Aerospace Engineering Department

Professor Daryl G. Boden
Chair

The research and publication efforts of the aerospace engineering faculty and students covered a broad range of topics in aeronautics, astronautics, and engineering education. The research resulted in numerous presentations, papers in conference proceedings, workshops, and publications in archival journals.

The capstone courses highlighted this year's research in the Aerospace Engineering Department. All the midshipmen in the capstone design course for the Astronautical Engineering track continued work on the design of small satellites that we expect to launch in the future. The Aeronautical Engineering track students designed, built, and tested three unmanned aerospace vehicles (UAVs) for an external customer.

Students and faculty enjoyed outstanding support from the National Air and Space Administration (NASA), the Naval Network and Space Operations Command, the Naval Research Laboratory (NRL), the Air Force Research Laboratory (AFRL), Naval Air Systems Command (NASC), the U. S. Air Force Space Test Program, the Naval Air Warfare Center (NAWC), the National Center for Advanced Manufacturing (NCAM), the Defense Intelligence Agency, Noesis Inc, National Space Biomedical Research Institute (NSBRI), and the Boeing Corporation to accomplish their research and to support the capstone courses.

The department continued work in pedagogical research on engineering education as part of the Conceive-Design-Implement-Operate (CDIO) Initiative. This effort has resulted in presentations and workshops at CDIO meetings and engineering education conferences.

Sponsored Research

Low Light Level Illumination for Enhanced Propeller Visibility

Researchers: Assistant Professor David S. Miklosovic,
and Mr. Richard W. Garman (Engineering & Weapons Technical Support Department)
Sponsor: Noesis, Inc.

In the frenzied environment of a big-deck carrier during flight operations, a low-visibility, spinning propeller blade creates a considerable hazard to personnel. This research focused on application materials and techniques to greatly improve the visibility of the E-2C propellers during operation. Different photo-luminescent and reflective materials and diverse adhesives and have been identified to improve spinning propeller visibility.

This program seeks to develop a current-technology method for enhancing the visibility awareness of aircraft propellers during operations to ensure crew safety. The program has the following goals:

- To validate aerodynamic performance and to reduce technical risk, of a photoluminescent propeller visual warning system, prior to actual flight testing

- To establish and then to minimize the impact on weight and power requirements for an E-2C propeller with a photoluminescent propeller visual warning system

- To validate these methods to be readily incorporated on existing propellers

- To maximize durability in a rigorous marine environment (optional)

- To test and refine a photoluminescent propeller visual warning system that will be capable of withstanding the operational forces on an E-2C propeller and provide the fleet with superior performance

The Naval Academy continued to support this effort with propeller endurance testing and propeller performance deficit analysis. The propeller endurance testing involve production aircraft propellers, 50-74 inches in diameter, operated at 3500 RPM to allow for more realistic test conditions without mounting full-size E-2C propellers. The propeller performance deficit analysis involved an analytic effort to predict the performance deficit due to propeller blade applications. It includes a simplified 2D analysis on the airfoil section and a 3D analysis on the propeller to estimate thrust and torque losses due to the applications.

This research supported an SBIR Phase II follow-on (Noesis subcontract DC05-001-45/F5) to Phase I work that was performed in 2002. This cumulative effort directly supported the Naval Academy's Fluids Laboratory.

Wind Tunnel Testing of Ship Motion Effect on Airwake

Researcher: Assistant Professor David S. Miklosovic
Sponsor: Naval Air Warfare Center (NAWC), Code 4.3.2.1

SAFEDI (Ship Aircraft Airwake Analysis For Enhanced Dynamic Interface) is an Office of Naval Research (ONR) sponsored initiative with a focus on developing computational fluid dynamics (CFD) airwake technology to enhance dynamic interface analysis, modeling, and simulation for all aircraft type and ship class combinations. One of the objectives of the program is to model the impact of ship motion on a ship's airwake using CFD. Validation data is required to provide confidence in the modeling capability. A wind tunnel test is proposed that will enable the flow over a ship moving with single degree-of-freedom motion to be examined in a controlled environment. CFD calculations, using the same flow conditions and geometry as the wind tunnel, will be compared with the model-scale test results to determine the accuracy of the predictions.

Wind tunnel measurements of the airflow over a model of a typical ship moving with single degree-of-freedom, sinusoidal pitch motion, are required to validate CFD predictions. Quantitative data consists of 3-component velocity measurements (u, v, w) using Particle Image Velocimetry (PIV), and spectral data using hot wire anemometry. Qualitative assessments of the flow field may also be possible with smoke and/or helium bubble flow visualization techniques, using both video and still photography.

This work is a continuation of efforts halted by tropical storm ISABEL (Sept 2003). It was accomplished through the duration of FY05. This collaborative effort with NAVAIR 4.3.2.1 has forged close ties and a combined technical competence that is expected to inspire continued funding in subsequent years.

Microdosimeter Instrument Suitable for Spaceflight

Researcher: Professor Vincent L. Pisacane
Sponsor: National Space Biomedical Research Institute (NSBRI)

The objective of this project was development of a rugged, portable, low power, lightweight, solid-state radiation instrument MIDN (MIcroDosimeter iNstrument) to measure probability or frequency distributions of energy deposited in real time in cell-size structures from charged and neutral primary and secondary radiations. Assessment of the space radiation environment addressed the development of a countermeasure of the highest priority for space exploration. Determination of the magnitude of the average radiation quality, Qave, was necessary to calculate the dose equivalent, which was assumed to be proportional to risk and upon which regulatory limits in space are based. Microdosimetry spectra are the most accepted data for calculating Qave. Consequently, the observations are more reliable as a monitor of human cell damage than other macroscopic detectors that measure fluence. A preliminary laboratory breadboard, partially funded by NASA, demonstrated feasibility. The project was augmented to include a student experiment of putting an early model of the instrument on the MidSTAR-I spacecraft.

Midshipman Space Technology Applications Research Satellite –1 (MidSTAR-1)

Researcher: Associate Research Professor Billy R. Smith Jr.
Sponsor: Department of Defense, Space Test Program

MidSTAR is a general-purpose satellite bus capable of supporting a variety of space missions by easily accommodating a wide range of space experiments and instruments. The integration of the experiments with the satellite bus must be accomplished with minimal changes to the satellite bus design. MidSTAR is intended to be a relatively low-cost, quick response platform accommodating small payloads approved by the Department of Defense Space Experiments Review Board (SERB) and awaiting launch through STP. MidSTAR satellites will be one of two types. MidSTAR mod 1 is designed for use on the Expendable Secondary Payload Adaptor (ESPA) Ring developed by Air Force Research Laboratory (AFRL) for placement on Delta IV or Atlas V expendable launch vehicles. MidSTAR mod 2, still to be developed, will be designed for deployment from the Space Shuttle via the Canister All Payload Ejection (CAPE) system developed by AFRL. Both mods are Class D spacecraft, produced at minimum cost with a correspondingly higher technical risk in production and operation. Both types of spacecraft are intentionally simple in design and rugged in construction, using commercial off-the-shelf "plug-and-play" components to the greatest extent possible. Component development and circuit-board level design are accomplished only when necessary. The baseline MidSTAR mission includes a single spacecraft under the command and control of a single satellite ground (SGS) station located at USNA, Annapolis MD. (Lat. 38.98 N, 76.49 W). The ground station forwards down linked data files to the Principal Investigators via the Internet. Secondary ground control will be available on an as-needed/space-available basis through Naval Postgraduate School (NPS), Monterey CA (36.6 N, 121.89 W). Launch segment for MidSTAR mod 1 is either the Delta IV or Atlas V EELV. Launch segment for MidSTAR mod 2 is the Space Shuttle CAPE. The orbit will be tailored to payload requirements; where no requirements exist, the orbit of the primary payload or one of the other secondary payloads will be accepted. In order for the spacecraft to be seen from USNA SGS at an elevation greater than 30 degrees and range simultaneously less than 900 km, the orbit must be 500 +/- 200 km with inclination greater than 35 degrees. MidSTAR-1 is the first implementation of the mod 1 design. It has been commissioned by STP to carry the Internet Communications Satellite (ICSat) Experiment for SSP (no. 39 on the 2002 SERB List) and the Configurable Fault Tolerant Processor (CFTP) Experiment for Naval Postgraduate School (NPS) (no. 34 on the 2002 SERB List). MidSTAR-1 is scheduled for launch on a Lockheed-Martin Atlas V from Cape Canaveral on the STP-1 mission in September 2006.

Microcracking in Composite Laminates

Researcher: Professor Gabriel N. Karpouzian
Sponsor: National Center for Advanced Manufacturing (NCAM)

This research project constitutes a part of a group effort for studying the microcracking phenomenon of composite laminates. The laminates are made of IM7/977-2, which are fiber-reinforced carbon epoxy composite panels with three different ply lay-ups: $[90_4/0_8/90_4]$, $[90_2/45_2/0_4/-45_2/90_2]$, $[90_4/0_4/90_4]$. The subscript after each number represents the number of plies in a ply group and the number itself represents the orientation angle of the fibers relative to the material coordinate system. The panels were subjected to a progressive tensile loading. For each applied loading to a panel the microcrack density (i.e. the number of microcracks per unit length of a panel) was calculated using a shear lag model with an energy-based failure criterion. A crack appeared when the strain energy release rate exceeded the critical strain energy release, which is a material property representing the material toughness. The results correlate well with the non-destructive evaluation (NDE) tests performed on the same panels by the other members of the group. Furthermore, since the development of microcracks affected the stiffness properties of the panels, the degradation of these properties is predicted as a function of crack density. This has enabled us to predict the design life of the panels.

Research Course Projects

Design Specifications Development for Unmanned Aircraft Carrier Landings: A Simulation Approach

Researcher: Midshipman 1/C Jared Wolcott, USN
Adviser: Captain Robert J. Niewoehner, USN

This project produced component elements for a simulation model of the T-34B airplane. The broader purpose of this effort is an engineering stability and control model which can be used to develop control laws for implementation on a T-34B. The following model components were completed: elevator and trim tab effectiveness, mathematical pilot model, and Continental IO-550 engine.

Composite Structural Integrity Assessment via High-Resolution Ultrasonic Microscopy

Researchers: Midshipman 1/C Eric D. Brege, USN and Midshipman 1/C Clayton Sands, USN
Adviser: Professor Gabriel N. Karpouzian

This research, supported by the National Center for Advanced Manufacturing (NCAM), outlines the effort to develop a non-destructive evaluation (NDE)/theoretical model-driven approach to predict the design life based on the extent of microcracking through a composite structure. Microcracking is a phenomenon that exists when microscopic breaks occur in the matrix of a composite material. This is caused when the energy dissipated throughout the material exceeds the critical strain energy release rate. In order to quantify these energies, specimens are tested under varying loads level to failure. The microcrack density of each specimen is obtained using NDE, specifically ultrasonic acoustic microscopy. These results are correlated to a dimensionless parameter so that it can be incorporated into the theoretical model. The latter uses the shear lag approach to predict the microcrack density as a function of applied load level. Once this prediction model is complete, a portable PC-based system can be configured in order to predict the remaining life in specific composite applications.

Microdosimeter Instrument (Midn) Suitable for Space Flight

Researchers: Midshipman 1/C Matthew O. Caylor, USN, Midshipman 1/C Daniel J. Flake, USN,
Midshipman 1/C Lance T. Heyen, USN, Midshipman Thomas Veade, USN,
Midshipman 1/C Errol O. Youngborg, USN,
Advisers: Professor Vincent L. Pisacane, Visiting Professor James F. Ziegler (Electrical Engineering Department),
and Assistant Research Professor Phillip Taddei (Aerospace Engineering Department)
and Professor Martin E. Nelson (Mechanical Engineering Department)

The instrument package that was designed in this project and that will be flown aboard the Midshipman Space Technology Applications Research Program (MidSTAR-1) satellite is a proof-of-concept prototype that highlights the exciting possibilities of what future microdosimeter technology will be able to achieve.

The mission of the MicroDosimeter Instrument aboard the MidSTAR-1 spacecraft is to measure the ionizing radiation spectra (primary emphasis on secondary neutrons) for a minimum of two months with a digital, real time, low power, solid state micro-dosimeter. Collected data will then be compared with accepted radiation models to validate the detector.

Trident Scholar Projects

An Historical and Applied Aerodynamic Study of the Wright Brothers' Wind Tunnel Test Program and Application to Successful Manned Flight

Researcher: Midshipman 1/C Michael G. Dodson
Adviser: Assistant Professor David S. Miklosovic
Sponsors: Office of Naval Research (ONR) and Bowman Scholar Program

In this project, a replica of the Wright Brothers' tunnel was constructed and then used to determine the effect that flow quality and experimental method had on the Brothers' results, and whether those results were useful in a quantitative sense. The research incorporated static and total pressure measurements, velocity surveys across the jet, and quantitative flow visualization. The velocity surveys involved high resolution dynamic pressure measurements along the horizontal and vertical axes in the test section. Quantitative flow visualization consisted of particle image velocimetry, which provided velocity magnitudes, turbulence intensities, and vorticity measurements in the region where the Wrights mounted airfoils. It also provided data for image subtraction so the effects of the balance on flow around the airfoil could be analyzed independently. Force measurements were conducted on an airfoil model to confirm the conclusions regarding the effect of flow quality on the airfoil forces and moments.

The tests revealed large boundary layers generated by the tunnel which extend 1.5″ from each wall. There is a 5″ diameter low-velocity "dead zone" in the center of the test section surrounded by isolated regions 20% faster. The boundary layers begin outside these faster regions. The Wrights' airfoils spanned all three regions. Since the size and shape of their airfoils varied, the effect of this spanwise velocity distribution on each would not have been consistent. Thus their quantitative data was not useful for predicting full scale data, and qualitative comparisons were not accurate. Additionally, data showed test section velocity characteristics were independent of fan selection and RPM, which adds robustness to conclusions drawn from the replica tunnel testing.

The experimental analyses, along with an historical analysis which focused on the Wrights' aeronautical education and background, indicate the Wrights were successful despite numerous holes in their understanding of basic aerodynamics. Their major source of aerodynamic understanding, their wind tunnel, was not capable of producing accurate quantitative data applicable to full scale design. Though not pertinent in modern aerodynamics, the conclusions provide insight into the birth of aviation and the two brilliant men who were the first to succeed despite limitations and deficiencies with their equipment, experience, and knowledge.

Journal (Refereed) Manuscripts

NIEWOEHNER, Robert J., Captain, USN, (Co-Author), "Use of Piloted Simulation for Evaluation of Abrupt Wing Stall Characteristics", *AIAA Journal of Aircraft*, Vol. 42, No. 3, May – June 2005.

> A piloted simulation architecture is presented for evaluating uncommanded wing drop due to asymmetric abrupt wing stall for a given aircraft configuration. The architecture incorporates a newly-proposed aerodynamic modeling technique that characterizes the wing drop motion as being triggered by aerodynamic stall, modeled by a nonzero basic rolling moment coefficient, and sustained by reduced or propelling roll modeled via the roll damping derivative. Models with varying nonzero basic rolling moment coefficients and varying roll damping were inserted into the aerodynamic model and then evaluated by a pilot familiar with wing drop. The pilot assessed the varying models, assigning handling qualities ratings to pre-developed tasks aimed at diagnosing the severity (or absence) of any wing stall characteristics. Tasks included wind-up turns, symmetrical pulls, and a closed loop tracking task in which the pilot tracked a target while flying a drop-prone simulation. The pilot was able to distinguish between satisfactory and unsatisfactory aerodynamic configurations. Pilot ratings and comments, as determined by the lateral aerodynamic model, were generally consistent with the expected handling qualities from flight test.

NIEWOEHNER, Robert J., Captain, USN, (Co-Author), "An Integrated Approach to Assessment of Abrupt Wing Stall for Advanced Aircraft", *AIAA Journal of Aircraft*, Vol. 42, No. 3, May – June 2005.

Several aircraft platforms have experienced abrupt wing stall at transonic flight conditions. This undesired aerodynamic phenomenon has led to uncommanded rolling motions that have degraded flying qualities, compromised mission performance, and reduced safety of flight. The National Abrupt Wing Stall program has advanced the state of the art in detection of abrupt wing stall through computational fluid dynamics, experimental aerodynamics, and flight dynamics. It is therefore essential that these tools be combined into an integrated approach that not only provides for the identification of abrupt wing stall, but also allows for the resulting flight characteristics to be assessed and the risks to the aircraft program be mitigated. The primary means of assessing the flying qualities impacts of transonic abrupt wing stall is through the construction of a math model that can accurately represent the aircraft. The primary means of mitigating program risks is through the inclusion of free-to-roll testing in the acquisition plan. Recommendations for assessing transonic abrupt wing stall are presented for the aircraft designer and for the program manager.

NIEWOEHNER, Robert J., Captain, USN, (Co-Author), and Joshua R. Filbey (Trident Scholar, Class of 2000), "A Computational Study of F/A-18 E/F Abrupt Wing Stall in the Approach Configuration", *AIAA Journal of Aircraft*, accepted for publication.

This computational study evaluated lateral instabilities observed during developmental testing of the pre-production F/A-18E/F in the Power Approach (PA) configuration. These instabilities, described here as "Abrupt Wing Stall" (AWS), occurred whenever the airplane exceeded 12° angle-of-attack. The AWS was quickly corrected in flight test by the closure of a vent at the wing root, without understanding its physical cause or cure. Computational solutions with both the vent open and closed provide insight into the likely cause of the instability, revealing two distinctive flow topologies. Specifically, all F/A-18 Hornet models depend upon strong vortex flows from the Leading Edge Extension (LEX) to provide lift at elevated Angle-of-attack. Flow through the open vent displaces the LEX vortex core inboard and up off the wing's upper surface. This displacement dramatically weakens the flow stability over the wing's entire upper surface. Wind tunnel studies performed in parallel by another researcher provide quantitative corroboration of the computational solutions. Finally, CFD metrics developed within the NASA/Navy/Industry Abrupt Wing Stall (AWS) program are applied to determine their validity at this low-speed flight condition and modified to enhance their viability as predictive tools for AWS prone configurations.

PETTIT, Chris L., Assistant Professor, "Uncertainty and Risk in Aerospace Vehicle Structures: Current Status and Recommended Directions", *International Journal of Vehicle Design*, in press.

Widespread interest in uncertainty quantification methods for airframe design and certification is driven by the desire to realize acquisition and operational cost savings through increased reliance on analysis, the goal being to design and produce more robust airframes. General sources of uncertainty are described that complicate airframe design and testing, thereby contributing to the high cost of airframes. Recent applications of uncertainty quantification are reviewed with the objective of highlighting promising research and transition applications. Finally, several challenges and needs are explored to suggest future steps that must be completed to enable practical application of uncertainty quantification in airframe design and certification.

PETTIT, Chris L., Assistant Professor, "Uncertainty Quantification in Aeroelasticity: Recent Results and Research Challenges", *Journal of Aircraft*, Vol. 41, No. 5, September-October, 2004, p. 1217-1229.

Accounting for static and dynamic aeroelasticity is a particularly important component of airframe design because they often control safety and performance; consequently, the impact of uncertainty on aeroelastic response prediction has begun to receive substantial attention in the research literature. In this paper, general sources of uncertainty that complicate airframe design and testing are briefly described. Recent applications of uncertainty quantification to various aeroelastic problems, (e.g., flutter flight testing,

prediction of limit-cycle oscillations, and design optimization with aeroelastic constraints) are reviewed with an emphasis on new physical insights and promising paths toward improved design methods that have resulted from these studies. Several challenges and needs are explored to suggest future steps that will enable practical application of uncertainty quantification in aeroelasticity design.

Conference Proceedings

PETTIT, Chris L., Assistant Professor, and BERAN, Philip S., Midshipman, USN, "Wiener-Haar Expansion of Airfoil Limit Cycle Oscillations", *46th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference*, Austin, TX, 18-21 April 2005.

Wiener chaos expansions are being evaluated for simulating randomness in the response of nonlinear aeroelastic systems, which often exhibit limit cycles. A two degree-of-freedom airfoil with nonlinear and random pitch stiffness is employed to simulate aeroelastic limit cycles. Polynomial chaos expansions faithfully reproduce the short term dynamics of the airfoil but consistently lose energy at large times relative to the period of oscillation. This is attributed to the continually increasing frequency of the process in the random dimension. The recently developed Wiener-Haar expansion is found to almost entirely eliminate the loss of energy at large times. This is shown initially for a sinusoidal model problem and then for the airfoil at reduced velocities close to and well above the critical value at which a limit cycle is first observed in the mean system. It is also shown that the discrete wavelet transform can be used to efficiently compute the expansion coefficients.

PETTIT, Chris L., Assistant Professor, (Co-Author),"Toward a Definition and Understanding of Correlation for Variables Constrained by Random Relations," *46th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference*, Austin, TX, 18-21 April 2005.

Random relations are random sets defined on a bi-dimensional space (or higher). Given that imprecision is the defining characteristic of a random set, it is natural to consider how imprecise representations of the constituent single-variable random sets influences the estimated correlation between the underlying random variables. After defining the correlation for two variables constrained by a random relation as an interval, the effect of imprecision was studied by using of a multi-valued mapping, the domain of which is the space of joint random variables. This perspective led to the notion of consistent and non-consistent marginals. The calculation of the correlation bounds requires solving two optimization problems that are NP-hard if addressed with interval analysis techniques; therefore, mathematical programming techniques were used in the numerical examples. It is shown that the hypothesis of non-consistent marginals leads to correlation bounds that are much larger (four orders of magnitude in some cases) than those obtained under the hypothesis of consistent marginals. An application to the reduction factor calculation for a multistory building shows that imprecision has a substantial impact on the design loads for base columns.

PETTIT, Chris L., Assistant Professor, (Co-Author), "Parameter Identification and Investigation of a Bolted Joint Model", *46th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference*, Austin, TX, 18-21 April 2005.

Mechanical joints are a primary source of variability in the dynamics of built-up structures. Physical phenomena in the joint are quite complex and therefore too impractical to model at the micro-scale. This motivates the development of lumped parameter joint models with discrete interfaces so that they can be easily implemented in FEM codes. Among the most important considerations in choosing a model for dynamically excited systems is its ability to model energy dissipation. This translates into the need for accurate and reliable methods to measure model parameters and estimate their inherent variability from experiments. The adjusted Iwan model was identified as a promising candidate for representing joint dynamics. Recent research focused on this model has exclusively employed impulse excitation in conjunction with neural networks to identify the model parameters. This paper presents an investigation of an alternative parameter identification approach for the adjusted Iwan model, which employs data from

oscillatory forcing. This approach is shown to produce parameter estimates with precision similar to the impulse excitation method for a range of model parameters.

PETTIT, Chris L., Assistant Professor, (Co-Author), "Sensor Placement Optimization for SHM Systems Under Uncertainty", *46th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference*, Austin, TX, 18-21 April 2005.

Structural health monitoring (SHM) systems that report in real-time the flight vehicle's condition in terms of reactions, stresses, and displacements, are central to meeting the demanding goals of increasing flight vehicle safety and reliability, while reducing vehicle-operating and maintenance costs. The sensing components of the SHM system must be extremely reliable, small, lightweight, and energy efficient, in order to be incorporated into the flight vehicle design with minimal impact on the structure's performance. The structural behavior of the flight vehicle is inherently random due to the uncertainties in the original properties structure, accumulated damage, mass distribution, and operating environment. Integrated SHM systems should be designed to optimize the likelihood of detecting damage given limited system resources. Reliability-based optimization is being combined with stochastic simulation methods to develop an algorithm for selecting sensor locations to meet these goals. The proposed methodology for optimal SHM design under uncertainty includes the following components: (1) damage detection algorithms, (2) structural modeling and analysis, (3) probabilistic and reliability analyses, and (4) sensor placement optimization. Key hurdles include: (1) development of accurate finite element models for simulating the localized dynamics of the structure as it is interrogated by the SHM system, and (2) selection or development of an appropriate discrete global optimization algorithm to select the best sensor locations given a set of candidate locations.

Book Chapters

BODEN, Daryl G., Professor, "Space Navigation and Maneuvering," Cost-Effective Space Mission Operations, 2nd Edition, Chapter 10, New York, McGraw-Hill.

In this chapter we provided the tools needed to calculate some basic parameters for orbit trajectory and mission geometry. We used these parameters to plan for and analyze the navigation function. We also helped you understand basic orbital theory, define key terms, and provide basic equations that allow you to calculate many orbital parameters by hand. We begin by explaining terms used to describe orbits and giving you equations for calculating orbital parameters. The next four sections describe aspects of Earth-orbiting spacecraft: orbit perturbations, orbit maneuvering, launch-window calculations, and orbit maintenance. We next describe interplanetary trajectories and a way to estimate velocity budgets for interplanetary trajectories. Finally, we describe parameters of orbit geometry for spacecraft in Earth orbit.

NIEWOEHNER, Robert J., Captain, USN, "Pilots Handbook for Critical and Exploratory Flight Testing," Society of Experimental Test Pilots, 2003. Author of "Flutter Flight Testing" chapter.

This manual was developed as part of the national Centennial of Flight to replace a 30-year-old edition. Contributors represented the country's most experienced test pilots. Its purpose was to provide an archival volume documenting lessons learned from a century worth of flight test engineering. The editor described the Flutter chapter as the most technically substantial of the entire manual.

Presentations at Professional Meetings and Conferences

BODEN, Daryl G., Professor, "USNA Adoption of the CDIO Syllabus", CDIO Meeting, 10-17 January 2004, Stockholm, Sweden.

BODEN, Daryl G., Professor, "USNA Adoption of the CDIO Syllabus", CDIO Meeting, 2-4 June 2004, Annapolis, MD.

BIRCKELBAW, Larry, Research Professor, "CDIO Design-Build Experiences", North America CDIO Regional Meeting, Boston, MA 4 November 2004.

BIRCKELBAW, Larry, Research Professor, "CDIO North American Regional Workspaces Report," North America CDIO Regional Meeting, Boston, MA 4 November 2004.

BRUNINGA, Robert, CDR, USN (ret), "The Naval Academy Small Satellite Program", AIAA/USU Small Satellite Symposium, Cubesat Seminar, Utah State University, 9 August 2004.

BRUNINGA, Robert, CDR, USN (ret), "Space Communications – International Educational Network Classroom Experience – SCIENCE and RAgeo Communications Transponder Projects", Navy Space Experiments Review Board (SERB), Navy Research Laboratory, Washington, DC., 28 July 2004.

BRUNINGA, Robert, CDR, USN (ret), "S.C.I.E.N.C.E Project", Department of Defense Space Experiments Review Board (SERB), Arlington, VA., 16 November 2004.

NEIWOEHNER, Robert J., Captain, USN, "Flight Test Engineering", Kansas University's Aerospace Short-course, Kansas City, MO.

PETTIT, Chris L., Assistant Professor, (Co-Author), "Toward a Definition and Understanding of Correlation for Variables Constrained by Random Relations", 46th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, Austin, TX, 18-21 April 2005.

PETTIT, Chris L., Assistant Professor, (Co-Author), "Parameter Identification and Investigation of a Bolted Joint Model", 46th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, Austin, TX, 18-21 April 2005.

PETTIT, Chris L., Assistant Professor, "Uncertainty Quantification in the Prediction of Nonlinear Aeroelasticty", Department of Civil and Environmental Engineering, University of Delaware, Newark, DE, October 2004, and Department of Civil Engineering, The Johns Hopkins University, Baltimore, MD, November 2004.

PETTIT, Chris L., Assistant Professor, (Co-Author), "Sensor Placement Optimization for SHM Systems Under Uncertainty", 46th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, Austin, TX, 18-21 April 2005.

PISACANE, Vincent L., Professor, ZIEGLER, James F., Visiting Professor, (Electrical Engineering Department) NELSON, Martin E., Professor, (Mechanical Engineering Department), CAYLOR, Matthew O., Midshipman, USN, FLAKE, Daniel J., Midshipman, USN, HEYEN, Lance T., Midshipman, USN, YOUNGBORG, Errol O., Midshipman, USN, " MIDN**:** A Spacecraft Microdosimeter Mission", 14th International Conference on Solid State Dosimeter, New Haven, CT, July 2004;

PISACANE, Vincent L., Professor, ZIEGLER, James F., Visiting Professor, (Electrical Engineering Department) NELSON, Martin E., Professor, (Mechanical Engineering Department), VEADE, Thomas N., Midshipman, USN, HEYEN, Lance T., Midshipman, USN, "The USNA MIDN Microdosimeter Instrument", AIAA 43rd Aerospace Sciences Meeting, Reno NV, January 2005.

PISACANE, Vincent L., Professor, ZIEGLER, James F., Visiting Professor, (Electrical Engineering Department) NELSON, Martin E., Professor, (Mechanical Engineering Department), "Microdosimetry Simulations Within Heterogeneous Structures", 2005 IEEE Nuclear and Space Radiation Effects Conference, Seattle, WA, 11-15 July, 2005.

PISACANE, Vincent L., Professor, (Co-Author), "Rugged, Compact Microdosimeters and the Applicability of Such Measurements for Assessing the Risk of Cancers from Exposures to Radiation", National Cancer Institute Symposium on Biosensors, Rockville MD, June 2005. (by invitation)

PISACANE, Vincent L., Professor, ZIEGLER, James F., Visiting Professor, (Electrical Engineering Department) NELSON, Martin E., Professor, (Mechanical Engineering Department), HEYEN, Lance T., Midshipman, USN, VEADE, Thomas N., Midshipman, USN, "MIcroDosimeter iNstrument (MIDN) System Scheduled for Launch in 2006", 15th IAA Human in Space Symposium, Graz, Austria, 22-26 May 2005.

PISACANE, Vincent L., Professor, ZIEGLER, James F., Visiting Professor, (Electrical Engineering Department) NELSON, Martin E., Professor, (Mechanical Engineering Department), "Response of a SOI Microdosimeter to a 238PuBe Neutron Source, IEEE Nuclear Science Symposium and Medical Imaging Conference, Puerto Rico, 23-29 October 2004.

PISACANE, Vincent L., Professor, VEADE, Thomas N., Midshipman, USN, HEYEN, Lance T., Midshipman, USN, TADDEI, Phillip, Assistant Research Professor, "MIDN**:** A Spacecraft Microdosimeter Mission", Dirksen Senate Office Building, Washington, DC, March 2005.

SMITH, Jr., Billy R., Associate Research Professor, "Laser Relativity Satellite: A Search for the Dragging of Inertial Frames (the Lense-Thirring Effect)", 2004 AMOS Technical Conference, Maui, HI, 8-12 September 2004.

SMITH, Jr., Billy R., "High-impact Science with University Satellites: USNA's Contribution to the Laser Relativity Satellite (LARES)", AIAA Space 2004 Conference, Long Beach, CA, 23-25 September 2004.

SMITH, Jr., Billy R., "USNA Small Satellite Program: PCSAT and SAPPHIRE One-year Reports", AIAA Space 2004 Conference, Long Beach, CA, 23-25 September 2004.

TADDEI, Phillip, Assistant Research Professor, "Using a TEPC for Radiation Safety for Astronauts in Space," United States Naval Academy, Annapolis, MD, December 2004.