Division of Engineering and Weapons

CAPT Douglas H. Rau, USN
Director

Aerospace Engineering Department

Professor Daryl G. Boden
Chair

The research and publication efforts of the Aerospace Engineering Department faculty and students covered a broad range of topics in aeronautics, astronautics, and rotor dynamics.

The capstone courses highlighted this year's research in the Aerospace Engineering Department. Following the success of the Naval Academy's first satellite, *PCSat*, all of the midshipmen in the capstone design course for the Astronautical Engineering track worked on the design of small satellites that we expect to launch in the future. The Aeronautical Engineering track students flew two airplanes in the American Institute of Aeronautics and Astronautics (AIAA) international remote control airplane contest in Ridgely, MD. The airplanes were designed, built and tested throughout the academic year and were successfully flown in competition the last week of April 2003.

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, the U. S. Air Force Space Test Program, and the Boeing Corporation to accomplish their research and to support the capstone courses.

This year there were three Trident Scholars in the Aerospace Engineering Department. Midn 1/C Michael Oliver conducted research on composite wings and was awarded the Harry E. Ward - Office of Naval Intelligence Trident Scholar Prize for Academic Year 2003. Our other two Trident Scholars conducted research on atmospheric density measurements for satellites in low-Earth orbit and autonomous flight control for carrier landings.

Sponsored Research

REX II Operations

Researchers: Professor Daryl G. Boden and CDR Robert Bruninga, USN (Ret.)
Sponsor: United States Air Force Space Test Program

The United States Naval Academy Satellite Ground Station (SGS) provides operational control on the REX II spacecraft on a daily basis.

U. S. Naval Academy Small Satellite Program

Researchers: Midshipmen majoring in Aerospace Engineering – Astronautics Track
Advisers: LTCol Billy R. Smith, (USAF), Professor Daryl G. Boden,
CDR Robert Bruninga, USN (Ret.) and Professor Vincent L. Pisacane
Sponsor: Boeing Astronautics

The United States Naval Academy Small Satellite program is a series of small satellites designed, fabricated, tested, launched, and operated by midshipmen at the United States Naval Academy. *PCSat*, launched on 30 September 2001, was the first of the series.

Surface Pressure Calculations of a Lunate Tail Based on Lifting-Line Theory

Researcher: Professor Gabriel N. Karpouzian
Sponsor: Naval Research Laboratory (NRL)

The asymptotic theory of a high aspect-ratio wing in an incompressible flow is applied to an oscillating lifting surface with a curved centerline in the low-frequency regime where the reduced frequency (Strouhal Number) based on a half-chord length is very small. The theory is suitable to aquatic animal locomotion in carangiform mode identified in the teleost fishes (Tuna, Swordfish), in elasmobranches (Whaleshark, Porbeagle), and in cetacean mammals (Dolphin). The carangiform swimming mode is characterized by the restriction of noticeable undulation to the posterior end of the body where the caudal fin is primarily responsible for the thrust generation. According to Marshall (1966), the corresponding morphological adaptations are: (i) a compact, muscular, airship-like body, (ii) a pronounced necking of the body anterior to the tail, and (iii) a crescent moon caudal fin of high aspect ratio, referred to as lunate tail. Because the aspect ratio is high, the present theory identifies a frequency domain, the stream wise and cross-stream components of the wake vorticities are comparable in magnitude. These low-frequency tail oscillations seem to occur in nature for leisure swimming or cruising of the fish in question, as can be asserted from Bainbridge (1958, 1963) studies.

Low Light Level Illumination for Enhanced Propeller Visibility

Researchers: Assistant Professor David S. Miklosovic, CDR James Jones, USN,
and Mr. Richard W. Garman (Aerospace Engineering Dept staff)
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 focuses 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 have been identified to improve spinning propeller visibility. Representative propellers will be endurance-tested in the Naval Academy's Rotor Laboratory.

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 photo luminescent 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 photo luminescent 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 photo luminescent 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 supports this program at three levels: facility reconfiguration of an existing test cell, propeller endurance testing, and propeller performance deficit analysis. Facility reconfiguration involves upgrading hardware in the USNA Rotor Laboratory, including a new drive system, hub, instrumentation, and a ½-ton wall mounted jib crane. The propeller endurance testing will involve production aircraft propellers, 50-74 inches in diameter, to be operated at 3500 RPM to allow for more realistic test conditions without mounting full-size E-2C propellers. The propeller performance deficit analysis will involve 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 supports an SBIR Phase II follow-on (Noesis subcontract DC05-001-45/F5) to Phase I work performed in 2002.

Static Performance Evaluation of the Dragon Warrior Rotor and Drive System

Researchers: Assistant Professor David S. Miklosovic
Sponsor: Naval Research Laboratory (NRL)

Dragon Warrior is a joint effort between the Naval Research Laboratory (NRL) and the Marine Corps Warfighting Laboratory (MCWL) to develop a Humvee (HMMWV)-transportable, vertical take-off and landing (VTOL) unmanned air vehicle for U.S. Marine Corps missions. With its fully autonomous flight operation and differential GPS navigation, the Dragon Warrior will perform Reconnaissance Surveillance Target Acquisition (RSTA) and Communications Relay missions. The first full-scale prototype flight tests were scheduled beginning May 2002 with mission demonstrations beginning in 2003. The overall body length was 84 inches and the rotor diameter was 96 inches. With a gross weight of 250 lb and a payload capacity of 25–35 lb, Dragon Warrior will have an estimated endurance of 3–5 hours and a dash speed of 100 kt.

This research task involved testing the Dragon Warrior rotor on a reaction plate mounted in the Naval Academy's Rotor Test Facility. Thrust and torque measurements were taken at full-scale operational conditions. The initial testing at the Academy was done during June of 2002, and early results prompted additional support of the project. Subsequent testing occurred during July and August of 2002.

Wind Tunnel Testing of Ship Motion Effect on Airwake

Researchers: Assistant Professor David S. Miklosovic
and Mr. Richard W. Garman (Aerospace Engineering Department staff)
Sponsor: Naval Air Systems Command, Code 4321

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 has been 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, are being compared with the model-scale test results to determine the accuracy of the predictions. The wind tunnel measurements of the airflow over of a ship model are needed in the areas of the flight deck, the bow, the superstructure, and aft of the ship and at points along a typical helicopter approach profile.

The accomplishments of 2003 involved the specification of the geometry combinations to be tested and the identification of key ship motion parameters to be modeled. The representative non-carrier ship chosen was the DD-963, with an appropriate wind tunnel model length of 64 inches. An analysis of ship motion simulation data revealed critical aerodynamic effects occur in the wake of the DD-963 when underway at 25 knots in 20' seas, which corresponds to sea state 6-7. Pitching motion was shown to be prominent, with an amplitude of 3.8 degrees and a period of 7 seconds for the full scale ship. The application of dynamic scaling laws produced wind tunnel test conditions that will simulate the nature of the unsteady aerodynamics: an oscillatory motion of, at most, 12 Hz at relative wind speeds of 30 ft/sec. Pitch rotation was selected to be coincident with the center of floatation, which is 57.6% aft in the waterplane.

Micro-Dosimeter iNstrument (MIDN) Development

Researcher: Professor Vincent L. Pisacane
Sponsor: National Air and Space Administration – Joint Space Command (NASA-JSC)

The objective of this research is to develop a micro-dosimeter system to monitor the radiation environment of astronauts in space, especially the space station. The system consists of five major components: (1) Sensor, (2) Signal Conditioner, (3) Multi-Channel Analyzer (MCA), (4) Peripheral Interface Computer (PIC), (the latter to interface to the space communication system), and (5) the communication system between the spacecraft and the ground. The sensor, MCA, Terminal Node Controller (TNC), ground transceiver, and test equipment have been procured. The signal conditioner has been constructed and the sensor, conditioner and MCA integrated through a student research project. As a result the energy spectra of radiation sources have been obtained. The communication system has been designed and is functioning independent of the micro-dosimeter instrument. This summer's effort will concentrate on development of the PIC to interface between the MCA and the space communication system.

Independent Research

Analytic and Experimental Aerodynamic Characterization of a Multiple-Bladed Flapped Autorotational Decelerator

Researcher: Assistant Professor David S. Miklosovic

This research supports a collaborative development program for the Rotary-wing Decelerator Vehicle (RDV), a precision-guided aerial delivery system for the U.S. armed forces. Based on an unpowered autorotating rotor, this system will significantly surpass the capabilities of conventional fabric canopies for precision aerial delivery of equipment and supplies. The principle advantages of this system include: increased aircraft/airborne force survivability, improved airdrop accuracy, reduced losses, autonomous guidance. The research approach involves applying established analytic methods to predict auto rotor performance and conducting wind tunnel tests of a 1/10-scale model rotor. Different control surfaces are considered by measuring the effectiveness of statically configured devices in the wind tunnel to determine the optimum configuration for a full-scale model.

Roughness Effects on Lift and Drag of a Laser Centerboard

Researchers: Assistant Professor David S. Miklosovic and
Assistant Professor Michael P. Schultz (Naval Architecture and Ocean Engineering Department)

Recent research at the U.S. Naval Academy has shown that surface roughness has a first-order effect on the hydrodynamic drag of flat plates. In an effort to apply these results to a geometry having an imposed pressure gradient, wind tunnel tests were conducted on production Laser centerboards modified for mounting purposes. The centerboards have a symmetric NACA 0009 airfoil section and a sweep of about 15° and were tested at the same Reynolds numbers experienced during sailing. After baseline tests were performed with a "production-quality" surface finish, a rough paint coating was applied. Subsequent tests were performed in which the coating was successively sanded down to finer finishes.

The results showed very minor improvements in the drag and the lift-to-drag ratio as the surface finish became smoother, but the magnitude of change was barely above the sensitivity of the instrumentation. This was attributed to the large percentage of turbulent flow over the conventional airfoil section at Reynolds numbers of around 1 million. Plans to test a laminar flow section on a centerboard model are being considered.

Wind Tunnel Measurements of the Effects of Tubercles on a Humpback Whale Flipper

Researchers: Assistant Professor David S. Miklosovic
and LCDR Mark M. Murray (Mechanical Engineering Department)

Humpback whales are baleen whales, with stocky bodies that are 40-50 feet long. The body is not as streamlined as other rorquals, but is quite round, narrowing to a slender peduncle (tail stock). Unusually large flippers that are 10-15 feet long aid whale locomotion and maneuvering. This research models the Humpback flipper to varying degrees of geometrical accuracy in order to determine the function of the tubercles. It is anticipated that these raised knobs on the flipper produce lift improvements at high angles of attack and drag improvements at low Reynolds numbers. The flipper was modeled in acrylic using three geometries: as an idealized smooth wing, as a smooth wing with a sinusoidal leading edge profile, and a scaled casting of an actual humpback flipper. Wind tunnel tests are being conducted at nearly the same Reynolds numbers experienced in the ocean (1-2 million).

This work is a continuing collaborative effort with Duke University and West Chester University.

Antenna Drag Study

Researcher: Professor David F. Rogers

This project involves an experimental study of the drag characteristics of a group of general aviation antennas at near flight velocities.

Midshipman Research Course Projects

PCSat Attitude Dynamics and Solar Panel Degradation

Researcher: Midshipman 1/C Rebecca Baumez, USN
Adviser: Professor Daryl G. Boden

This project describes the attitude dynamics of a USNA-01 satellite, *PCSat*, based on limited telemetry. We compared telemetry data from *PCSat* dated October 2001 to October 2002 to analytic predictions derived from a MATLAB simulation. The analytical predictions were derived from Euler's equations of motion. We propagated the orbit forward, integrated Euler's equations, computed the Euler angles, and repeated the process for one year. The attitude dynamics of *PCSat* were such that the period of *PCSat*'s rotation rate was equivalent to the period of the orbit. Analyzing the maximum currents during cycles and fitting the maximum currents to a linear regression line determined the degradation of *PCSat*'s solar panels. The result was a negative trend line, which shows the rate of solar panel degradation.

Effects of Weightlessness on Cardiovascular Function

Researchers: Midshipman 1/C Bryce Abbott, USN and Midshipman 1/C Sarah Atwater, USN
Advisers: Professor Vincent L. Pisacane
and Dr. A. Shoukas, The Johns Hopkins University
Sponsor: Heinlein Foundation

The objectives of this project were to research mechanisms of decreased vasoreactivity due to exposure to micro-gravity environment and the degree to which this mechanism is endothelium dependent. Orthostatic intolerance of astronauts on return to a gravity environment is caused by reduced volume of blood, ability of blood vessels to vasoconstrict, and cardiac deconditioning. This study addressed up-regulation of nitrous oxide synthase (NOS) to produce nitrous oxide in the endothelium that causes increased vasodialation enhancing hypotension. Rats were hind limb suspended for three days, sacrificed, and sections of their aorta were exposed to NOS blockers (L-Name and ODQ) to measure contractile response. Project conclusions are (1) that NOS is up-regulated in endothelium intact aortic rings of 3 day hind limb suspended rats; (2) the up-regulation of NOS depresses the contractile response, (3) up-regulation decreases relaxation in the presence of a vasoconstrictor, and (4) the condition appears to be endothelium dependent. This research was conducted at The Johns Hopkins University School of Medicine.

Hard and Soft Error Rates on Memory Chip Exposed to Radiation

Researcher: Midshipman 1/C Benjamin Arron, USN
Adviser: Professor Vincent L. Pisacane

In this research, a test unit was loaded from Johns Hopkins that included a microprocessor and test memory chip. The equipment was set up and tested and a series of experiments carried out that evaluated soft and hard memory errors as a function of the radiation environments, especially neutrons. Only soft errors were detected. The error rates were then compared to theoretical estimates. The chip was found to be much harder that the theory predicted. The discrepancy was not resolved, and further investigation is warranted.

Development of Radiation Micro-Dosimeter iNstrument (MIDN)

Researcher: Midshipman 1/C Roger Callahan, USN
Adviser: Professor Vincent L. Pisacane
Sponsor: National Air and Space Administration (NASA)

A variable amplifier was developed for a micro-dosimeter measurement system and the micro-dosimeter sensor and amplifier were integrated with a micro-channel analyzer (MCA) to produce the total system. Radiation spectra were determined for simulated and actual radiation sources. (The amplifier reconditions the sensor output for input to the micro-channel analyzer.) The voltage required was 6V and the total power 150mW with the MCA consuming less than 300 mW. Development of a minimum power system is critical for test flight of the instrument on the MIDSTAR spacecraft to be launched in 2005. The system was then turned over to the midshipman team working on the EA470 Spacecraft Design Project that had designed and instrumented the communications system to transmit the observations to the Naval Academy's Satellite Ground Station. The MIDSTAR spacecraft mission will demonstrate the viability of the digital micro-dosimeter that can be used to assess the radiation exposure of astronauts in the International Space Station and Shuttle.

A Vortex Lattice Analysis and Experimental Validation of Multiple Winglet Configurations

Researcher: Midshipman 1/C Patrick B. Bookey, USN
Adviser: Assistant Professor David S. Miklosovic

Remote sensing, surveillance, and combat missions are increasingly accomplished through the use of small, autonomous flight vehicles. These aircraft rely on high lift to drag ratios and minimal maneuvering to attain high ranges and endurance. Thus, the ability to increase the efficiency of these aircraft will increase their endurance and their effectiveness. Multiple winglets are one solution to this problem. Not only can the winglets reduce the induced drag, they could be used for flight-optimized roll/stall control. This application would be highly suited to the military's UAV's by adding range and improving performance.

Analytical and experimental efforts were undertaken during the fall and spring semesters to assess the effectiveness of three individual winglets mounted chordwise on the tip of a symmetrical NACA 0018 semi-span wing. The primary degree of freedom studied in this series was the local dihedral angle of the winglets with respect to the chord plane of the wing. The analytic trade studies were done by modeling a zero thickness wing and winglets using the "Vortex-Lattice FORTRAN Program for Estimating Subsonic Aerodynamic Characteristics of Complex Planforms," written by Richard J. Margason and John E. Lamar for the Langley Research Center. The FORTRAN based program was used to predict the aerodynamic characteristics of different configurations of winglet local dihedral angles. These predictions allowed the scope of the wind tunnel testing to be narrowed to encompass those configurations that showed the most promising results.

Consequently, twenty configurations were tested in the Naval Academy's Closed-Circuit Wind Tunnel at a Reynolds number of 600,000. The results showed that the winglets placed at 60, 45, and 30 degrees from the leading winglet to the trailing winglet produced the best results, increasing the range of high L/D operation from 3-8° for a configuration with all winglets at zero degrees dihedral to 3-13°. It saw nominal increases in C_L of 4%, at most 46% decrease in C_D. The findings from this and other configurations suggest that changing the dihedral angles of multiple winglets effects changes in the lift, drag, and pitching moment in such a way that they are feasible for use as actively controlled surfaces to improve the performance of aircraft at various flight conditions.

Trident Scholar Projects

Determination of Atmospheric Density in Low Earth Orbit Using GPS Data From the USNA Satellite (Trident Report # 308)

Researcher: Midshipman 1/C Katherine E. Groenenboom, USN
Advisers: Visiting Professor Richard P. Fahey and Professor Daryl G. Boden

This project used real-time data from the U.S. Naval Academy's Prototype Communications Satellite's (*PCSat*) to calculate atmospheric density in the satellite's orbit during specific time intervals. The research involved using the latitude,

longitude, altitude, and time data from a GPS receiver on board PC-Sat and transforming these quantities into the classical orbital elements (COEs). The velocity vector at each GPS position of PC-Sat's orbit was also known.

The Herrick Gibbs method, using three consecutive and close position vectors, was used to determine the velocity at the middle position vector, and a Kalman filter was used to remove noise from the data. From the COEs, the change in the size of the orbit was determined, via the change in the semi-major axis. This change was due to the non-spherical Earth and the atmosphere. Therefore, by accounting for the change in semi-major axis due to the non-spherical Earth, the researcher concluded that the remaining change was due solely to atmospheric density. The calculation for atmospheric density from the change in semi-major axis also required the cross-sectional area and mass of the satellite, the position of the satellite in its orbit (a COE calculated with the semi-major axis), and the velocity of the satellite with respect to the atmosphere.

The ability to determine atmospheric density in a specific orbit by knowing only the position of the satellite and few characteristics of the satellite itself will in the future allow many small satellites with GPS receivers on board to contribute to the collection of data about the upper atmosphere. Knowing the Earth's atmospheric density much more accurately will then allow satellite predictions and fuel usage predictions to be much more accurate and therefore would lower the cost of missions.

The Aeroelastic Effects of Transverse Shear Deformation on Composite Wings in High Speed Flow Regimes (Trident Report # 313)

Researcher: Midshipman 1/C Michael Oliver, USN
Adviser: Professor Gabriel N. Karpouzian

This project analyzed the effect of transverse shear deformation upon the aeroelastic response of composite wings in high-speed flow regimes. Previously, models have been developed to predict the aeroelastic characteristics of classical materials in high speed flow. However, these studies ignored transverse shear by assuming an infinite modulus of rigidity. This assumption underestimates transverse flexibility by ignoring the transfer of loads through the wing thickness. By assuming a finite modulus of transverse shear rigidity and redeveloping the governing equations, this model more accurately predicts the aeroelastic response of composite wings. This analysis was primarily concerned with the determination of aeroelastic trends vice more detailed solutions and associated accuracy. Thus, linearized flow theory was used. Upon conclusion, this study gave results for divergence speed and flutter speeds, as well as the aeroelastic stability mode shapes.

Design Specifications Development for Unmanned Aircraft Carrier Landings: A Simulation Approach (Trident Report # 316)

Researcher: Midshipman 1/C Joseph F. Sweger, USN
Adviser: CAPT Robert J. Niewoehner, USN

This project investigated the influence unmanned-aircraft characteristics on landing precision. The goal of this analysis was the determination of a minimum set of performance and maneuverability criteria that ensure satisfactory carrier landing precision and consistency. The first step in this project was to design and write a comprehensive computer model to simulate unmanned carrier landings. The model includes ship dynamics, atmospheric turbulence, navigational information errors, dynamic airplane control structure, and aircraft dynamics. The airplane senses and correct for three disturbances: wind gusts, unsteady ship motion, and navigational information errors. The second step involved varying aircraft attributes and recording landing performance statistics for each configuration. Some examples of aircraft attributes are elevator effectiveness, roll control power, throttle lag, and center of gravity location. The influence of each attribute was extracted from the landing statistics. This was done for various weather conditions because the ship motion increases with wave size and the gust intensity increases with average wind velocity. The third step was the development of preliminary criteria to be refined and verified with test cases. The fourth and final step was to generate a report presenting the above process and the final aircraft design limits. The significance of the anticipated performance requirements is reduced airplane cost and increased design freedom.

Technical Report

KARPOUZIAN, Gabriel, Professor, and Kostoff , Ronald N., "Abrupt Wing Stall Text Mining Using Bibliometerics and Database Tomography," Technical Report for Patuxent Naval Air Station, June 2003.

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 database derived from the Science Citation Index (SCI) database. Phrase frequency analysis by the technical domain experts provided the pervasive technical themes of the Abrupt Wing Stall database, and the phrase proximity analysis provided the relationships among the pervasive technical themes. Bibliometric analysis of the Abrupt Wing Stall literature supplemented the DT results with author/journal/institution publication and citation data.

Conference Proceedings

BARTZ, Jamie, Midshipman 1/C (USN), and MIKLOSOVIC, David S., Assistant Professor, "An Experimental Analysis of Camber Effects of a 6-Bladed Flapped Autorotational Aerodynamic Decelerator," *17th AIAA Aerodynamic Decelerator Systems Technology Conference* (paper no. AIAA-2003-2143), Monterey, CA, 19-22 May 2003.

This research effort compared the influence of effective blade camber through the use of static trailing edge blade-flap configurations on an autorotational aerodynamic decelerator. Wind tunnel force measurements were conducted at velocities up to 60 ft/sec and Reynolds numbers up to $7x10^6$ based on the rotor tip speed. The test article was a six-bladed autorotor with small stationary outboard flaps. The result of adding the flaps showed significant improvements in the aerodynamic performance: up to 193% increase in the overall drag coefficient and a 67% decrease in the autorotational advance ratio. These conclusions indicate a favorable scaling to larger diameters and the potential for the implementation of active control systems for trajectory management capabilities.

Presentations at Professional Meetings and Conferences

BOOKEY, Patrick B., Midshipman 1/C (USN) and MIKLOSOVIC, David S., Assistant Professor, "Experimental Validation of a Vortex Lattice Analysis of Multiple Winglet Configurations," NASA Langley Research Center - Configuration Aerodynamics Branch, 29 April 2003.

BODEN, Daryl G., Professor, "Overview of the United States Naval Academy," Conceive, Design, Implement, and Operate (CDIO) Meeting, Vadstena, Sweden, 24-27 February 2003.

ROGERS, David F., Professor, "Short Course at SIGGRAPH 2002, Non-Uniform Rational B-Splines (NURBS), A Primer," San Antonio, TX, July 2002.

ROGERS, David F., Professor, "Turnback After Engine Failure on Take-off – Altitude Effects," World Beechcraft Society, The Johns Hopkins University, August 2002.