) and the Engineering Compendex (EC). Phrase frequency analysis by the technical domain experts provided the pervasive technical themes of the AWS database, and the phrase proximity analysis provided the relationships among the pervasive technical themes.

Bibliometric analysis of the AWS literature supplemented the DT results with author/ journal/ institution publication and citation data. Comparisons of AWS results with past analyses of similarly structured Near-Earth Space, Chemistry, Hypersonic and Supersonic flow, Aircraft, Ship Hydrodynamics, and Fullerness databases are made.

REX II Operations

Researchers: Professor Daryl G. Boden,
CDR Robert Bruninga, USN (Ret.) and LtCol Billy R. Smith, USAF
Sponsor: Air Force Space Test Program

The U.S. Naval Academy Satellite Ground Station (SGS) continues to operate the REX II spacecraft for the Air Force Space Test Program. Part of the effort is to incorporate the REX II telemetry data and operational requirements into several courses in the astronautics curriculum.

Independent Research

Drag of an Antenna

Researcher: Professor David F. Rogers

A wind tunnel test was made to determine the drag of a simple radar altimeter antenna.

Effect of Vortex Generator in Aircraft Performance

Researcher: Professor David F. Rogers

Comparative flight tests were made to determine the effect of adding vortex generators to a light general aviation aircraft on cruise performance, stall velocity power on/power off and control effective.

Effect of Balanced Flow Injectors on Piston Engine Vibration Levels

Researcher: Professor David F. Rogers

Comparative flight tests were made using vertical accelerometers to determine the relative vibration levels for a light general aviation aircraft.

Research Course Projects

Prototype Communications Satellite (PCSAT)

Researchers: Midshipmen 1/C Daniel A. Boutros, USN, Midshipman 1/C Laura E. Nolan, USN, Midshipman 1/C Robert B. Schwenzer, USN, Midshipman 1/C Daniel M. Sullivan, Jr., USN, Midshipman 1/C Alex A. Gutweiler, USN and Midshipman 1/C Steven C. Lawrence, USN
Advisers: Professor Daryl G. Boden and LtCol Billy R. Smith, USAF

PCSAT is a simple communications satellite designed to provide a space-based node to the Amateur Position Reporting System (APRS). Conceived by CDR Robert Bruninga, USN (ret) of the U.S. Naval Academy Satellite Ground Station (USNA-SGS), and operating in the amateur radio band, it will receive position and identification data from amateur radio operators participating in APRS, and then rebroadcast that data to the USNA-SGS for integration into the APRS database. The midshipmen involved in this project built the spacecraft structure, the communications payload and the thermal control system. The PCSAT was launched, via a Department of Defense Space Test Program on 30 September 2001.

Splitflow Predictions of an F-18

Researcher: Midshipman 1/C Brian E. Sisco, USN
Adviser: Dr. Alex Cenko (Visiting Professor, Naval Air Systems Command Research Chair)

The paper explored the advantages and disadvantages of using computational fluid dynamics (CFD) to predict store separation. The focus will be comparing CFD based store separation predictions with experimental data derived from wind tunnel and flight tests. Of particular interest are the abilities of splitflow supports of real stores clearance processes. The CF-18 aircraft will be used as the basic aircraft under investigation. The first phase will make use of existing pressure sensitive paint (PSP) data from the National Research Council's high speed wind tunnel and flight test trajectory data from flight-tests on-going with the Canadian Air Force. The specific store configuration under analysis is the release of a single MK-83 from a vertical ejector rack (carrying a second MK-83) on the wing of a CF-18.

Overflow Predictions of an F-18

Researcher: Midshipman 1/C John A. Walsh, USN
Adviser: Dr. Alex Cenko (Visiting Professor, Naval Air Systems Command Research Chair)

The paper explored the advantages and disadvantages of using computational fluid dynamics (CFD) to predict store separation. The focus will be comparing CFD based store separation predictions with experimental data derived from wind tunnel and flight tests. Of particular interest are the abilities of TetrUSS supports of real stores clearance processes. The CF-18 aircraft will be used as the basic aircraft under investigation. The first phase will make use of existing pressure sensitive paint (PSP) data from the National Research Council's high speed wind tunnel and flight test trajectory data from flight-tests on-going with the Canadian Air Force. The specific store configuration under analysis is the release of a single MK-83 from a vertical ejector rack (carrying a second MK-83) on the wing of a CF-18.

Trident Scholar Project

Determining Atmospheric Density in Low-Earth Orbit Using GPS Measurements

Researcher: Midshipman 1/C John L. Young, III, USN
Adviser: Professor Daryl G. Boden

The goal of this project was to develop an algorithm to process GPS data from a satellite in low-Earth orbit to obtain precise measurement of atmospheric density. In developing the algorithm in this project, the researcher used an orbit propagation software to generate data via one of several atmospheric models. By measuring the changes in the satellite's orbit due to atmospheric drag, the density was calculated. To validate the algorithm, the density output was compared to that of the actual model used in the propagation software. The U.S. Naval Academy Small Satellite Program is planning to place a USNA-designed satellite in low-Earth orbit, with a GPS receiver onboard. Once the satellite is on orbit, the algorithm can be used to create a database of densities.

Publications

Journal (Refereed) Manuscripts

ROGERS, David F., Professor, "ASI Calibrations," *World Beechcraft Society*, Jul/Aug 2000, pp. 10-11, 37.

This article discusses the fallacy behind using GPS ground speed acquired by flying reciprocal GPS ground tracks to determine true airspeed. An alternate technique is suggested.

ROGERS, David F., Professor, "Turning Performance," *World Beechcraft Society*, Nov/Dec 2000, pp. 38-39.

This article discusses the fundamental elements of aircraft turning flight. The equation for the radius in a steady level turn is derived and it illustrates the effect of bank angle and velocity on the turn radius.

ROGERS, David F., Professor, "Turning Performance – Sustained Level Turn," *World Beechcraft Society*, Mar/Apr 2001, pp. 32-33.

This article discusses the constraints of stall and power available on sustained level turns at sea level. It shows the combinations of velocity and bank angle that allow an aircraft to climb while turning at sea level.

Conference Proceedings

BODEN, Daryl G., Professor, "USNA Small Satellite Program," *Proceedings from the 2000 ASEE Annual Conference and Exposition*, St. Louis, MO, 19 June 2000.

This paper describes the United States Naval Academy's (USNA) Small Satellite Program. The program actively pursues flight opportunities for miniature satellites designed, constructed, tested, and commanded or controlled by Midshipmen. The Small Satellite Program provides funds for component purchase and construction, travel in support of testing and integration, coordination with DoD/NASA laboratories or universities for collaborative projects, and guides USNA Midshipmen through the DoD Space Experiment Review Board (SERB) flight selection process.

The satellite development process is a multi-semester effort requiring the contributions of Midshipmen from several consecutive graduating classes. Senior students in our Aerospace Design course initiate the process in the spring semester with identification of the mission and determination of requirements, followed by development of the conceptual design. Students in subsequent classes will take the satellite through feasibility study, final design, construction, testing, and launch platform integration. Each spring, students in the design class begin the process anew with a new satellite concept, so that new projects are germinating to take the place of those that are coming to completion and awaiting launch.

USNA-1 is a simple communications satellite designed to provide a space-based node to the Amateur Position Reporting System (APRS). Conceived by R. Bruninga of the USNA Satellite Ground Station (SGS), and operating in the amateur radio band, it will receive position and identification data from amateur radio operators participating in APRS, and them rebroadcast that data to the USNA SGS for integration into the APRS database.

Books

ROGERS, David F., Professor, "An Introduction to NURBS, with Historical Perspective," Morgan Kaufmann Publisher, 2001.

Presentations

BODEN, Daryl G., "USNA Small Satellite Program," ASEE Annual Conference and Exposition, St. Louis, MO, 19 June 2000.

ROGERS, David F., "High Altitude Effects on Aircraft Performance," World Beechcraft Society Meeting, Brunswick, GA, 31 May-2 June 2001.