DEPARTMENT SUMMARY

Aerodynamics

TOPICS RELATED TO ROTORCRAFT AND VERTICAL FLIGHT: The rotary wing program led by Professor Wood has four areas. These are: (1) sponsored research support of the Army's principal program, the RAH-66 *Comanche* helicopter. The prototype helicopter is now undergoing engineering flight development at Sikorsky's test center in West Palm Beach, FL. In this area, Professors Wood and Kolar (Department of Aeronautics and Astronautics), Professor Danielson (Department of Mathematics), and Professor Gordis (Department of Mechanical Engineering), are being funded by the Army RAH-66 *Comanche* Office to apply a NASTRAN structural dynamics model of the *Comanche* for exploring potential vibration and weapons system problem areas. In other areas, (2) research in ground and air resonance of soft-inplane hingeless rotor systems (Army Research Office and Sikorsky Aircraft) to eliminate the instability without requiring heavy and costly blade dampers (with AA Lecturer LCDR R. L. King); (3) technical support of Boeing Helicopters-Mesa and SatCon Technology for application of higher harmonic control for improved rotor performance; and (4) development of an improved weapons performance model (Comanche 20-mm gun) for U. S. Army Proving Ground at Yuma, AZ.

FLAPPING WING PROPULSION: In support of the Naval Research Laboratory, Professors Platzer and Jones are performing experimental and computational studies to explore flapping wing propulsion for micro-air vehicles. The numerical simulations were made with an unsteady panel code and a model with flapping wings was built and tested in the NPS low-speed wind tunnel. The measured thrust values agreed well with the prediction.

ENHANCED HELICOPTER MANEUVERABILITY: Professors Chandrasekhara, Platzer, and Jones are performing experimental and computational studies to investigate the fundamental fluid flow physics of compressible flow separation and dynamic stall onset over fixed and variable geometry airfoils, leading to innovative flow control methods. These studies are partially supported by the Army Research Office. Also, in support to the Army Research Office, Professor Chandrasekhara is performing experiments to develop flow control schemes by dynamically deforming the leading edge of an airfoil for prevention of flow separation.

Research funded by the Office of Naval Research was performed to define six possible missions for uninhabited combat air vehicles (UCAVs); a notional configuration was developed for a close-air-support (CAS) platform. Unfunded research was also conducted in waverider, Second Law (thermodynamics) aircraft design methodology and environmental security. Proposals have been submitted to funding sources associated with waverider, environmental security and UCAV systems.

Aeroelasticity

HYPERSONIC FIN FLUTTER: In support of the Naval Air Warfare Center, China Lake, Professors Platzer and Kolar performed a flutter analysis of missile fins flying at hypersonic speeds.

GUST LOAD ANALYSIS: In support of the Naval Air Warfare Center, Patuxent River, Professors Platzer and Tuncer performed computational studies to assess the gust sensitivity of the C-130J aircraft.

Propulsion

ADVANCED AIRCRAFT ENGINE AND MISSILE PROPULSION STUDIES: The validation of CFD design and analysis methods motivates advanced compressor and turbine studies. Professor Shreeve is using a transonic research compressor to validate 3D CFD design methods for advanced fans. Pressure-sensitive paint is being used as a rotor-flow diagnostic. Professor Hobson is investigating both stall in controlled-diffusion compressor blading, and tip-clearance flows in an axial turbine. His work involves both multi-component LDV measurements and CFD analysis. In a new program related to high-cycle fatigue (HCF), Professors Shreeve and Hobson are collaborating with the Naval Air Warfare Center to develop blade-excitation and measurement techniques for spin-test facilities. Small gas turbine engine variants for UAV applications are also being examined.

PLUME SIGNATURE AND PULSE-DETONATION ENGINES: Professors Netzer and Brophy are working to experimentally determine the effects of operating conditions, combustor design, fuel composition and additives on the exhaust plume sooting characteristics of liquid-fueled rocket motors. Also, they are experimentally determining the combustion requirements for sustainment of full strength detonations and the detonation characteristics of liquid-fueled, pulse detonation engines.

Flight Mechanics and Controls

UNMANNED AIR VEHICLE (UAV) TECHNOLOGY: In support of the DoD's role in the development of UAVs, Professor Howard, working with Professors Kaminer and Duren, has developed a UAV flight research laboratory at NPS using several flight platforms for the development and testing of flight control technologies and to address relevant issues of aerodynamics, flight mechanics and intelligent flight control. Projects currently in progress include autonomous flight using passive sensors, voice control of UAVs, an aircraft high-altitude drop simulation, and rotary-wing modeling. A study of key UAV marinization issues is ongoing in support of the Center for Naval Analyses.

SPACECRAFT ATTITUDE CONTROL AND SMART STRUCTURES: In this program, under the supervision of Professor Agrawal and in response to DoD requirements, the emphasis is on the development of improved control techniques for the attitude control of flexible spacecraft and vibration and shape control using smart structures. Improved control techniques have been developed using the technique of input shaping in conjunction with PWPF thrusters to minimize structural vibrations. Neural control has been used for attitude control. A finite element model has been developed to analyze composite plates with piezoelectric actuators. Analytical techniques to determine optimum actuator voltages to minimize surface error were developed. A Smart Structures Laboratory, consisting of vibration isolation platform, space truss, proof mass actuator, fiber optic, shape memory ally, and piezoelectric actuators has been developed.

ASTRODYNAMICS: In support of DoD's role to develop advanced concepts in maneuverability for future space missions, Professor Ross' research in astrodynamics is focused on theoretical and numerical aspects of modeling, analysis, simulation, guidance and control of nonlinear dynamical systems. His research on the stability of dual-spin spacecraft has lead to the development of a refined Energy-Sink theory that has narrowed the gap between theory and practice. He has also developed a new maneuver called aerobang that achieves rapid, minimum-fuel orbital plane-changes for a space plane. Professor Ross and his students continue to work with Jet Propulsion Laboratory (JPL) on advanced technologies for Mars missions. Their recent work has been in developing user-friendly software to analyze aerocaputure missions. Professor Ross and Professor Fahroo from the Mathematics Department have completed Phase I of a project to develop an algorithm for efficient solutions to nonlinear optimal control problems. In this project, they have demonstrated that one can achieve mathematically optimal solutions to a wide class of astrodynamical problems. A research team led by Professor Ross has designed a space mission project for minimizing energy requirements for deflecting Earth-crossing asteroids. Finally, Professors Baldwin and Ross, and their students have worked on a classified small satellite project.

Systems Design

MISSION DEFINITION: Research funded by the Office of Naval Research (ONR) was performed by Professor Newberry to define six possible missions for uninhabited combat air vehicles (UCAVs); a notional configuration was developed for a close-air-support (CAS) platform.

SYSTEM DEVEOPMENT: Research was conducted by Professor Newberry to refine the design methodology associated with waveriders. Aircrew-Centered and Second Law (thermodynamics) aircraft design methodology research was also initiated by Professor Newberry.

ENVIRONMENTAL SECURITY: Professor Newberry led a research effort to define the system concepts of environmental security.

MULTI-DISCIPLINARY DESIGN OPTIMIZATION: Under a Cooperative Research and Development Agreement with the Boeing Company Professors Platzer and Jones are contributing to the development of advanced multi-disciplinary analysis and design methods for subsonic transport aircraft.

JOINT STAND-OFF WEAPON CAPTIVE AIR TRAINING MISSILE (JSOW CATM) PROJECT: This project involves the preliminary conceptual development of a Captive Air Training Missile (CATM) to be used in fleet operations for training pilots in the use of the Joint Stand-Off Weapon (JSOW) missile. A concept of operations for the CATM has been written, from which functional requirements are to be drawn up. Exploratory work by Professors Lindsey, Biblarz, Kaminer, Jenn and Ms. Scrivener on the conceptual design is to be done in: (1) airframe structural design and weight estimation; (2) aerodynamic analyses for flight loads and contour shaping for minimum drag; (3) flight simulation of the JSOW by the CATM carrier aircraft; and (4) exploration of communications between the CATM on the carrier aircraft and the data link pod on the control aircraft. This program has been terminated.

AIRCRAFT COMBAT SURVIVABILITY AND AIR DEFENSE LETHALITY ASSESSMENT: Professor Ball originated the study of aircraft combat survivability at NPS in 1974 and has provided technical support for the Naval Air Systems Command (NAVAIR) and the Joint Technical Coordinating Group on Aircraft Survivability (JTCG/AS) by: (1) developing the 11 week graduate level course AA 3251, “Aircraft Combat Survivability,” in 1978 and teaching it twice a year since then; (2) creating and monitoring since 1982 the self–study course AA 3250 “An Introduction to Aircraft Combat Survivability Analysis and Design;” (3) writing a textbook in aircraft combat survivability, *The Fundamentals of Aircraft Combat Survivability and Design*, published by the American Institute of Aeronautics and Astronautics (AIAA), 1985; (4) conducting over 15 short (one week) and several shorter (three day) courses in survivability since 1978, (5) developing the NPS/NAVAIR Survivability and Lethality Assessment Center (SLAC); and (6) conducting a variety of studies on the survivability of U.S. aircraft and the lethality of air defense weapons. In CY 1998, the majority of efforts were devoted to: (1) the continued development of the second edition of the AIAA survivability textbook; (2) the presentation of another one week short course in survivability at NPS (over 100 students); and (3) two Master’s theses on the survivability of aircraft. The subjects of the Master’s theses were the current technology for vulnerability reduction of tilt rotor aircraft and helicopters and the analysis for the critical components and kill modes of the JSF designs.