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 departmental faculty reflect interest in both highly theatrical topics and very practical long time concerns to the flying community. Although the capstone courses are not explicitly listed, midshipmen and faculty advisors were aligned with research and current interest in other government agencies. Scientists and engineers from National Air and Space Administration (NASA), the Naval Space Command, and the Center for Naval Analysis assisted in review and evaluation of midshpmen projects. This occasionally leads to follow-on research and midshipmen opportunities. By use of numerical methods and sophisticated computer graphics techniues, extensive work or 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 Academy in three fundamental areas: midshipmen have had opportunities to participate in research work at the leading edge of both aeronautical and astronautical engineering technology, and the Defense Department has been the beneficiary of the Academy's extensive computer and manpower resources. Also, faculty participation in developments in the field of aerospace engineering has enhanced the learning process in the classroom, from the most fundamental courses to sophisticated design course projects.

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

Independent Research

Stress Analysis of Light Weight Closely Coiled Hollow Helical Springs

RESEARCHER: Professor William J. Bagaria

The helical spring is a widely used structural element. Traditionally, it has been constructed out of solid bar stock. Significant weight savings can be achieved by fabricating helical springs from hollow tubing. Ultimately, structural weight savings result in significant transportation fuel savings. Another application for the hollow spring is in hot environments. A cooling fluid can be circulated through the hollow spring thereby cooling it. This paper gives the necessary stress and deflection design equations for the lightweight closely coiled hollow helical spring. A criterion was developed to quantify the thickness to outside diameter ratio of thin tubes. This paper has been submitted for publication to ASME.

Manufacturing and Testing of Light Weight Closely Coiled Hollow Helical Springs

RESEARCHER: Professor William J. Bagaria

Helical springs of low pitch angle, fabricated from solid bar, have been extensively analyzed. Significant weight reduction can be achieved by fabrication them from hollow bar. The theory for analyzing hollow springs has been developed. Test data has been collected to verify the theory. The theory gives results within 2 - 4 % of experimental values. In addition to verifying the theory, two different manufacturing techniques were demonstrated. Testing has been completed, and the technical paper is in progress.

Design of Light Weight Closely Coiled Hollow Helical Springs

RESEARCHER: Professor William J. Bagaria

The theory for analyzing hollow springs has been developed, and test data has been collected to verify the theory. The design equations contain several parameters that are to be selected by the hollow spring designer. Numerical iteration techniques can result in designs that cannot be fabricated. Thus, design charts and nomograms are being developed to enable the designer to quickly determine the necessary spring parameters. These charts and monograms will parallel those used for the design of helical springs fabricated from solid bar stock. This work is in progress.

Recovery of Pulsed Signals Buried in Noise

RESEARCHERS: Professor William J. Bagaria,
Associate Professor Colin Ratcliffe (Mechanical Engineering Department),
Associate Professor Sonia M.Garcia (Mathematics Department) and Visiting Professor Richard P. Fahey

Pulsars that are in the Milky Way Galaxy can be used for orbital velocity and position determination. However, the pulsar signal is about 100 orders of magnitude lower than the background noise. Vibration techniques, such as cross-correlation, are being used to detect the pulsar signal, and the Doppler shift in near real time. Once the signals from three or more pulsars are measured, the velocity and position of an object, like the earth, can be determined.

Research in Automating Space Mission Operations

RESEARCHER: Professor Daryl G. Boden

Research in Automating Space Mission Operations is a joint Navy / NASA / Industry / Academia research and development project which uses existing facilities in the Department of Aerospace Engineering at the U.S. Naval Academy (USNA). The goals of the project are to test and evaluate automation techniques for command and control of space systems. The laboratory is also used to support USNA classes and associated laboratories, as well as midshipmen and faculty research projects.

REX II Operations

RESEARCHERS: Professor Daryl G. Boden, CDR Bob Bruninga, USN (Ret.), and LtCol Billy Smith, USAF

The USNA SGS will operate the REX II spacecraft for the Air Force Space Test Program. Part of the effort will be to incorporate the REX II telemetry data and operational requirements into several courses in the astronautics curriculum.

Space Technology Series

RESEARCHER: Professor Daryl G. Boden (Editor)

The Space Technology Series is a series of books that focus on the process of moving from a mission need, through the systems' acquisition phases, 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 Department of Aerospace Engineering 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.

Asymmetric Changes in the C IV Emission Profiles of the Seyfert I AGN NGC 3516 and NGC 4151

RESEARCHER: Dr. Richard P. Fahey
Visiting Professor, Naval Space Command Research Chair

The C IV l1549 emission feature in the spectra of the AGN NGC 3516 and NGC 4151 shows two narrow peaks, about 1-2,000 km s^{-1} wide and 3,000 km s^{-1} apart. Both peaks vary in response to changes in the activity level of the system, but the blueward of these peaks varies in amplitude and in total flux by more than a factor of two relative to the redward one. Moreover, the ratio of the blueward to redward amplitude, or the blueward to flux, correlates strongly with the strength of the continuum, e.g. at 1300 Å, in a way similar to the Baldwin effect. When examined at the resolution of the International Ultraviolet Explorer (IUE), the pair of peaks seem to be a result of asymmetric absorption of light from a single Lorentzian shaped emission feature at almost the same wavelength. At the resolution of the Goddard High Resolution Spectrometer (GHRS), the C IV l1549 absorption feature has the appearance of a deep, rectangular well, indicating saturation, with several weak, narrow Gaussian emission lines superimposed. We suggest that this effect could be due to the wind between the observer and the source of the predominant emission line. The current study extends our previous findings, and leads to the possibility that several Seyfert IAGN share the same behavior.

Ages, Isochrones, and Limits in Lemaître Two-Fluid and Friedmann Universes

RESEARCHER: Dr. Richard P. Fahey (Visiting Professor, Naval Space Command Research Chair),
James E. Fenton and Richard Isaacman

We illustrate by examples the run of the dimensionless scale factor $R(\ddot{A})$ versus $\ddot{A}$ (time in units of H_0^{-1}) in generalized "Lemaitre two-fluid universes," *i.e.* those containing an arbitrary cosmological constant L plus two non-interacting fluids with densities *pnr* and *pr*, the second of which exerts pressure $p= (v\text{-}1)\ prc^2$, with v a constant.

UOSAT-22 Communications Experiment

RESEARCHER: CDR Bob Bruninga, USN (Ret.)

Principal investigator studied the use of existing PACSAT-PROTOCOL satellites for the real-time digital relay of two-way position/status and messages from mobiles and portable satellite stations. Experiment was conducted from Nov 99 through May 2000 with the participation of the University of Surrey, UK.

SUNSAT-35 Telemetry and Communications Experiment

RESEARCHER: CDR Bob Bruninga, USN (Ret.)

Principal Investigator studied the failed high-speed modem on SUNSAT to improve the downlink of data files and imagery from 20 minutes a day to almost 5 hours a day by using multiple linked ground stations sharing live down linked data via the Internet. Work evolved into additional experiments to include routine telemetry so that whole-orbit data was available all the time at a low duty cycle in real-time and the resulting power savings allowed the default activation of an APRS transponder mode on all passes when the satellite was not otherwise transmitting mission data. Work was collaborated with the Universiteit Van Stellenbosch, South Africa.

USNA Satellite Design Project (PCsat)

RESEARCHER: CDR Bob Bruninga, USN (ret)

PCsat is the culmination of over 14 years of my Naval Academy Involvement in the design of a Packet payload for the Amateur Satellite program. This year we had 8 students dedicated to finalizing the detail design and beginning construction for a launch opportunity in 2001. The mission is to provide position/status and message reporting from mobiles and portable stations that are out of range of the terrestrial data communications infrastructure.

Svalbard Antenna Alignment

RESEARCHER: CDR Bob Bruninga, USN (ret)

Consultant on the analysis and determination of the accuracy of alignment of the 11 meter Lockheed Martin Satellite Ground Station at Svalbard in the Arctic Circle.

Research Course Projects

Prototype Communications Satellite (PCSAT)

RESEARCHERS: Midshipman1/C Erik T. Lundberg, USN, Midshipman 1/C Brian E. Scrabeck, USN, Midshipman 1/C John A. Kollar, USN, Midshipman 1/C George A. Ortiz, USN, Midshipman 1/C Lester M. Melanson, USN and Midshipman 1/C David J. Burroughs, USN
ADVISER: Professor Daryl G. Boden

PCSAT 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.

Publications

BODEN, Daryl G., Professor, "Introduction to Astrodynamics," Space Mission Analysis and Design, 3rd Edition, Chapter 6, Torrance, CA: Microcosm Inc., 1999, pp. 131 – 158.

Space Mission Analysis and Design addresses the art and science of designing a space mission from concept to preliminary design. Chapter 6 explains the terms used to describe satellite orbits, provides equations necessary to calculate classical orbital elements from position and velocity, and shows how to predict the future position and velocity of a satellite. The chapter also discusses orbit perturbations and orbit maneuvering strategies.

BODEN, Daryl G., Professor, and Hoffman, Stephen J., "Orbit Selection and Astrodynamics," Human Space Mission Analysis and Design, Chapter 9, New York: McGraw-Hill, 1999, 1st Edition, pp. 213 – 270.

Human Space Mission Analysis and Design describes the process for designing human space missions with a goal of achieving low-Earth orbit, a lunar mission, or a Mar's mission. Chapter 9 specifically describes the mission design as it applies to the three different missions. Numerous example trajectories for lunar and Mar's missions are shown.

BODEN, Daryl G., Professor, "USNA Small Satellite Program," Proceedings from 2000 ASEE Annual Conference and Exposition., St. Louis, MO, 19 June, 2000. Available on CD-ROM.

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.

BRUNINGA, Bob, CDR, USN (Ret.), "AMSAT Builders Channels for HT and Mobile Satellite Communications," Proceedings of the AMSAT-NA 17th Space Symposium, San Diego, CA, October 8-10, 1999, pp. 191-195.

BRUNINGA, Bob, CDR, USN (Ret.), "APRS Generic Digipeating Satellites for HT and Mobile Satellite Communications," Conference Proceedings, 18th ARRL/TAPR Digital Communications Conference, Phoenix, AZ, Sept 24-26, 1999, pp. 132-135.

BRUNINGA, Bob, CDR, USN (Ret.), "APRS Mic-Lite," Conference Proceedings, 18th ARRL/TAPR Digital Communications Conference, Phoenix, AZ, Sept 24-26, 1999, p. 136.

MACKNEY, Michael, Associate Professor, BARTON, Oscar, Associate Professor, MOURING, Sarah E., Associate Professor, and KARPOUZIAN, Gabriel N., Professor, "The Longitudinal and Transverse Properties of Fiber-Steered Composites," Proceedings of the American Society for Composites 14th Technical Conference, Dayton, OH, September 27-29, 1999, pp. 587-596.

In this paper, results are reported for the mechanical properties of test coupons that have been manufactured using steered fibers. The motivation of the research is to assess the effect of fiber curvature on the mechanical properties. The properties under investigation include longitudinal tension and compression response, transverse tension and compression response, and both the longitudinal and transverse compressive strengths. To accomplish this effort, six composite panels were fabricated using a production fiber placement machine. Fiber placement is the technology that uses composite materials in the form of tape to be placed in any desired path thus maximizing the utility of the material. The tape, called tows, can vary in width from 0.125 in to 0.182 in. Each panel is constructed using an IM7/977-3 composite system in the form of 10.7 mil slit tape which is stacked either in a 4 or 8 ply unidirectional lay-up. For these tests, the fiber placement occurred along paths with radii varying from 18 in to 45 in. This generated test specimens with 20 in, 30 in and 40 in radii. Specimens tested included a set of baseline coupons with straight fibers for comparison.

NIEWOEHNER, R.J., CDR USN, Heller, Mike and Lawson, Stephen, "High Angle of Attack Control Law Development and Testing of the F/A-18 E/F Super Hornet," Proceedings of 1999 AIAA Guidance, Navigation and Control Conference, Portland, Oregon, August 1999. Available on CD-ROM.

NIEWOEHNER, R.J., CDR USN, and FILBEY, Joshua R., Midn 1/C, "Using the TetrUSS CFD Suite in Undergraduate Research," 2000 Proceedings American Society of Engineering Educators, St. Louis, MO, June, 2000. Available on CD-ROM.

NIEWOEHNER, R.J., CDR USN, and FILBEY, Joshua R., Midn 1/C, "Computational Study of Wing Drop on the F/A-18E Super Hornet in the Power Approach Configuration," USNA Trident Scholar Report No. 274, U.S. Naval Academy, May 2000.

ROGERS, David F., Professor, "Airspeed," World Beechcraft Society, Sept/Oct 1999, pp 12, 13, 26.

Discusses the underlying theory and characteristics of a low speed airspeed indicator including the possible error and the source of those errors.

ROGERS, David F., Professor, "Wind and Range," World Beechcraft Society, July/August 1999, pp 16, 17, 26.

Discusses the effects of wind on the range of an aircraft and develops a new and more accurate 'rule of thumb' for estimating the amount by which the no wind maximum range velocity should be adjusted due to either a headwind or tailwind.

Presentations

BODEN, Daryl G., Professor, "Satellite Artificial Intelligence Lab," ASEE Annual Conference and Exposition, Charlotte, NC, 22 June 1999.

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

BRUNINGA, Bob, CDR, USN (Ret.), As a participant in the US Naval Academy Speakers Bureau, provided local lectures, and demonstrations on satellite technology to a number of local Clubs and Organizations including the Baltimore Electronics Museum; the Anne Arundel Radio Club; the Maryland Mobileers; Field-day, Downe's Park, Anne Arundel County; Laurel Radio Club.

BRUNINGA, Bob, CDR, USN (Ret.), U.S. Naval Academy Amateur Satellite Missions; The Amateur Satellite Workshop for Colleges and Universities, Sponsored by the Amateur Satellite Corporation, North America, 7 October 1999, San Diego, CA.

BRUNINGA, Bob, CDR, USN (Ret.), "AMSAT Builders Channels for HT and Mobile Satellite Communications," The AMSAT-NA 17th Space Symposium, San Diego, CA, October 8-10, 1999.

BRUNINGA, Bob, CDR, USN (Ret.), "APRS Generic Digipeating Satellites for HT and Mobile Satellite Communications," Conference Proceedings, 18th ARRL/TAPR Digital Communications Conference, Phoenix, AZ September 24-26, 1999.

BRUNINGA, Bob, CDR, USN (Ret.), "APRS Mic-Lite," Conference Proceedings, 18th ARRL/TAPR Digital Communications Conference, Phoenix, AZ, September 24-26, 1999.

BRUNINGA, Bob, CDR, USN (Ret.), "Mobile and Handheld APRS Satellite Communications," ARRL Pacific Division Convention, Queen Mary, Long Beach, CA, 18-20 Feb, 2000.

BRUNINGA, Bob, CDR, USN (Ret.), "The Future of APRS," National ARRL Conference and Dayton Hamvention, 19-21 May, 2000.

NIEWOEHNER, R.J., CDR USN, Heller, Mike and Lawson, Stephen, "High Angle of Attack Control Law Development and Testing of the F/A-18 E/F Super Hornet," Proceedings of 1999 AIAA Guidance, Navigation and Control Conference, Portland, Oregon, August 1999.

NIEWOEHNER, R.J., CDR USN, and FILBEY, Joshua R., Midn 1/C, "Using the TetrUSS CFD Suite in Undergraduate Research," 2000 Proceedings American Society of Engineering Educators, St. Louis, MO, June, 2000.