NAVAL POSTGRADUATE SCHOOL

RESEARCH

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DEVELOPMENT OF AFFORDABLE GUIDED AUTONOMOUS PARACHUTES

LCDR Jim J. Johnson, United States Navy
ENS Tim Williams, United States Navy
LT Charles Hewgley, United States Navy
Research Associate Professor Oleg Yakimenko, Associate Professor Isaac I. Kaminer and Associate Professor Richard M. Howard, Department of Aeronautics and Astronautics
Dr. Vladimir Dobrokhodov, National Research Council Research Associate
Scott Dellicker, U.S. Army Yuma Proving Ground, Yuma, AZ
Richard Benney, U.S. Army Soldier and Biological Chemical Command, Natick, MA

This article discusses the development of autonomous guidance, navigation and control algorithms for a flat solid circular parachute. This effort is a part of the Affordable Guided Airdrop System (AGAS) that integrates a low-cost guidance and control system into fielded cargo air delivery systems. We describe the underlying AGAS concept, architecture, and components. Then the results of the final AGAS demonstration performed at the U.S. Army Yuma Proving Ground (YPG) in September 2001 are presented. Success of this joint effort that involved the U.S. Army Natick Soldier Center (NSC), YPG, Draper Labs, Planning Systems Inc. (PSI), Vertigo Inc., and the Naval Postgraduate School (NPS) led to the establishment of the Aerodynamic Decelerator Systems Center.

Introduction

As identified in [1] there is an urgent need to improve the point-of-use delivery; that is, getting the materiel where it needs to be and when it needs to be there. This statement served as an initial point for the AGAS project, initiated by the U.S. Army in 1999.[2, 3]

Currently, high-altitude/low-opening and high-altitude/high-opening airdropped personnel are the only assets that can be released from altitudes above 1500*m* while still realizing an acceptable landing accuracy. Aerial missions over Bosnia in 1993 underscored high-altitude airdropped payload delivery accuracy concerns during operations conducted from above 3000*m* for re-supply and humanitarian purposes. Humanitarian-relief airdrops over Kosovo in 1999 and Afghanistan in 2001 demanded that airdrop aircraft operate from even higher altitudes, with an expected further degradation of payload delivery accuracy.

These facts led to the main design goal of the AGAS development – to provide a guidance, navigation, and control (GNC) system that can be placed in-line with existing fielded cargo parachute systems (G-12 and G-11) and standard delivery containers (A-22). The system was required to provide an accuracy of at least 100*m* with a desired goal of 50*m*. No changes to the parachute or cargo system were

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NPS RESEARCH

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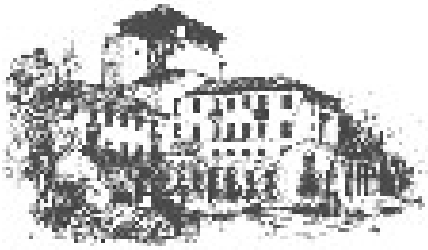

NAVAL POSTGRADUATE SCHOOL, MONTEREY, CA
Superintendent
RADM David R. Ellison, USN
Provost
Dr. Richard Elster
Associate Provost and Dean of Research
Dr. David W. Netzer
Editor, *NPS Research*
Danielle Kuska

FEATURED PROJECT

DEVELOPMENT OF AFFORDABLE GUIDED AUTONOMOUS PARACHUTES, *continued from page 1*

allowed.

As a first step to address the problem of GNC development for AGAS, a reliable parachute model must be available. An extensive literature search was conducted to determine that no such model exists[4-20]. Although the basic equations for the 6-DoF (degree of freedom) model are known[6], there is still some uncertainty about the definition and computation of the added mass tensor. Aerodynamic force and moment coefficients are poorly defined as well. Finally there is very little data verifying a parachute model using flight test data.

Furthermore, while autonomous control of the high-glide parafoils has been studied extensively[21-24], nothing was found on the autonomous control of a low-glide circular parachute. The only results reported beyond uncontrolled dynamics of round parachutes and CFD-based aerodynamics of their canopy addressed open-loop stability[13-20] (CFD computational fluid dynamics).

Therefore initial investigation of the anticipated performance of the AGAS system used a simple 3-DoF model incorporating sensor and actuator dynamics and a simple control strategy. Two major objectives were pursued. First, to verify the effectiveness of the "predefined-trajectory seeking" control strategy with a good wind estimate versus a control strategy that simply seeks the target area (TA) without using any knowledge of the winds. Second, to estimate the impact of changing the characteristics of the sensor suite and actuator dynamics on the overall system performance[25,26]. The resulting GNC algorithm was successfully tested in simulation[27].

Initial flight tests of this GNC algorithm showed the 3-DoF model is not sufficient to study further performance improvements in the GNC algorithms. In particular, certain physical phenomenon has been observed that the 3-DoF parachute model could not predict. Therefore, the second stage of research aimed primarily at flight-testing designed algorithms and included the development of a complete 6-DoF model of controlled circular parachutes[28]. This stage also included extensive hardware-in-the-loop simulation[29, 30].

In 2001 about 15 drops were accomplished at YPG. These drops have led to a better understanding of the dynam-

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About the INVESTIGATORS

Isaac I. Kaminer

Isaac I. Kaminer is an Associate Professor in the Department of Aeronautics and Astronautics. He received his B.S. and M.E. from the University of Minnesota followed by his Ph.D. from the University of Michigan. He joined the faculty of NPS in 1992. Previous experience includes positions with the Technical University of Lisbon, University of Michigan, and Boeing Commercial Airplane Company. His research interests include unmanned air vehicles, modeling and simulation, and flight controls. Dr. Kaminer is the recipient of the Menneken Annual Faculty Award for Excellence in Scientific Research.

Richard M. Howard is an Associate Professor in the Department of Aeronautics and Astronautics and Director of the Unmanned Air Vehicle Flight Research Lab. Dr. Howard completed his B.S. at Rice University, followed by his M.S. at Purdue University and Ph.D. at Texas A&M University. His research interests are in the areas of unmanned air vehicles, aircraft performance and flying qualities, flight test, high angle-of-attack aerodynamics, and parachute modeling. Dr. Howard is the recipient of the Admiral John Jay Schieffelin Award for Excellence in Teaching.

Richard M. Howard

Oleg Yakimenko is a Research Associate Professor in the Department of Aeronautics and Astronautics. Dr. Yakimenko has a dual doctorate from the Russian Academy of Sciences and the Air Force Engineering Academy (Moscow). Dr. Yakimenko originally joined NPS as a Senior Research Associate under the National Research Council Research Associateship Program. He previously taught at the Air Force Engineering Academy in

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DEVELOPMENT OF AFFORDABLE GUIDED AUTONOMOUS PARACHUTES, *continued from page 2*

ics of the parachute, improved hardware design for the control system, and improved GNC algorithms.

This article reviews the AGAS project starting with the underlying concept, architecture and components of the system, followed by the setup and results of a final flight test performed at the YPG in September 2001[31]. The article closes with a discussion on the establishment of the Aerodynamic Decelerator Systems Center and describes current and future work by the Center in the area of precision payload delivery.

System Architecture and Components

AGAS Concept

The key ideas of the AGAS concept can be easily understood by exploring Figure 1.

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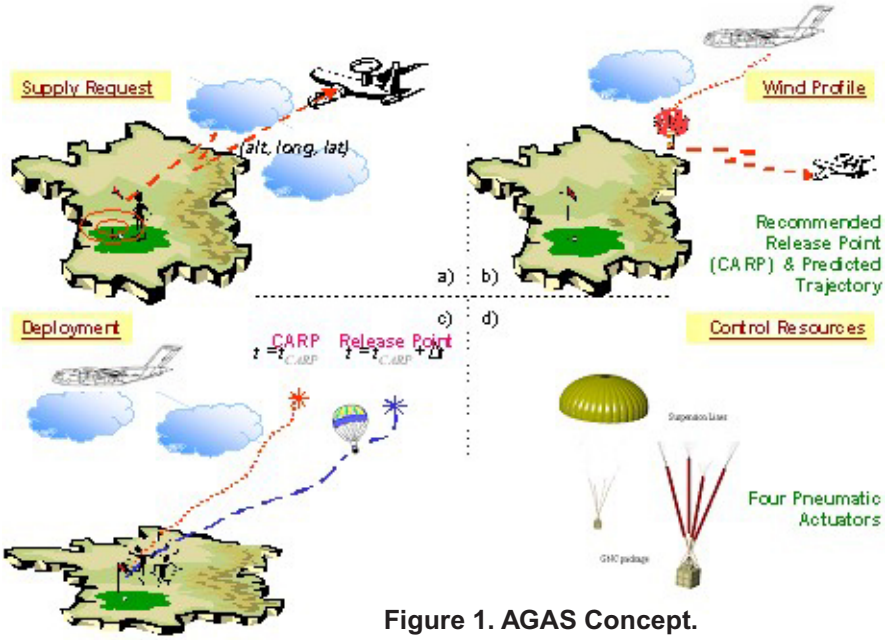

Figure 1. AGAS Concept.

About the INVESTIGATORS, *continued from page 2*

Moscow. His research interests include atmospheric flight mechanics, optimal control, avionics, modeling and simulation, and human factors. He is an Associate Fellow of the American Institute of Aeronautics and Astronautics and the Russian Aviation and Aeronautics Academy of Sciences.

Oleg Yakimenko

Vladimir Dobrokhodov is at NPS as a Research Associate under the National Research Council Research Associateship Program. Dr. Dobrokhodov has a Ph.D. from the Air Force Engineering Academy (Moscow). He previously taught at the Air Force Engineering Academy in Moscow. His research interests are in the areas of atmospheric flight mechanics, pursuit-evasion games, collision avoidance, optimal control, and modeling and simulation.

LCDR Jim J. Johnson, USN, (Master of Science Summer 2001), **ENS Tim Williams, USN**, (Master of Science, Summer 2000) and **LT Charles Hewgley, USN**, (NPS-Test Pilot School Cooperative Program, Summer 2001) were all NPS students.

Scott Dellicker is the director of Air Combat and Soldier Systems Testing at the U.S. Army Yuma Proving Ground. He has an M.S. degree in Aeronautical Engineering from the Naval Postgraduate School. His interests are research, development, and test and evaluation of advanced airdrop system, helicopter systems, and navigation/targeting sensors. Current work includes the evaluation of precision airdrop systems, GN&C for airdrop, and oversight of test and evaluation of helicopter weapon systems and personnel and cargo parachute systems.

Richard Benney has been an Aerospace Engineer at the U.S. Army Soldier & Biological Chemical Command, Soldier Systems Center (Natick) since April 1991. Mr. Benney is currently the Team Leader Airdrop Technology Team with responsibility for executing numerous airdrop programs for the U.S. Army, the U.S. Air Force, Special Operations Command, and other customers related to personnel, cargo and precision airdrop applications. Mr. Benney completed the U.S. Army Basic Airborne School in November 1998 as a civilian employee. He received an M.S. in Applied Sciences from Harvard University in 1990, an M.S. in Mechanical Engineering from Northeastern University in 1989, and a B.S. in Mechanical Engineering from Northeastern University in 1987.

FEATURED PROJECT

MONSOON METEOROLOGY AND CLIMATE

Professor Chih-Pei Chang, Department of Meteorology
Professor R. Terry Williams, Department of Meteorology
Visiting Research Professor Hung-Chi Kuo, Department of Meteorology
Research Associate Hway-Jen Chen, Department of Meteorology
Professor George T. Chen, National Taiwan University
Associate Professor Tim Li, University of Hawaii
Associate Professor Ching-Hwang Liu, Chinese Culture University
Mr. C. W. Tham, Ministry of Defense, Republic of Singapore

Historically, weather and the ability to use the weather information played crucial roles in deciding the results of many great battles and wars. Even today, many facets of tactical operations depend on weather. These include both the obvious elements that directly affect air and sea operations, and the less obvious but no less important aspects. Sophisticated modern weapon systems and radars are affected by the electromagnetic/electro-optical (EM/EO) properties of the changing atmospheric and oceanic environment. The observation, analysis, modeling and applications of these properties have little value unless there is success in the weather observation, analysis and modeling.

The Navy operates in and around oceanic areas, of which two thirds is in the tropics. Due to the sparseness of observation data, the knowledge and understanding of weather in the tropical oceans lags significantly behind that in the extratropical region. This difficulty is further handicapped severely by the fundamental problem of atmospheric dynamics in the tropics where the control of air motions by the effect of the earth's rotation diminishes rapidly. Thus, the well-developed theoretical framework for midlatitude weather breaks down in the tropical regions. As a result, state-of-the art weather prediction models all perform rather poorly over the tropical oceans.

Since World War II, the Navy's most important deployment region is the West Pacific and Indian Ocean. The surrounding land areas, including the Middle East, South and East Asia nearly encompass all of the most explosive flash points for major conflicts. This vast region of continent and oceans is, meteorologically, the major monsoon region in which much of the weather changes are affected by seasonal reversing patterns. The monsoon is a gigantic heat engine that generates atmospheric circulation of all scales and affects the entire region. The energy and circulation are produced through complex interactions of the warm Indian Ocean and

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About the INVESTIGATORS

Professor Chih-Pei Chang received his B. S. from National Taiwan University in 1966, served in the ROC Air Force in 1966-67, as a teaching fellow for USAF meteorology program at St. Louis University in 1967-68, and received his Ph.D. in Atmospheric Sciences from the University of Washington in 1972. He joined NPS the same year. In 1980, Dr. Chang received the Menneken Research Award. In 1981 he was elected a Fellow of the American Meteorological Society (AMS). In 1983 he received the AMS Clarence Meisinger Award for his research in the observations and theories of the tropical atmosphere. In 1988 he received the Best Paper Award in *Papers in Meteorological Research*. He was also recognized for excellence in teaching in 1978, and excellence in research in 1993 and 2000. In 2001 Dr. Chang was appointed Chair of the Editorial Board of the new *World Scientific Series on Meteorology of East Asia*. Other editorial boards he served include *Journal of the Atmospheric Sciences*, *Papers in Meteorological Research*, and *Advances in Atmospheric Sciences*. He currently holds leadership positions on the World Meteorological Organization's International Panel for East Asian Monsoon, the Pacific Science Association's Atmospheric Sciences Committee, and the U.S. and International SCSMEX Committees. He has served on external review committees for the Hong Kong Observatory, National Center for Ocean Research of Taiwan, Columbia University - NOAA Office of Global Programs, Navy Global Atmospheric Model Program, and graduate degree committees of University of California Davis, University of Hawaii International Pacific Research Center, National Taiwan University, Hong Kong

Chih-Pei Chang

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MONSOON METEOROLOGY AND CLIMATE, *continued from page 4*

West Pacific sea surface and the complicated terrain including the Tibetan Plateau and the Southeast Asian island-sea complex. These interactions make modeling and prediction of weather over the monsoon region even more difficult than other parts of the tropical ocean. Furthermore, the monsoon region is strongly affected by global climate changes. It experiences interannual and decadal variations that on the one hand alters the basic climate state thus making weather predictions more difficult, and on the other hand causes disasters (droughts, floods, storms) that have major economic, humanitarian, international relationship and security impacts.

The NPS monsoon project studies all aspects of the monsoon meteorology, in order to improve the understanding and modeling capability of the weather and climate changes over the region. The project was started in 1974 when it received the first grant from the National Science Foundation (NSF), which has since continuously funded the project through renewals. The project presently includes four sponsors funding different components of the research.

Dynamics of Northwest Pacific Tropical Vortices and Monsoon (NSF)

This component studies the processes involved in the development of closed circulations, such as tropical cyclones, from weak wavelike disturbances. Such events usually occur with waves propagating northwestward (Figure1).

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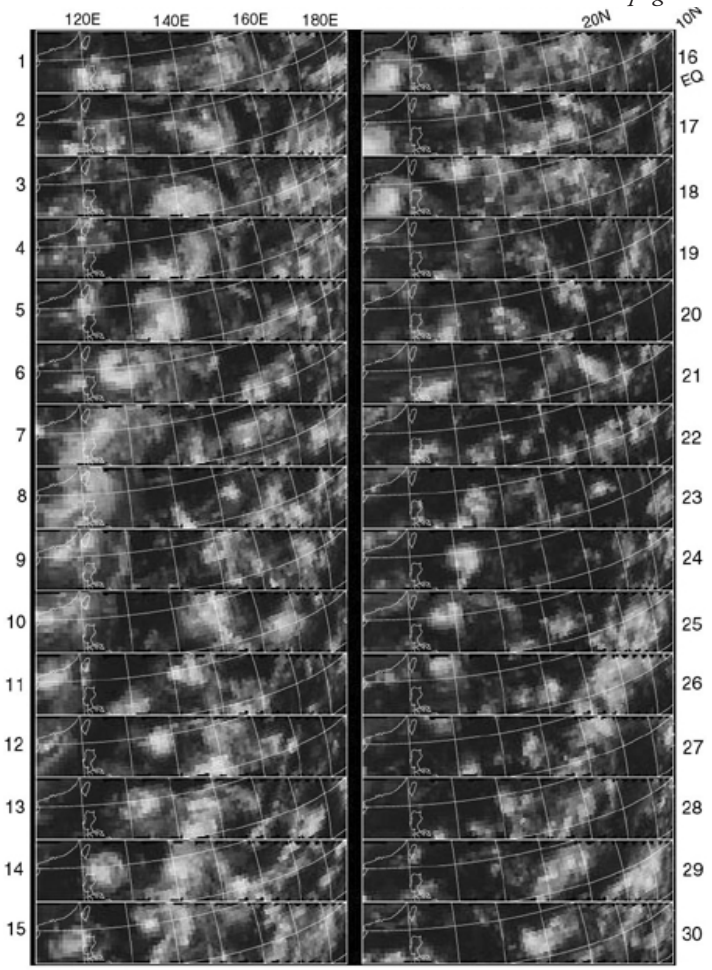

Figure 1. Time series of daily satellite IR images in the Northwest Pacific. In each day the latitude lines (oriented lower-left to upper-right) shown are, from left to right, 20N, 10N and the Equator. The diagram shows a series of tropical disturbances propagating northwestward with the stronger ones developing into typhoons.

About the INVESTIGATORS, *continued from page 4*

City University, and University of Malaya. His edited books include *Monsoon Meteorology* (Oxford University Press, 1987) and *East Asian and Western Pacific Meteorology and Climate* (World Scientific, 2002).

Roger Terry Williams

Professor Roger Terry Williams received his B. S. in 1959, M. S. in 1961 and Ph.D. in 1963 from UCLA, all in Meteorology. He was a Ford Foundation Fellow in 1963-64, a research scientist at MIT between 1964-66, and an Assistant Professor at the University of Utah from 1966-68. He joined the NPS Department of Meteorology in 1968. He was the first person to successfully model the process of the formation of atmospheric discontinuity – the weather fronts, and was elected a Fellow of the American Meteorological Society in 1986. He was recognized for excellent faculty research in 1992. He has served on the American Meteorological Society Scientific Committees on Waves and Stability, and on Hurricanes and Tropical Meteorology. He is the co-author of the textbook *Numerical Weather Prediction and Dynamic Meteorology* (Wiley, 1980).

THE CENTER FOR CONTEMPORARY CONFLICT

Organizations typically change in response to crises. The response of the Naval Postgraduate School (NPS) to the devastating terrorist attacks of 11 September is no exception. As readers will discover in this and subsequent issues of the *Research Newsletter*, several new NPS research centers were created after 11 September or revised the focus and scope of their research activities in order to provide more timely, relevant and valuable research support to offices in the Navy, the Department of Defense, and the U.S. Government. The Center for Contemporary Conflict (CCC) is a case of the latter. Launched by faculty from the NPS Department of National Security Affairs (NSA) *prior to* September 2001, CCC has emerged as a campus hub of policy-relevant teaching and research activity in recent months.

CCC conducts research on current and emerging security issues and conveys its findings to U.S. and Allied policymakers and military forces. Propelled by a seasoned staff of NSA Department faculty with ready access to military and academic circles, the CCC is uniquely positioned to develop security research of high quality and relevance. Through aggressive outreach highlighted by the Regional Security Education Program (RSEP), the CCC ensures that its analyses benefit the makers and executers of U.S. defense policy. Active in the academy and in the field, the CCC bridges the gap between the security researcher and the warfighter to the benefit of both.

The NPS faculty members and research associates who comprise the CCC are a diverse and widely experienced group, coming from academic and military backgrounds and from many regions of the world. Research interests tend toward several crosscutting issue areas:

- *Asymmetric conflict*, including terrorism and counter-terrorism, information operations (IO), and homeland defense;
- *Weapons of mass destruction (WMD) proliferation*, nonproliferation, and counterproliferation;
- *Regional instability*, including intra-regional conflict, civil-military relations, peacekeeping, and humanitarian missions; and
- *Strategic nuclear policy*, including deterrence doctrine, command and control, strategic arms control, and missile defense.

CCC research projects range from tightly focused queries that engage one or two CCC members, to widely collaborative undertakings in which the efforts of CCC personnel are complemented by contributions from outside governmental, military, and academic experts from the United States and from Allied or other cooperating nations. Typically group research projects feature multiple conferences and workshops. The CCC disseminates its research findings in a variety of ways.

- Reports and briefings are provided to defense policy makers.
- Through the Regional Security Education Program (RSEP), CCC personnel travel to ships or bases to brief deploying or forward-deployed Naval forces on security issues critical to their particular missions.
- Some research projects generate books or other publications.
- CCC research informs our teaching of students in the NPS Department of National Security Affairs.
- CCC personnel are active in hosting or attending conferences, partici-

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RSEP Team Members aboard the *Constellation*: Major Bruce Oswald, Australian Defence Force, Senior Lecturer Ahmad Ghoreshi (Department of National Security Affairs), Assistant Professor Peter Lavoy (Co-Director of the CCC) and VADM Philip Quast, USN (Ret.).

FOUR NEW CENTERS ADDRESS CONTEMPORARY ISSUES

The **Center for the Study of Potential Outcomes** applies novel multi-agent systems (MAS) simulation technology to anticipating unexpected actions on the part of organizations such as terrorist groups. MAS technology simulates behaviors found in complex systems of people, machines, and hostile environments to expose blind spots, weaknesses, and risks.

MAS research promulgated by the MOVES Institute has led to five new tools for multi-agent construction: 1) a social-and-organizational relationship-management engine; 2) a composite agent architecture; 3) an agent-goal apparatus; 4) a structure for capturing and applying procedural knowledge; and 5) the ability to bring these technologies to bear at the right time and proper context.

The principle activity of the center is to develop a family of MAS software tools and analysis aids and apply them to modeling potential threats. The models run on high-performance computer systems, which generate outlier, or unanticipated, actions and point to remedies or countermoves that might have been overlooked without the assistance of MAS software.

Current tasks are to build two major software tools: a MAS-integrated development environment to support the Center's MAS software projects, and an auto-narrator package for incorporation into the Center's models. The auto-narrator tool will support development-time debugging and tuning, and run-time narration.

Once these tools become available, they will be used to build models and run them as simulations. Candidate models include, but are not limited to:

- information/computer network security
- airport security
- power-plant security near-shore ship movements (the *USS Cole* scenario)

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CENTER FOR CONTEMPORARY CONFLICT, *continued from page 6*

pating in public fora, and other knowledge-sharing activities.

- Through the CCC web site (www.ccc.nps.navy.mil) activities are publicized and educational resources distributed including monthly Strategic Insights that provide concise assessments of key regions and issue areas.

The CCC is currently undertaking several large-scale, collaborative research projects. These include:

- *U.S. Strategy and Gulf Security in the New Millennium*. The CCC Gulf Project will convene a group of experts from academia and government to examine the current U.S. security strategy in the Persian Gulf. These experts will consider whether this strategy should be adjusted to reflect new threats and the evolution of the regional security environment over the last ten years.
- *The Future of Pakistan: U.S. Policy Options Beyond the War on Terrorism*. This CCC research project will analyze the political and security issues facing Pakistan in the aftermath of the U.S.-led anti-terrorist campaign in Afghanistan. The project will feature small workshops to help frame policy options for U.S. defense officials.
- *Asymmetric Conflict in South Asia: The Cause and Consequences of the 1999 Limited War in Kargil*. The CCC Kargil Project aims to develop new insights into the 1999 India-Pakistan confrontation in central Kashmir, and to draw from these insights a better understanding of India-Pakistan military rivalry, asymmetric conflict, and the role of nuclear weapons in crisis dynamics. The project will both develop new empirical material and engage theoretical debates about deterrence and the impact of nuclear proliferation. This CCC undertaking will be the first effort to study the Kargil conflict from a balanced, international perspective. Project participants are internationally recognized political scientists, security analysts, and military professionals. An international conference was held at NPS on this subject in late May and early June 2002.
- *U.S.-Russia CBMs in Strategic Nuclear Forces.* This CCC research project examines prospective U.S.-Russia confidence-building measures (CBMs) in strategic nuclear forces. The project will feature small workshops to help frame policy options for U.S. defense officials. The workshops will bring together Russian and American experts in strategic nuclear systems to discuss how the two nations can strengthen strategic stability under conditions of deep cuts of offensive arsenals by means of greater transparency of nuclear postures, improving information about missile launches by third parties, and so on.

For further information about the Center for Contemporary Conflict, contact CCC Director **Peter R. Lavoy** at plavoy@nps.navy.mil.

FOUR NEW CENTERS ADDRESS CONTEMPORARY ISSUES, *continued from page 7*

- natural-gas-line security

The Center will deploy models and simulation results that uncover potential outcomes. The Center plans a phased approach to tool development, with first models tested in FY03.

Professor Ted Lewis of the Department of Computer Science is the Center Director.

The **Undersea Warfare Center** has been established to support and improve Undersea Warfare (USW) curriculum postgraduate education and continuing curriculum oversight by the Undersea Warfare Academic Committee. The goals of the Center are to:

- Ensure the USW curriculum continues to meet sponsor educational skill requirements and postgraduate degree requirements, including updating to reflect changing Navy and sponsor educational requirements and methods of education.
- Coordinate and conduct USW sponsor curriculum reviews.
- Coordinate research topics for professor/student thesis work to meet USW research objectives.
- Recruit members to the USW Center.
- Recruit candidates for associated faculty chair positions.
- Oversee development of USW courses in support of other curricula.
- Establish a comprehensive, integrated research program in undersea warfare, to support officer student needs and accomplish USW research with valuable input from officers with warfare and/or acquisition experience.

The envisioned USW research program will directly reflect the goals and objectives of Navy organizations such as the Office of Naval Research, OPNAV program and resource sponsors (in particular, OPNAV N77), acquisition program managers, fleet commands, and defense laboratory organizations.

The USW research program is anticipated to expand to cover USW research in support of Homeland Defense and Anti-terrorism by tapping into, and participating in, the research underway and exploiting the courses available at NPS. This effort will supplement the traditional applications of USW research.

The USW research program will be organized to provide integrated efforts among NPS and defense research organizations in the public and private sector. The UWC is expected to play a significant, collaborative role in integration of research areas/topics among these organizations.

The establishment of this center is in direct support of the 525/526 curricula at NPS – the U.S. and foreign Undersea Warfare student population. The Center Director is **Professor Clyde Scandrett** of the Department of Mathematics.

The **Center for Homeland Security** (CHLS) will conduct interdisciplinary research and graduate-level non-degree education programs in Homeland Security (HLS), through activities that complement and support related work performed at other NPS Centers, Academic Departments and Institutes. Research activities will link technical issues (including critical infrastructure protection) with non-technical issues (such as the interagency challenge of HLS planning) to produce studies that will help build the academic and policy foundations of this new field. NPS students will be brought into the Center's research activities, through supervision of student thesis on HLS topics and through student-faculty teams performing research on topics of special concern to sponsor organizations. This research will provide for: 1) creation of source materials for use in NPS courses; 2) policy development by sponsoring organizations; and 3) general diffusion of cutting-edge knowledge on Homeland Security via publications in refereed journals and books.

Teaching activities in the Center will complement the Master of Arts Degree track that the Department of National Security Affairs is expected to develop in Homeland Security. These teaching activities will include 1) mobile education teams (METs) to deliver graduate-level short courses to remote locations throughout the United States, and 2) short courses at NPS. Under the guidance of the Dean of Research, all CHLS teaching and research activities will be structured to complement and support related work performed by other NPS Centers, Academic Departments and Institutes, so as to strengthen program synergy and maximize the efficient use of NPS resources.

The research and teaching activities of CHLS will directly support the core mission and priorities of the Naval Postgraduate School. In particular, research initiatives will build upon and expand the existing areas of expertise of NPS on issues related to HLS, and provide opportunities for faculty (and students) to apply their research skills to help meet a top-priority national security challenge. This research will also provide teaching materials and faculty expertise that will be brought to bear on the MA curricular offerings in

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FOUR NEW CENTERS ADDRESS CONTEMPORARY ISSUES, *continued from page 8*

the National Security Department (especially in Curriculum 689) for students from all services, and in the Operations Research Department, Computer Science Department and other Departments. DoN has an evolving interest in HLS, and CHLS will be structured to ensure that DoN priorities are served by the broader activities of the Center (especially on port security and related issues). DoD and other Executive Department missions in Homeland Security will also be supported by the Center, as provided for by close liaison links between CHLS and appropriate points-of-contact in those Departments.

Associate Professor Paul Stockton of the Department of National Security Affairs is the Center Director.

The **Center for the Study of Mobile Devices and Communications** (CSMDC) has been established to focus research attention on the emerging fields of ubiquitous devices that communicate by some form of wireless network and the applications that run on them. This includes devices such as wirelessly enabled desktops, laptops, palmtops, tablet, and wearable computers, and wireless network infrastructure such as cellular WANs, wi-fi PANs (Personal Area Networks), and emerging ultra wide band networks capable of speeds ranging from 1 Mbps (such as Bluetooth), to ultra wide band networks capable of running in the giga-hertz range. Of particular interest is the emerging public-switched cellular networks running 2.5G (GPRS), and 3G (CDMA as well as GSM). 3G networks promise to support from 144kbps to 2Mbps, and wi-fi networks that form computing grids for ad hoc battlefield deployment as well as mundane applications in warehouse inventory and supply-chain management promise to support much higher bandwidths, e.g. up to 200 Mbps.

It is inevitable that the Navy will continue to incorporate commercial mobile computing devices based upon wireless LAN/MAN communications technology in tactical, support and administrative areas. There is great promise in the application of mobile and wireless communications technology to military operations, but there are also many problems to be resolved. The following list forms the basis of the Center's research agenda:

- *Network Security*: Currently, wireless networks are extremely vulnerable to information assurance attacks. Some of the solutions posed within IPsec may work in the wireless world, but the fact that wireless networks operate in the open ether, poses additional risks. Thus, a major emphasis across the various wireless technologies will be the issue of hacking both defensive and offensive. Security issues will permeate all other areas of research, below.
- *Network Management*. Unlike wired networks, there is no analog SNMP or RMON-II standard across wireless networks. Hence it is currently impossible to manage wireless networks as extensions to SNMP networks. Tools such as OpenView and Spectrum simply do not auto discover wireless network devices (access point bridges contain RMON-II MIBs, but the devices they serve do not). The question is, how will ubiquitous devices be managed? What can be done to enhance the manageability of wireless networks?
- *Productivity*. Do mobile devices increase or decrease productivity? NPS has already conducted research in this area, both at sea and ashore. In the NPS experiment that automated the watch command function onboard an aircraft carrier, wearable computers appeared to improve reliability and productivity. But how far might this extend to other Navy applications such as supply-chain management, maintenance manuals, inventory management, etc.? The online service benefits of these devices need to be explored. In addition possible disadvantages of mobile devices need to be understood prior to their deployment. Could certain mobile devices because of the distracting nature of screens or other feedback mechanisms cause more harm than good?
- *Grids*. The wi-fi network is typically implemented in consumer electronic appliances such as home entertainment centers, etc. by adding 802.11 PAN (Personal Area Network) cards to computers, video games, and DVD players. This allows consumers to push videos and music around the living room, for example. More recently, this technology has been used by groups such as Freenet and GridNetworks to build ad hoc persistent networks centered on shopping malls, gasoline stations, and stadiums. Ad hoc networks work much like short-range cellular networks but with much higher bandwidth. Access stations placed around a shopping mall, for example, can sense the presence of a wireless device such as a PDA and relay the short-range wi-fi signal to the Internet backbone. Such a network could turn ordinary hand held devices into terminals with broadband access to the Internet. The application of this technology to military operations remains unclear, but consider the deployment of a wi-fi based ad hoc network onto a battlefield or across a fleet of ships. Assuming each person is both an access point and a receiver of wi-fi network signals, an ad hoc network can be deployed automatically by merely relaying the short-range wi-fi signal

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INSTITUTE OF SYSTEMS ENGINEERING NAMED FOR "FATHER OF AEGIS"

The Institute for Defense Systems Engineering and Analysis (IDSEA) has been renamed in honor of RADM Wayne E. Meyer, USN (ret.) the Father of AEGIS. The **Wayne E. Meyer Institute of Systems Engineering** was dedicated at a ceremony followed by the official unveiling of the new Wayne E. Meyer Institute of Systems Engineering sign at Bullard Hall. The ceremony was the capstone event of the 2002 Surface Navy Association Symposium.

The Institute's vision is to provide unique graduate education and research that increases the knowledge and skills of military officers and the supporting civilian workforce in systems engineering and analysis and large scale experimentation. A major initiative of the Institute is the coordination of a yearly systems engineering project. CROSSBOW – a warfighting system concept consisting of small carriers, manned and/or unmanned aircraft supported by small, swift combat logistics support ship and accompanied by small inshore combatants – was completed earlier this year. The Institute is under the direction of **Dr. Phil DePoy.**

VADM Timothy W. LaFleur, Commander, Naval Surface Force, U.S. Pacific Fleet; RADM Wayne E. Meyer, USN (ret.), Dr. Phil DePoy, Institute Director, and RADM David R. Ellison, Superintendent, NPS, at the dedication of the Wayne E. Meyer Institute of System Engineering.

The importance to the nation of the AEGIS weapons system cannot be underestimated. With the passage of time, it is easy to forget the environment within which the AEGIS system was developed. Like the nuclear submarine and Polaris ballistic-missile system before it, there was a major threat to our nation that made the development of the AEGIS system a national priority.

Beginning with the Battle of Leyte Gulf and later in Okinawa, the longest and most decimating battle in Navy history, the success of the Kamikaze in attacking surface ships was obvious to all. Later in the mid-east, the early anti-ship cruise missiles, although crude by current standards, also proved to be very effective.

Beginning in the 1950s and 1960s, there were many who argued that the days of surface Navies were over – that surface ships could no longer survive in combat, even against an unsophisticated enemy. Thus the motivation for developing a shipboard defense system that could counter both aircraft and missiles. AEGIS represented a major transformation, in which the ship, the combat systems and the training systems were designed as a single unit.

The AEGIS system was designed as a total weapons system, from detection to kill. The heart of the system is an advanced, automatic detect and track, multi-function phased-array radar. This high-powered radar is able to perform search, track and missile guidance functions simultaneously with a track capacity of over 100 targets. The core of the AEGIS combat system is the computer-based command and decision element - this interface makes the AEGIS combat system capable of simultaneous operation against a multi-mission threat: anti-air, anti-surface and anti-submarine warfare.

AEGIS was the first truly system-engineered Navy platform. RADM Meyer's role in spearheading the development of this vitally important weapons system and securing the

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FOUR NEW CENTERS ADDRESS CONTEMPORARY ISSUES, *continued from page 9*

from person-to-person. Thus a grid is set up that can sustain a high bandwidth connection for as long as the participants are within 100 meters of one another. Potential applications of ad hoc networks merit further study because of their utility to rapid deployment, forward forces, and broadband wireless network applications.

• *Location-Based Computing*. GPS receivers can easily be combined with mobile devices and linked together to form a network grid as described above. The resulting network can provide highly accurate GPS traces which can be analyzed by appropriate software to dynamically create various kinds of maps. Hence, location-based computing emerges as a new information superiority weapon. A field commander, for example, could view the GPS traces or signatures left by his or her troops and determine, before the enemy, vulnerabilities and emerging weaknesses in defensive lines. Similarly, GPS traces that emerge from ship, airplane, and tank movements reveal, ahead of real time, weaknesses that may preclude the outcome. This technology has not been studied in great detail, and hence provides a new research area focused on location-based computing. Such mapping applications go far beyond the obvious use of GPS traces in cartography.

• *Context-Aware Computing*: Related to Location-based computing, context-aware computing uses a wide range of inputs, including location, time, activity, presence of other people or equipment, etc. to provide advice, information and assistance to the user. Currently, most wearable computer systems require a great deal of the user's attention, both in inputting data about the world and the user and retrieving the system's output, to be useful in most situations. However, Context-Aware computing is envisioned as being easy to use, ideally being transparent to the user and taking very little of his/her time to use.

• *Transforming technology for 21st century warfare*. How will mobile devices change U.S. military forces? How will our adversaries use such technology? Are there poorly understood barriers to the use of this technology by certain groups? These and other questions must be explored.

• *Electronic Signatures*. Even though low-power wi-fi ad hoc networks have limited range, tests onboard aircraft carrier class ships have shown that emissions can be detected as far as 30 miles away. The electronic signature of these devices needs to be studied in the context of both offensive

--continued on page 54

AEGIS, *continued from page 10*

safety of our Navy and our nation render it unreservedly appropriate that the Institute of Systems Engineering bear his name.

Wayne E. Meyer began his naval career in 1943 as an apprentice seaman, was later commissioned an Ensign, U.S. Naval Reserve, in 1946, and transferred to the regular Navy in 1948. RADM Meyer earned his B.S. degrees in electrical engineering at the University of Kansas (1946) and the Naval Postgraduate School (1960). He also holds a B.S. degree in electrical engineering and an M.S. degree in astronautics and aeronautics from MIT. His first sea duty on the *USS GOODRICH* (DDR 831) was followed by consecutive sea tours. From 1951 through 1955, he attended the Joint Guided Missile School, Fort Bliss, TX, the Naval Line School, Monterey, CA, and served as instructor at the Special Weapons School, Norfolk, VA. He returned to sea as X.O. on the *USS STRICKLAND* (DER 333) and then served as Staff of Commander, Destroyer Force, Atlantic.

After graduate school, he served aboard the TALOS cruiser *USS GALVESTON* (CLG) as Fire Control Officer and Weapons Officer. He then reported to the SecNav's Special Task Force for Surface Missile Systems in Washington, DC. In 1965, he transferred to the Naval Ordnance Engineering Corps. In 1967, he reported as Director of Engineering at the Naval Ship Missile Systems Engineering Station, Port Hueneme, CA. In 1970, he reported to the Naval Ordnance Systems Command, as Manager, AEGIS Weapons System. He was named Project Manager for Surface Missile Systems in 1972 and in July 1974, he was named the first Director of Surface Warfare, Naval Sea Systems Command.

He was selected for Admiral in January 1975. In July 1975, he assumed duties as Project Manager, AEGIS Shipbuilding Program. In September 1983, he assumed duties as Deputy Commander, Weapons and Combat Systems, Naval Sea Systems Command. RADM Meyer retired in 1985 as the Deputy Commander for Weapons and Combat systems, Naval Sea Systems Command, and Ordnance Officer of the Navy. Rear Admiral Meyer holds numerous personal decorations and service medals.

STUDENT RESEARCH

SMALL SAT SENSOR LAUNCH ENVIRONMENT SIMULATION

LT Richard H. Harrison, USN, Master of Science in Space Systems Operations
LT Dale D. McGehee, USN, Master of Science in Space Systems Operations
Thesis Advisor: Dr. Stephen A. Whitmore, Michael J. Smith NASA Chair Professor, Space Systems Academic Group

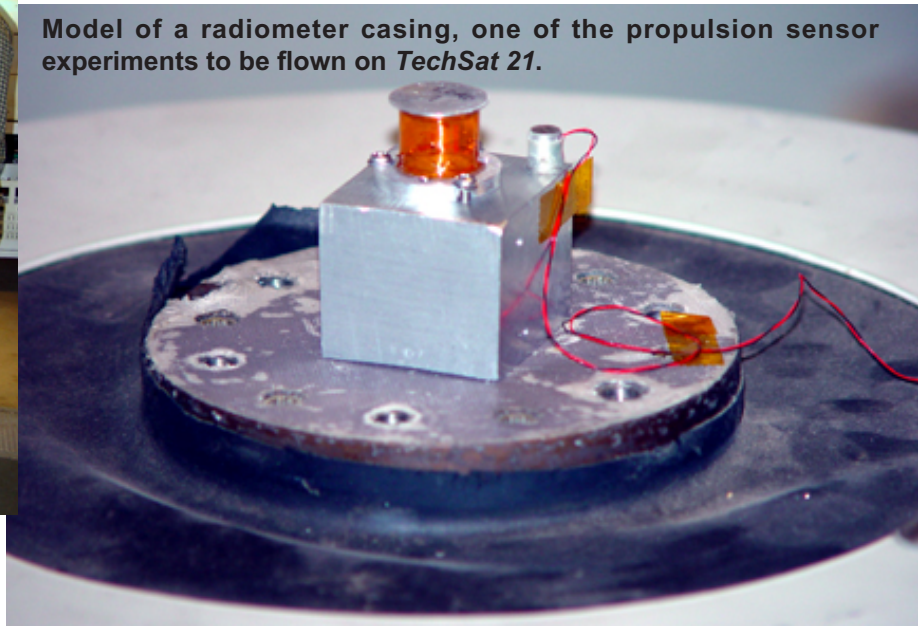
With an increasing desire to design smaller satellites, alternative propulsion systems are being explored. A maturing technology in this arena is Electrical Propulsion (EP). The impacts on spacecraft systems using this type of propulsion are still in question and must be modeled and measured to determine their exact effects. *TechSat 21*, a constellation of three small satellites linked as a sparse aperture radar, are experimental spacecraft being designed by the Air Force Research Lab (AFRL) that contain a sensor suite to determine these effects.

The picture below is a model of a radiometer casing, one of the propulsion sensor experiments to be flown on *TechSat 21*. The model shown is composed of two small aluminum plates with a Kapton ring between them, bonded by epoxy. The sensor casing tested is approximately twice as large as the flight model. The flight model will contain two Analog Devices AD590 temperature-measuring devices that act as current regulators and output an equivalent value of 1 amp/K. The two AD590s will be contained within the Kapton ring; one will be secured to the underside of the upper aluminum plate whose front is exposed to the thruster environment, while the second is secured to the bottom plate in good thermal contact with the spacecraft. Each of the individual radiometer upper plates will be coated with a different type of thermal control paint. The theory behind the experiment is to measure the heat flux differential ($mc_p\ dT/dt = dQ/dt_{tot}$) between the two devices which in turn determines the thruster-induced changes in paint absorptivity (α) and emissivity (ε) when exposed to the spacecraft thruster environment over time.

In order to verify that the radiometer will withstand the stresses imposed by the launch vehicle, the sensor casings were attached to an NPS shaker table and tested through the project-specified frequency spectrum of the launch vehicle (20-2000Hz). The acceptance level for the radiometers tested is 11.7 g^2/Hz while the proto-flight qualification level is 16.6 g^2/Hz. The NPS shake table parameters allowed testing of the radiometers to the 16.6 g^2/Hz level. The radiometers survived these levels without damage, indicating that this casing design will withstand the qualification testing and launch vehicle environment.

TechSat 21 will be launched on the Delta IV Medium Launch Vehicle, and is currently scheduled to launch on the same flight as *NPSAT1* on the Evolved Expandable Launch Vehicle (EELV) Secondary Payload Adapter (ESPA) ring.

Lieutenants Richard Harrison and Dale McGehee, USN, in the Space Systems Laboratories.



Model of a radiometer casing, one of the propulsion sensor experiments to be flown on *TechSat 21*.

CORE COMPETENCY NEEDS ANALYSIS FOR U.S. NAVY RESERVE TRAINING AND ADMINISTRATION OF RESERVE (TAR) OFFICERS

LCDR Carol E. Newman, United States Naval Reserve
Master of Science in Management – March 2002
Advisors: Senior Lecturer Alice Crawford and Professor Gail F. Thomas, Graduate School of Business and Public Policy

This thesis identifies fundamental Reserve management-related core competencies required for Training and Administration of the Reserve (TAR) officers. In-depth interviews were conducted with 21 experienced TAR officers who defined and described essential competencies for TAR officers. Additionally, they identified competency gaps and offered recommendations as to how TAR officers could better develop the competencies. Based on the analysis of the interview data, nine core competencies were determined. Interview participants then prioritized the nine competencies by responding to an electronic survey. The thesis describes each competency, prioritizes the competencies, and discusses the skill gaps that currently exist among TAR officers. Recommendations for a career-focused TAR officer professional development program are provided that address billet or career phase-based training needs.

EFFECTS OF ACOUSTIC SCATTERING ON THE PERFORMANCE OF A 688I CLASS SUBMARINES HULL SONAR ARRAY

LT Travis M. Petzoldt, United States Navy
Master of Science in Engineering Acoustics – March 2002
Advisors: Associate Professor Steven Baker, Department of Physics, and Professor Clyde Scandrett, Department of Mathematics

Rigid and elastic scattering theory was used to model the effects of acoustic scattering on the performance of a 688I class submarine's hull sonar array. The analytical results were compared to experimental data. The submarine's bow was reduced to the sonar sphere, and was modeled as both a rigid sphere and an elastic (steel) spherical shell. Scandrett's method of solution of the coupled acoustic and elastic equations was used to solve for the response of an elastic sphere. Basic beam forming theory was used to estimate the type of effects such scattering would have on the beam pattern of a sonar array. The results showed that the pressures seen at the elements of the hull array during the experiment were caused by scattering, but the simple model used failed to completely match the experimental results. The beam forming analysis showed both main lobe and side lob strengths to increase.

A NOVEL APPROACH FOR THE SIMULATION AND MODELING OF STATE-OF-THE-ART MULTIJUNCTION SOLAR CELLS

LT Panayiotis Michalopoulos, Hellenic Navy
Master of Science in Electrical Engineering and Master of Science in Computer Science – March 2002
Advisors: Associate Professor Sherif Michael, Department of Electrical and Computer Engineering, and Associate Professor Bret Michael, Department of Computer Science

In this thesis, a new method for developing realistic simulation models of advanced solar cells is presented. Several electrical and optical properties of exotic materials, used in such designs, are researched and calculated. Additional software has been developed to facilitate and enhance the modeling process. Furthermore, specific models of an InGaP/GaAs and of InGaP/GaAs/Ge multi-junction solar cells are prepared and are fully simulated. The major stages of the process are explained and the simulation results are compared to published experimental data. Finally, additional optimization is performed on the last state-of-the-art cell, to further improve its efficiency. The flexibility of the proposed methodology is demonstrated and example results are shown throughout the whole process.

STUDENT'S THESIS EFFORTS REFLECTED IN MARINE CORPS' WEIGHT AND BODY FAT SCREENING POLICY

Maj William J. Inserra, USMC, an NPS alumni (M.S. in Operations Research, September 1998), played an important role in leading changes that were recently implemented in the *Marine Corps Physical Fitness Test and Body Composition Program Manual*. Maj Inserra's thesis, "Analysis of Weight, Body-Fat, and Physical Fitness Testing Standards, for Active Duty Male Marines, with Proposed Alternatives," addressed the inherent concerns for the safety and welfare of Marines in relation to the Physical Fitness Test (PFT). The thesis used newly collected data from the Marine Corps to analyze current weight and body-fat standards and compare them with proposed alternatives.

STUDENT RESEARCH

APPLYING INDUSTRIAL DESIGN BEST PRACTICES IN THE ACQUISITION OF SOLDIER EQUIPMENT

MAJ Theodore Perryman, United States Army
Master of Science in Management – March 2002
Advisors: Assistant Professor Nita Miller and Associate Professor Susan Sanchez, Department of Operations Research

Too often a piece of equipment is delivered which, though functional, is unusable. The computer provides us an excellent example of this phenomenon in our daily life. There are so many features on most computers that we will never understand them all, we will never use all the features, and what is worse, the excess features confuse the user and may even make accomplishment of the core task more difficult.

The goal of any designer should be to develop a piece of equipment that facilitates the accomplishment of a task and is a pleasure to use. These criteria must be the overriding considerations of the developer whenever designing a new system or piece of equipment. System designers are better trained and have more resources at their disposal than at any time in history. In addition, designers have media, such as software, which provide unique opportunities to make incredibly effective pieces of equipment to facilitate the accomplishment of virtually any task.

Certainly military program managers are concerned with the acceptance of the equipment they field. However, undesirable equipment is still in our inventory, examples being some of the radio systems, and certain features on military vehicles. This thesis examines why a good design is critical and explores the best ways the program manager can apply industrial design best practices in the development of soldier equipment.

STUDENTS PARTICIPATE IN "FLEET TRANSIT" PROGRAM

As a part of the continued interaction between the Naval Postgraduate School and the Third Fleet a "Fleet Transit" program has been initiated in which some of the latest S&T being conducted at NPS is made available for Fleet utilization while in transit along the West coast. Areas of interest may include information assurance, new sensors and communications methods and UAVs. Students will utilize this opportunity for their thesis research and faculty will be able to test their most recent developments in an operational environment. To begin to develop this program and initial experiment was conducted in port in San Diego. Lessons learned from that effort are being used to develop the processes and procedures for future activities.

MH-60S HELICOPTER AND PILOTS TO HELICOPTER COMBAT SUPPORT SQUADRONS

LT Cory Culver, United States Navy
Master of Science in Operations Research – March 2002
Advisors: Distinguished Professor Gerald Brown and Professor Kevin Wood, Department of Operations Research

The U.S. Navy is replacing the H-46 helicopter with the new MH-60S helicopter. The Fleet Introduction Team has developed a spreadsheet-based schedule that distributes new aircraft and MH-60S trained pilots to the active duty Helicopter Combat Support squadrons. This thesis develops an optimal distribution schedule for helicopters and pilots using an integer-programming model called OTHCAM (Optimal Transition, HC Allocation Model) that minimizes lost flying days. OTHCAM takes into account variable training durations, travel times and tour lengths, as well as manpower and aircraft constraints. The output is a distribution schedule for new MH-60S helicopters and Fleet Replacement Squadron graduates that minimizes lost flying days while meeting manpower and operational requirements. The schedule developed by OTHCAM reduces lost flying days by 26% compared to the Fleet Introduction Teams existing spreadsheet schedule.

INCREASING PROMPT RESPONSE FROM IMPULSE RADIATING ANTENNA BY APERTURE SHAPING

LCDR Michael Baretela, United States Navy
Master of Science in Electrical Engineering – March 2002
Advisors: Capt J. Scott Tyo, USAF,
Department of Electrical and Computer Engineering, and Professor Michael Morgan, Department of Mathematics

In order to improve the prompt response from an impulse radiating antenna (IRA) a number of studies have suggested controlling the spatial distribution of the aperture fields by changing the feed arm angle. Other work has suggested that proper shaping of the aperture can further enhance the radiated signal for a given feed structure. This paper shows how the radiated prompt response can be maximized for a given feed arm configuration by shaping the aperture to eliminate fields oriented in the wrong direction.

The percent increase in the prompt radiated electric field for a 200 IRA with an ideally shaped aperture compared to a standard circular aperture ranged from 0.42% to 39.94% depending on the input electrode angle. For the most common electrode angles of 45 and 60, the increases are 6.00% and 16.63% respectively.

NPS STUDENTS COMPETE AT STANFORD SYMPOSIUM

Stanford University's chapter of the Institute for Operations Research and the Management Sciences (INFORMS) recently hosted the Pacific Region Intercollegiate Symposium for the Management Sciences. Students from several west coast universities participated, including NPS. Operations Research masters students **LT James Campbell, USNR**, **LT Donald Jenkins, USN**, **LT John Nguyen**, **USN** and **LT Hsinfu Wu, USN,** attended the symposium and constituted one of the nine teams in the Case Study Competition.

The case study competition simulated high-pressure analysis situations that might occur in the real world when students graduate. Each team was given a small amount of time to read and analyze a business case and prepare a presentation on their analysis. They had no advance knowledge of the subject of the case – it required them to recommend a course of action for a failing dot-com startup. They presented their case analyses and recommendations to a panel of professors who served as judges.

The team from NPS decided to participate in the competition as part of a class project on "decision making under stress." All teams were handed an envelope with the case, ten blank overhead slides, dry erase markers, judging rules and scratch pads. The team brainstormed and quickly prepared slides on the Problem Statement, Analysis of Alternatives, Recommended Alternatives and Implementation Plan.

Although the NPS students thought they lacked some of the business and finance background needed to solve civilian problems like this, they felt their problem-solving experience in the Fleet, their analysis skills obtained in the Operations Research Department, and their presentation abilities enabled them to compete effectively. They earned the second place award in the competition.

The Keynote Address of the Stanford Symposium was delivered by **Professor Rick Rosenthal** of the NPS Operations Research Department.

SPACE AND NAVAL WARFARE SYSTEMS CENTER-SAN DIEGO AWARDS STUDENT FELLOWSHIPS

The Space and Naval Warfare Systems Center-San Diego (SSC-SD) announced the awards of the latest round of SSC-SD Fellowships. SSC-SD sponsors a Research Fellowship Program at NPS. The program was instituted to promote NPS's partnership with SSC-SD, address SSC-SD's research focus areas, lay the groundwork for future technical and project management assignments, and foster long-term professional associations with SSC-SD's technical personnel and management. There are two rounds of awards each year. NPS students submit proposals that are reviewed by the technical staff of SSC-SD and approved by the SSC-SD Commander, CAPT T.V. Flynn. Fifty-six students have been awarded fellowships to date. The fellowship includes a $10,000 award to support the students research. The latest recipients are:

- **LT Michael Snelling, USN**
  Topic: A Space-Based Flexible Digital Downconverter within a Reconfigurable FPGA Architecture for Software Defined Radio Applications.
  NPS Advisor: **Professor Tri Ha**, Department of Electrical and Computer Engineering
  SSC-SD Mentor: Dr. Roy Axford, Communication and Information Systems Department
- **LT James Harney, USN**
  Topic: Agent Based Simulation of U.S. Navy Anti-Terrorism/Force Protection Doctrine in Web 3D Environments
  NPS Advisor: **Associate Professor Don Brutzman**, Department of Information Systems
  SSC-SD Mentor: Ms. Celia Metz, Navigation and Applied Sciences Department
- **LT Joshua Hansen, USN**
  Topic: Classified
  NPS Advisor: **Associate Professor Cynthia Irvine**, Department of Computer Science
  SSC-SD Mentor: Mr. Glenn Tolentino, Command and Control Department
- **CDR Leonard Hamilton, USN**
  Topic: Numerical Analysis of Heat Exchanger Performance for a Staggered Short Pin-Fin Array
  NPS Advisor: **Associate Professor Ashok Gopinath**, Department of Mechanical Engineering
  SSC-SD Mentors: Dr. Aram Kevorkian and Dr. George Benthien, Intelligence, Surveillance and Reconnaissance Department
- **LT Sharif Calfee, USN**
  Topic: Autonomous Agent-Based Simulation of an AEGIS Cruiser Combat Information Center Performing Battle Group Air Defense Commander Operations
  NPS Advisor: **Associate Professor Neil Rowe**, Department of Computer Science
  SSC-SD Mentor: Dr. Glenn Osga, Command and Control Department.

SCHOOL OF AVIATION SAFETY JOINS EFFORT ON HOMELAND DEFENSE

CDR Andrew H. Bellenkes, Ph.D., MSC, USN
School of Aviation Safety

The war against terrorism will, as you know, go on for a long time, and with it comes many new challenges. We are all in a new area in dealing with these issues: the operations, lines of research, and technologies designed to carry out the war against terrorism will be constantly and quickly evolving. Many NPS faculty, staff, and students are already at the "tip of the spear" working with the plethora of critical operational and research issues associated with homeland defense. **CDR Andrew H. Bellenkes, PhD, MSC, USN**, is in the process of establishing a joint-service Working Group specifically devoted to addressing "Human Factors in Homeland Defense" (i.e., terrorism/counter-terrorism, chemical-biological warfare, special operations systems and training, aviation security, etc.). This group will meet once every quarter via video-teleconference and then annually face-to-face. The products from this working group fall into three major areas:

1) Consultancy: This working group (with NPS as lead) will be the primary recognized repository of homeland defense human factors expertise, and working group members will be available for consultation by government, industry, and other public and professional bodies.

2) Immediate Action Response Team: The working group will address specific by-demand "hot" time-critical issues, the results of which will be disseminated to specific "customers" and, when appropriate, to the general public.

3) Education: Working group members will develop and implement on-line and in-person workshops/courses on human factors in homeland defense. The group will also sponsor an unclassified panel on Human Factors in Homeland Defense at an annual scientific professional society meeting. In this regard, CDR Bellenkes chaired the first of these, a double-session panel on Human Factors in Homeland Defense (see block below), at the Annual Congress of the Aerospace Medical Association in Montreal on 5-10 May 2002. Other NPS faculty on the panel were: **Associate Professor David Tucker**, Department of Defense Analysis, "Countering Terrorism: The Critical Challenge to Homeland Defense;" **Assistant Professor Anna Simons**, Department of Defense Analysis, "Special Operations Forces: Who They Are and How They Are Employed Against Terrorism;" **Dr. James Fobes**, Federal Aviation Agency Chair Professor, "The Department of Transportation Counter-Terrorism Technology Base."

THE HUMAN FACTOR IN HOMELAND DEFENSE

American Homeland Defense policies have been designed to ensure this nation's physical security against attack from without and within; no simple task considering the plethora of complex security risks existing today. The United States has always planned for the possibility of an attack on its territory ("Home Plate"). However, the tragic events of 11 September 2001 and the bio-terrorism emerging since then are painful reminders that Homeland Defense programs must be as diverse in nature and scope as are the threats. This panel addressed the unique nature of "Home Plate"-directed asymmetric warfare as well as the challenge of providing defenses against and responses to the use of weapons of mass destruction (WMD). There was a discussion on the employment of operational risk management as an apriori (rather than reactive) process used to identify and implement controls against terrorism. Panelists also demonstrated how such a proactive approach to homeland defense can be substantially facilitated through the use of databases such as that currently being developed for the Department of Transportation. This repository will contain counter-terrorism resources for each particular type of WMD threat, and should thereby prove an invaluable tool in counter-terrorism operations. However, should an attack actually occur, then it will be necessary to limit the extent of damage and injury from that attack. One of these is the Chemical Biological Incident Response Force (CBIRF) - a unique military unit with a consequence management mission to provide rapid and effective responses to WMD incidents. Panelists provided an introduction to the CBIRF, describing how it uses a host of human and technological resources to combat these threats. Another way to defend one's territory is to prevent or respond to threats before they even physically reach "Home Plate." A critical weapon in implementing this approach is the use of Special Forces personnel. By the nature of their mission, Special Forces troops are often faced with a host of challenging human factors issues. The panel is expected to be the first of a series devoted to human factors issues in asymmetric warfare and homeland defense.

RECONFIGURABLE, FAULT-TOLERANT PROCESSOR FOR SPACE

Professor Hersch Loomis, Department of Electrical and Computer Engineering and Space Systems Academic Group

A research team led by **Professor Hersch Loomis** and **Dr. Alan Ross**, Navy TENCAP Chair Professor, has recently received a grant from the National Reconnaissance Office to develop a reconfigurable, fault-tolerant microprocessor for space applications. The processor is to fly as an experiment on the next Naval Postgraduate School satellite, *NPSAT1*, with a target launch date of January 2006.

The team led by Loomis and Ross also includes two Electrical and Computer Engineering graduate students, **Maj Dean Ebert, USMC**, and **LT Steve Johnson, USN**, and an *NPSAT1* engineer, **David Rigmaiden**. The design currently under development is a follow-on to seven Masters-degree theses and one Ph.D. dissertation.

The processor will have the structure shown in the figure below.

The entire contents of the dotted box in the figure will be realized in a Field Programmable Gate Array (FPGA). The technology of the FPGA will provide sufficient logic to realize three identical highly capable processor architectures plus the voting, input/output, and Error Detection and Correction Logic for memory. The FPGA technology to be employed will provide resistance to accumulated space radiation effects (called total-dose effects) and will provide the ability to reconfigure the system once it is on orbit. In normal operation, the processors operate in lock step and appear as one processor to the bus and the memory. The transient errors in the processors, that are inescapable in space, (called single-event upsets) will be detected and corrected as follows:

1) The voter compares the address and data outputs of the three processors.

2) When an upset in one of the processors causes a discrepancy in voter inputs, the voter

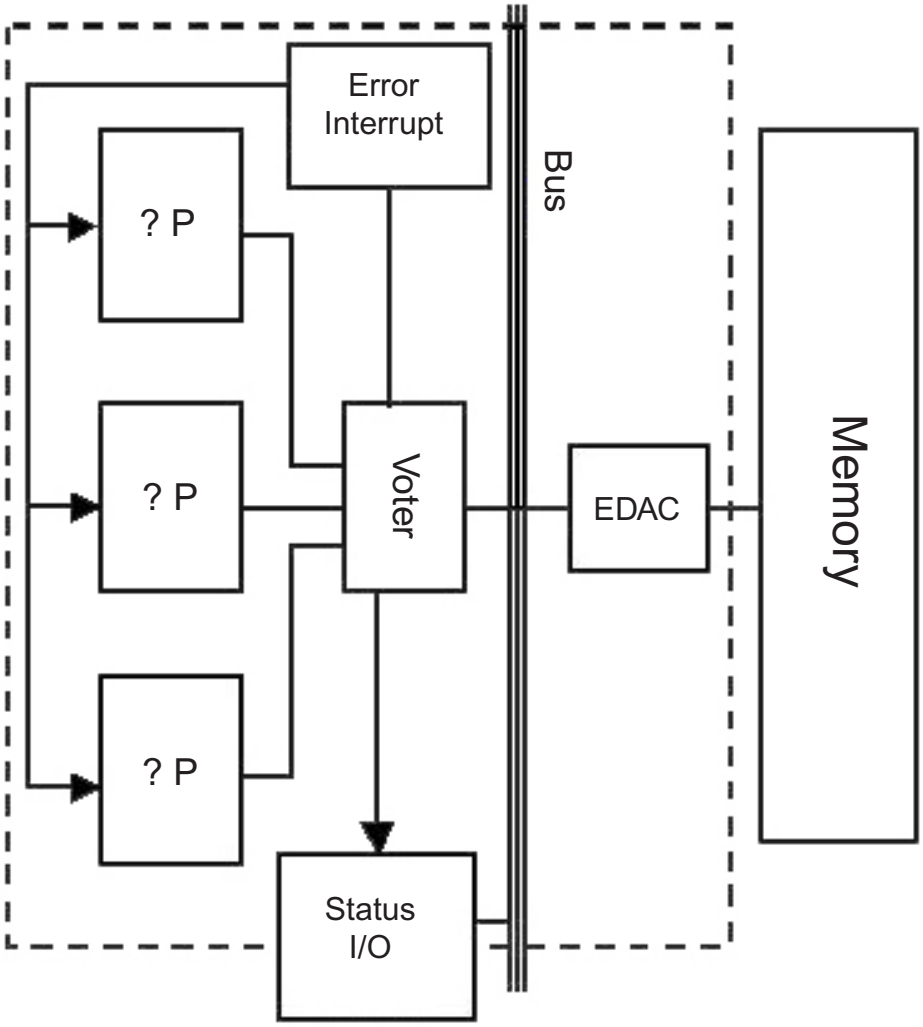
- By majority vote, determines the correct values to be put on the system bus, so correct results are written to memory, and
- Interrupts each of the processors.

3) When interrupted, each processors interrupt service routine executes (in lock step)

- A context save of its internal state. Any errors, including the one that caused the interrupt, are voted out, so only correct state values are saved.
- Then, each processors interrupt service routine executes (in lock step) a restoration of the state of each processor.

4) Finally, the return from interrupt causes resumption of the program with error-free processors at the point where the error was detected.

The processor design experiment has great potential to provide powerful computational resources that are reconfigurable and radiation tolerant to both military and civil space missions.



Reconfigurable, Fault-Tolerant Processor

CENTER FOR JOINT SERVICES ELECTRONIC WARFARE TO ACT AS NAVAIR PMA-234'S SOFTWARE SUPPORT ACTIVITY

Professor Phillip Pace, Department of Electrical and Computer Engineering and Director, Center for Joint Services Electronic Warfare
LCDR Mark Colombo, USN

NAVAIR PMA-234 has contracted the NPS Center for Joint Services Electronic Warfare to act as the Software Support Activity for the Electronic Warfare Network-Centric Simulation (EWNCS) programs. These tools are being used in the Airborne Electronic Attack, Analysis of Alternatives (AEA AoA), to examine potential new acquisition programs to initially augment and eventually replace the EA-6B force beginning in 2010. The EWNCS tools run on both PCs and a LINUX Beowolf cluster.

LCDR Mark (Klinger) Colombo, USN, an EA-6B Electronic Countermeasures Officer (ECMO), is receiving his Masters of Science in Aeronautical Engineering (Avionics) degree and has been instrumental in pulling together a study that will determine the network architecture for the future suppression of enemy air defense (SEAD). As an EA-6B ECMO he is forming new theories and principles governing reactive electronic attack (EA). Specifically, he has developed a Monte Carlo mathematical model written in MATLAB to study the minimum jamming response times for reactive EA targeting. The model is being applied to selected radars extracted from the 1996 Defense Planning Guidance Illustrative Planning RT-4 Scenario. A comprehensive comparison of Link-16 and the Improved Data Modem (IDM) with application to reactive EW efforts is also being quantified. Another major emphasis of his thesis is to examine the interaction of SEAD assets against a likely hostile integrated air defense system (IADS) in representative AEA scenarios. Networked SEAD assets examined in this work include the:

- EA-6B aircraft (LR700, AN/ALQ-99),
- Miniature air launched vehicles MALD (AN/ALQ-99),
- Global Hawk Unmanned Air Vehicle (UAV) (LR100)
- Predator Unmanned Air Vehicle (UAV) (LR100 and AN/ALQ-99)

The concept of using the EA-6B to cue several miniature air launched decoys/unmanned air vehicles (MALDs/UAVs) is being examined to determine how many can be controlled and their operational benefit. This depends on the link performance, the platforms involved, the packets that must be subscribed to and published on the link. That is, by permuting various components of the EW scenario, LCDR Colombo's research examines the timeliness of reactive EA and identifies the critical components, such as network limitations, in the associated SEAD architecture. Ultimately, his recommendations will be derived based on scenario results designed to focus future reactive EA efforts and address potential concerns of EA-6B network-centric electronic warfare. He is also documenting the first draft of the Operational Requirements for an EA-6B future mission planning system. Although JMPS (Joint Mission Planning System) and TEAMS (Tactical EA-6B Mission Support System) are workable solutions, a new genetically adapted software tool such as EWNCS could provide substantially better information and the investigation into the operational requirements is a necessary first step in this study.

METEOROLOGY FACULTY PARTICIPATE IN USAF UNMANNED AIR VEHICLE TESTS

Department of Meteorology personnel and equipment were part of two separate U.S. Air Force coordinated flight tests of the Hunter Unmanned Air Vehicle (UAV) and associate ground electromagnetic interference/radio frequency interference (EMI/RFI) testing performed near Fort Huachuca, Arizona (Concise College Flight Facility) during February and March 2002. An objective of the flight tests was to demonstrate the operation of a dispenser system on the Hunter UAV and performance of launched sensors to measure profiles of pressure, temperature and percent relative humidity, and data relay of information to a ground station. The dispensed sensors were part of a Tactical Dropsonde (Tdrop). The Tdrop is a Navy developed METOC measurement system. Accuracies of the TDrop temperature, humidity and pressure measurements were evaluated by comparisons with three sources obtained by measurements taken by NPS personnel, during the tests. These were 1) Vaisala RS-80 rawinsonde attached to a balloon that was timed to release at a certain altitude above the TDrop deployment altitude which enabled two comparison atmospheric profiles, one going up and one coming down, 2) Vaisala RS-80 rawinsondes attached to a balloon that is tethered by a light line to a portable winch and allowed several profiles of the lower atmosphere to be obtained within the first 400 meters of the surface, and finally, 3) a surface meteorology station that measured temperature, humidity, pressure and winds at an elevation of 3 meters above the surface. Results from the NPS provided data in these tests are being evaluated for future Hunter UAV as well as other systems technical development and operational demonstrations.

PROJECT NOTES

OCEANOGRAPHY RESEARCHER PARTICIPATES IN NATIONAL SCIENCE FOUNDATION SPONSORED NORTH POLE ENVIRONMENTAL OBSERVATORY

Research Professor Tim Stanton of the Department of Oceanography participated in the National Science Foundation-sponsored North Pole Environmental Observatory (NPEO) this April by deploying the first of a series of autonomous ocean flux buoys developed at NPS by his research group. The buoy, which measures the vertical transport of heat, salinity and momentum from the ocean interior to the ice/atmosphere, was deployed from an ice camp 80 miles south of the North Pole. The flux buoy was co-located with ice flux and atmospheric forcing buoys from the Cold Regions Environmental Laboratory (CREL) and National Oceanic and Atmospheric Agency (NOAA) allowing the local flux balance to be determined in this climate-sensitive region as the ice flow drifts out of the Arctic toward the Atlantic Ocean over the next year. (See http://www.oc.nps.navy.mil/~stanton/fluxbuoy/index.html).

Autonomous Ocean Flux Buoy developed by NPS.

NPS RESEARCHERS RECEIVE DEFENSE UNIVERSITY RESEARCH INSTRUMENTATION PROGRAM (DURIP) AWARDS

The Department of Defense sponsors the Defense University Research Instrumentation Program (DURIP). The DURIP supports the purchase of state-of-the-art equipment that augments current capabilities or develops new university capabilities to perform cutting-edge defense research. A merit competition is conducted by the Army Research Office, Office of Naval Research, Air Force Office of Scientific Research, and the Advanced Technology Development Directorate of the Missile Defense Agency. The offices solicited proposals from university investigators working in areas of importance to DoD such as information technology, remote sensing, propulsion, electronics and electro-optics, advanced materials and ocean science and engineering. In response to the solicitation, 733 proposals were received. DoD plans to award $45 million to 209 researchers at 102 academic institutions. Five NPS faculty were recipients of DURIP awards:

- **Research Assistant Professor Christopher Brophy**, Department of Aeronautics and Astronautics, for his proposal, "A Diagnostically Enhanced Six Degree-of-Freedom Thrust Stand for Pulse Detonation Engine Testing." (Office of Naval Research)
- **Professor Anthony J. Healey**, Department of Mechanical Engineering, for his proposal, "Command and Control Initiatives Cooperating Vehicles." (Office of Naval Research)
- **Research Professor Steven Ramp**, Department of Oceanography, for his proposal, "A Relocatable, Real-Time, Coastal Ocean Observing System." (Office of Naval Research)
- **Distinguished Professor Edward Thornton** and **Research Professor Timothy Stanton**, Department of Oceanography, for their proposal, "Littoral Wave Dissipation Measurement System." (Office of Naval Research)
- **Professor R. Kevin Wood**, Department of Operations Research, for his proposal, "Parallel Computing for the NPS Optimization Laboratory." (Office of Naval Research)

USNA FEATURE

UNITED STATES NAVAL ACADEMY TRIDENT SCHOLAR PROGRAM

The United States Naval Academy instituted the Trident Scholar Program in 1963 to provide an opportunity for a limited number of exceptionally capable students to engage in independent study and research during their senior year. Under this program, midshipmen in the top ten percent of their class at the end of the first semester of their junior year are invited to submit proposed research program and programs of study for evaluation. Midshipmen selected to participate are accorded an unusually exciting educational experience. There were fifteen scholars appointed in the class of 2002.

The Trident Scholar Committee recommended the Harry E. Ward - Office of Naval Intelligence Trident Scholar Prize for this academic year. In the collective judgment of the members of the committee, four midshipmen particularly excelled in their Trident Scholar projects during the fall and spring semesters, culminating with their talks at the Trident Scholar Conference on 25 and 26 April, and submission of their final Trident reports.

Midshipman First Class Jeremiah Joseph Wathen is awarded the Harry E. Ward - Office of Naval Intelligence Trident Scholar Prize for Academic Year 2002. Three midshipmen first class, **Benjamin Murray Heineike**, **Peter Daniel Huffman**, and **Noah Freeman Reddell** are recognized for receiving honorable mention for this prize. These four graduating midshipmen, whose research proved to be especially outstanding, were recognized during the Prizes and Awards Ceremony on 23 May in Alumni Hall at the Naval Academy.

DRIVER ASSISTANCE STEERING CONTROL COMPENSATION OF ACCELERATING VEHICLE MOTION

Steven R. Burns (Systems Engineering major)
Advisors: Assistant Professor Richard T. OBrien, Jr. and Assistant Professor Jenelle L. Piepmier

A dangerous and common situation during highway automotive use is the emergency turning/braking (ETB) maneuver. An ETB maneuver is defined by full application of the brakes combined with a significant steering input from the driver. To date, there has been no known development of a dedicated driver assistance controller for this common situation. The proposed ETB controller assists the driver in maintaining control over the vehicle during the ETB maneuver.

The ETB controller and similar vehicle subsystem development is limited as a result of the high material cost and space intensiveness of full-size vehicle testing. Normally, physical testing of automotive components is cost and space prohibitive at small research facilities. The use of scale-model vehicle testing in automotive engineering is a recent innovation and, therefore, the development of a scale-model platform is a significant contribution to this field.

The scale-model platform components in this Trident project include a treadmill, scale-model vehicle assembled from kit, camera system, desktop computer, and sensor suite. The treadmill and scale-model vehicle simulate the road and vehicle, respectively, while the camera system provides position and orientation data to the vehicle controller. Utilizing sensor data, the computer maintains the vehicle's position on the treadmill in a closed-loop system, while the treadmill speed controller functions in a parallel open loop.

A mathematical model of a full-sized vehicle has been

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Midshipman Burns with advisors, Assistant Professors Richard T. OBrien and Jenelle L. Piepmier

SURVIVABLE CONTROL ALGORITHMS FOR THE INTEGRATED POWER SYSTEM

Daniel F. Chiafair (Systems Engineering major)
Advisor: Assistant Professor Edwin L. Zivi

Future electric warships will contain one integrated electrical power infrastructure for propulsion, ships service, and weapons systems. This integrated power system (IPS) must provide continuous power to mission and life critical systems, including during major combat battle damage disruptions. This research investigated a novel nonlinear systems stabilizing control (NSSC) strategy and associated stability assessment tools recently proposed by Sudhoff. Using a MATLAB-based DC stability toolbox, nonlinear stability augmentation of a prototype DC IPS was investigated with respect to changes in system parameters and system structure.

Midshipman Chiafair with advisor, Assistant Professor Edwin L. Zivi

Today's warships are constructed with segregated mechanical propulsion and electric power systems. In current ships, the power dedicated to ship propulsion is about 90% of total ship power and power dedicated to electrical generation is about 10%. The existing ship service electrical system is not very robust. Because the system is very tightly coupled, a single casualty can disrupt the entire system, causing a total loss of electrical power. Even though the mechanical propulsion system may be in perfect working condition, it cannot provide any electrical power to the ship. An integrated power system will be deployed on future naval combatants to resolve this problem. The key advantage of an electronically controlled, integrated power system is the ability to actively control the flow of power throughout distribution systems. The system requires sophisticated control algorithms and automation infrastructure to maintain power and, if necessary, re-route power to critical systems. The ultimate goal of integrating active, survivable control algorithms into an integrated, solid-state power distribution system will be to maintain power continuity during major, combat induced casualties.

This research analyzed a prototype DC Zonal Electrical Distribution System (DC-ZEDS) with respect to system parameter changes and casualty disruption. The DC-ZEDS testbed has been installed at the University of Missouri at Rolla as part of the Energy Systems Analysis Consortium (ESAC) and it is funded by the U. S. Navy. This testbed is representative of future, integrated ship service power distribution systems. DC-ZEDS stability analysis was performed using Sudhoff's extensions of the Nyquist stability criteria and time-domain simulation. The results indicate that significant improvements in system stability can be achieved using innovative control strategies and algorithms.

DRIVER ASSISTANCE STEERING CONTROL, *continued from page 20*

developed and a scale-model vehicle platform constructed. The ETB controller prototype has been designed using Linear Quadratic optimal control methods and simulated using both the scale-model vehicle and the mathematical model. The effects of various vehicle parameters have been studied using the computer simulation. Controller experiments have been performed using the scale-vehicle testbed for a variety of maneuvers.

The system concept tested in this project will assist the driver in controlling the vehicle during the ETB maneuver, thus decreasing the likelihood of an accident and increasing a driver's control over the vehicle. This is accomplished by controlling the aspects of the emergency braking/turning maneuver that are beyond the drivers influence, and therefore normally go uncontrolled.

DEVELOPING A JOINING ALGORITHM FOR THE NETWORK CENTRIC INFRASTRUCTURE IN TACTICAL TARGETING NETWORKING TECHNOLOGY

Joshua B. Datko (Computer Science major)
Advisor: Assistant Professor Margaret M. McMahon and Assistant Professor Donald M. Needham

Modern warfare tactics demand timely, high quality intelligence information. Strike aircraft are in special need of accurate, real-time targeting information due to their proximity to hostile targets. The Defense Advanced Research Project Agency's Tactical Targeting Network Technology (TTNT) initiative focuses on responding to this need by improving distributed command and control operations through a low-latency, high bandwidth, and dynamically re-configurable network infrastructure. In this research, an algorithm was developed that supports the wireless entry of a TTNT participant into a pre-existing, ad hoc, net-centric environment.

Midshipman Datko and advisors, Associate Professor Donald M. Needham and Assistant Professor Margaret M. McMahon

Analysis of the shortcomings of similar current technologies, specifically Jini networking technology and Bluetooth, established a need for a security-focused approach to ad hoc networking. Likewise, popular secure Public Key Infrastructures (PKIs) implementations have also proven insufficient due to their reliance on non-mobile systems. The algorithm presented in this project applied a novel key management procedure to provide information assurance in the TTNT realm. The implementation of the key management scheme included the creation of a simulation to test different network joining scenarios.

This simulation provided both a successful implementation of the secure joining algorithm, as well as the means to collect empirical runtime measurements. To counter the natural growth in running time as the scenario complexity increased, the algorithm incorporated a trust management scheme. This approach subdued the growth in the complex scenarios where a previously authenticated node could verify the joining user's credibility.

This research provided a necessary first step in the development of ad hoc networks that are suitable for employment in network centric warfare operations. It demonstrated the capability for wireless nodes to rapidly, and securely, join existing TTNT networks. Additionally, this research provided a key management approach that contributed to the design of secure, ad hoc networks.

UNITED STATES NAVAL ACADEMY CLASS OF 2003 TRIDENT SCHOLARS

Midshipman 2/C Matthew J. Ahlert
Wavelet Based Optic Flow for Application to Sonar Imagery
Faculty Advisors: Associate Professor John F. Pierce and Professor Reza Malek-Madani

Midshipman 2/C Tyler H. Churchill
Probing the Nuclear Structure of Te-130 Using (neutron, neutron, gamma) Scattering
Faculty Advisor: Professor Jeffrey R. Vanhoy

Midshipman 2/C Nicholas S. Collier
Cooperative and Noncooperative Research and Development Facing a Monopsonistic Buyer in the Development of the Joint Strike Fighter
Faculty Advisors: Assistant Professor Pamela M. Schmitt and Professor W. Charles Mylander

Midshipman 2/C Kristen L. Deffenbaugh
The Effect of Processing on the Strength and Environmentally Assisted Cracking Resistance of an Aerospace Aluminum Alloy Extrusion
Faculty Advisors: Assistant Professor Michelle A. Koul and Associate Professor Angela L. Moran

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INVESTIGATION INTO VARIATION OF THE THERMAL NEUTRON FLUX DUE TO COSMIC RAYS INTERACTING WITH DIFFERENT ENVIRONMENTAL CONDITIONS

John D. Dirk (Physic major)
Advisors: Professor Martin E. Nelson and Visiting Professor James F. Ziegler

Boron that is used in the manufacturing process of microelectronics is highly sensitive to low energy (thermal) neutrons. When background thermal neutrons originating from cosmic rays interact with the nucleus of certain atoms, ionizing radiation is produced that can change the logic state of a cell on the microchip. This phenomenon is known as a Single Event Upset or Soft Error and is an important problem facing computer manufacturers who employ boron-based materials in their microelectronics. The goal of this project was to characterize the environmental thermal neutron flux with respect to electronic reliability.

Midshipman Dirk and advisor Professor Martin E. Nelson

The detection of thermal neutrons was based on He3 gas-proportional counters. Two detectors were employed at each field location. One detector was bare while the other was shrouded with boron-impregnated rubber that shielded it from thermal neutrons. Fast neutrons still penetrated the rubber and they were counted. The difference in the response between the detectors yielded the thermal flux. The device was packaged into a single suitcase for portability. The detectors have been calibrated at the National Institute of Standards and Technology (NIST) and the Armed Forces Radiobiology Research Institute (AFRRI) with an estimated accuracy of 20%.

Measurements of the thermal neutron flux have been completed in various locations at the Naval Academy and in surrounding sites. Prior experimental results had indicated large terrestrial changes in the flux of thermal neutrons (more than 50x at different sea level locations). The current measurements show less than 10x difference in thermal neutrons, and most of this difference can be explained by natural attenuation from building materials.

The observed flux of neutrons has been used to predict the soft-fail rate of modern memory modules in terrestrial locations. The results agree well with published reports of "life-testing" reliability, in which hundreds of chips are tested using natural ambient conditions of cosmic rays. The results obtained in this project were also compared with similar reliability estimates based on previous scientific measurements of the thermal neutron flux.

USNA CLASS OF 2003 TRIDENT SCHOLARS, *continued from page 22*

Midshpman 2/C Jeffrey H. Dormo
Optical Calibration of TLD Readers
Faculty Advisors: Associate Professor R. Brian Jenkins and Professor Martin E. Nelson

Midshipman 2/C Luke R. Dundon
Observations of the Physical Properties for a Sample of Near-Earth Objects
Faculty Advisor: Associate Professor Debora M. Katz

Midshipman 2/C Nathan A. Fleischaker
Development of Novel Mobile Ad Hoc Networking Protocols for Troop Transport Operations in a Littoral Environment
Faculty Advisor: CAPT Joseph C. McGowan, USNR

Midshipman 2/C Katherine E. Groenenboom
Analysis of Earth Atmospheric Density Using the USNA Satellite
Faculty Advisors: Dr. Richard P. Fahey and Professor Daryl G. Boden

Midshipman 2/C Philip C. Hoblet
Scale-Model Vehicle Analysis for the Design of a Steering Controller

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RELATIONSHIPS

INTERAGENCY AGREEMENT PROVIDES SUPPORT FOR DEVEOPMENT OF HOMELAND SECURITY LEADERSHIP DEVELOPMENT CURRICULUM

An Interagency Agreement between the Office of Justice Programs/Office for Domestic Preparedness and the Naval Postgraduate School, setforth the conditions under which NPS will develop a Homeland Security Leadership Development curriculum to help develop the state, local and federal leadership needed to defeat terrorism. Graduates of this course of instruction would be prepared to strengthen U.S. capacity to deter, defeat and effectively respond to terrorist attacks, and to build the interagency and civil-military cooperation that Homeland Security requires. (See related story, p. 7).

STATEMENT OF INTENT PROVIDES FOR ESTABLISHMENT AND OFFERING OF A JOINT MASTER OF BUSINESS ADMINISTRATION DEGREE

A Statement of Intent between the University of Maryland College Park (UMCP) and the Naval Postgraduate School (NPS) outlines the intent for the two schools to establish and offer jointly a Master of Business Administration (MBA) degree with a concentration in Defense Analysis. The NPS Graduate School of Business and Public Policy and the UMCP Smith School of Business will be implementing the program. The joint program will include a Defense Analysis area of concentration. This area will focus on critical Department of Navy and Department of Defense management and leadership issues.

MEMORANDUM OF UNDERSTANDING FORMALIZES CONTINUED SUPPORT FROM SPACE AND NAVAL WARFARE SYSTEMS CENTER-SAN DIEGO

A Memorandum of Understanding between the Naval Postgraduate School (NPS) and the Space and Naval Warfare Systems Center-San Diego (SSC-SD) formalizes the continued establishment and support of management and research chair positions for SSC-SD at NPS. The creation of these positions at NPS will foster relationships by identifying opportunities for interfacility collaboration. Currently three SSC-SD employees are detailed to NPS. These are **Rita Painter**, Cryptologic Program Manager, **Nathan Beltz**, Cryptologic Research Lab Manager, and **Joe Rice**, Engineering Acoustics Chair. The Autonomous

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USNA CLASS OF 2003 TRIDENT SCHOLARS, *continued from page 23*

Faculty Advisors: Assistant Professor Richard T. O'Brien, Jr. and Assistant Professor Jenelle L. Piepmeier

Midshipman 2/C Kenneth J. Hoover
The Capabilities and Limitations of a Bluetooth Wireless Network in a Shipboard Environment
Faculty Advisors: Professor Antal A. Sarkady and CDR Charles B. Cameron, USN

Midshipman 2/C Bryan M. Hudock
Robot Design for Urban Search and Rescue
Faculty Advisors: Assistant Professor Bradley E. Bishop and Assistant Professor Frederick L. Crabbe, IV

Midshipman 2/C Eric H. Larsen
Electronic Cooling Using Capillary Pump Loops
Faculty Advisors: Associate Professor Martin R. Cerza and Assistant Professor Andrew N. Smith

Midshipman 2/C Michael Oliver
Effects of Transverse Shear Deformation and Warping Restraint on Composite Wings in High Speed Flow Regimes
Faculty Advisor: Professor Gabriel N. Karpouzian

Midshipman 2/C Sean A. Patterson
A Study of the Principles of Reconfigurable Magnetically-Latched Independent Modular Robots
Faculty Advisors: Professor Kenneth A. Knowles and Assistant Professor Bradley E. Bishop

Midshipman 2/C Jon P. Silverberg
Methods of Ship Performance Prediction and Design with Respect to Tank Testing and Computational Fluid Dynamics
Faculty Advisor: Assistant Professor Paul H. Miller

Midshipman 2/C Joseph F. Sweger
Unmanned Carrier Landing Simulation
Faculty Advisor: Commander Robert J. Niewoehner, USN

Midshipman 2/C David L. Zane
Optimizing Final Exam and Course Scheduling at the U.S. Naval Academy
Faculty Advisors: Assistant Professor William N. Traves and Assistant Professor Christopher W. Brown

NPS JOINS THE COMMUNITY OF SCIENCE

The Naval Postgraduate School has become a member of the Community of Science (COS) which is a Web site for scientists and scholars to find funding, promote their research, and collaborate with peers worldwide. COS enables R&D professionals to communicate across a Web network of shared research, funding information, and comprehensive science and technology data, facilitating "virtual communities" whereby societies and scholars in selected disciplines can convene and collaborate on the Web. Researchers in a wide variety of disciplines contribute information and use the system - biomedical experts, physicists, chemists, engineers, materials scientists, social scientists, and humanists.

According to the COS literature, the expertise service includes profiles of 490,000 scientists and scholars from 1300 research institutions worldwide. The information in these profiles includes contact information, positions held, publications, patents, finding received, current research activities and expertise. The foundation of the database is detailed, first-person profiles submitted by individual researchers and validated by their institution. The COS membership includes 80 of the top 100 U.S. research universities, 235 total U.S. and Canadian Universities, 490 Commonwealth universities, 86 Fortune 500 R&D corporations, and national and international government agencies.

The COS membership includes a weekly service alerting individual members of new or updated funding opportunities. These alerts are customized by the faculty member to target grant opportunities in their areas of interest. The COS database also provides opportunities for speaking engagements, and expands access to information about available extramural funding.

Active participation in contributing to the COS databases is expected to enable other experts around the world to identify our faculty and their areas of expertise. As in all collaborative databases, the value of the tool is dependent upon the willingness of members to contribute information relating to their areas of disciplinary expertise, publications, and research interests.

One of the primary benefits of membership will be to promote the expertise of NPS faculty and staff locally, regionally, and nationally. Continued membership in COS will be dependent upon the perceived value of the tool in promoting faculty and obtaining research funding.

Implementation of the Community of Science is being spearheaded by **Distinguished Professor David Netzer**, Associate Provost and Dean of Research, and **Professor Maxine Reneker**, Associate Provost for Library and Information Resources.

NAVAL WARFARE SYSTEMS CENTER-SAN DIEGO,

continued from page 24

Sensor Systems Research Chair is currently vacant.

SSC-SD conducts many Research, Development, Test and Evaluation (RDT&E) projects for the Navy. These projects incorporate a broad spectrum of technologies, many of which are taught in the research programs at NPS. A clearly mutually beneficial opportunity exists for NPS and SSC-SD to participate in collaborative RDT&E projects.

NPS JOINS Internet2

As part of the work of the Information Technology strategic planning process, the Naval Postgraduate School recently applied for membership in Internet2. Internet2 is a consortium led by approximately 190 American universities with industry and government partners that is accelerating the development of tomorrow's Internet.

Provost Dick Elster received confirmation of membership last week. He remarked, "This membership is a milestone in the Naval Postgraduate School's progress in Information Technology (IT). Member institutions are required to show expenditures of at least $500,000 per year in IT-related research, and, of course, NPS exceeds that amount many times over. We are the smallest university member of Internet2 and plan to be one of its most active participants."

The major goal of Internet2 is the development of a network able to sustain the work of research universities, and to speed the transfer of network innovations to the larger Internet community. Topics about which Internet2 members are collaborating include:

- Advanced applications
- Middleware
- New networking capabilities
- Advanced network infrastructure

Internet2 is not a physical network and does not replace today's Internet. However, it is a consortium of universities and laboratories and agencies working together to develop new network tools, applications, and services. Some of those initiatives such as Ipv6, multicasting and quality of service (QoS) need network performance that is not available on the current Internet. As a result, Abilene was developed as the network that provides the venue for Internet2 research. **Chief Technology Officer Tom Halwachs** reports that Abilene, operates at warp-speed some 10 gigabits a

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FIFTH INTERNATIONAL SYMPOSIUM ON TECHNOLOGY AND THE MINE PROBLEM

The Fifth International Symposium on Technology and the Mine Problem was held at the Naval Postgraduate School 22-25 April 2002. Approximately 300 individuals were in attendance including about 60 from 15 allied and friendly countries. The 120 technical papers were evenly distributed between naval mine warfare topics and topics related to land mine warfare, humanitarian demining and remediation of areas contaminated by Unexploded Ordnance.

The Symposium attracted as plenary speakers LT GEN Robert B. Flowers, U.S. Army Chief of Engineers and Commanding General, U.S. Army Corps of Engineers; RADM Paul Ryan, USN, Commander of the Navy's Mine Warfare Command, and Dr. Edward Salazar, a senior Foreign Service Officer assigned to NATO. The Commanding General of the Marine Corps Combat Development Command, LT GEN Edward Hanlon, USMC, could not attend and was represented by his Requirements Division Director, Col Len Blasiol, USMC.

Official sponsorship of the Symposium, in addition to the Naval Postgraduate School, included the Office of Naval Research, the PEO Mine and Undersea Warfare, the Pacific Division, Naval Facilities Engineering Command, and the Defense Advanced Research Program Agency (DARPA). Several companies generously provided support through the Mine Warfare Association for the Monday evening reception in downtown Monterey.

This Symposium Series has become recognized as filling a technological niche in the international effort to conquer the mine problem. Details of the PROCEEDINGS and the QUICK LOOK SUMMARY can be found at the websites <www.demine.org> and <www.minwara.org>.

NPS HOSTS GEOSPATIAL INFORMATION SYSTEMS TECHNOLOGY DAY

The Naval Postgraduate School and Environmental Systems Research Institute (ESRI) co-hosted a Geospatial Information Technology day. Geospatial information is any data with a geographic tag attached. Its ability to use software and computers to leverage the

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NPS JOINS Internet2, *continued from page 25*

second. The challenge, he notes, is to gain access to the closet access point to Abilene as soon as possible – something we will attempt to do in the next two months. Abilene was developed by a partnership of Qwest Communications, Cisco Systems, Nortel Networks and Indiana University, and connects network aggregation points, called gigaPops, to support Internet2 research.

Associate Professor Don Brutzman, Department of Information Sciences and Technical Director for Networked Virtual Environments in The MOVES Institute, chairs the Internet2 Research Group at NPS. Dr. Brutzman notes, "Many new possibilities for collaboration are opening up for NPS through the Internet2 organization. Our access to participate in top-level computational science is improved, and new high-bandwidth applications with remote partners can strengthen our conduct of fundamentally important research."

Associate Professor Alex Bordetsky, also of the Department of Information Sciences, and **Research Associate Don McGregor**, Department of Computer Science, both attended the annual Internet2 meeting last week. Dr. Bordetsky reported, "There are many opportunities for our faculty to get involved in Internet2, and we will be looking for ways to forge constructive collaborations to investigate problems of common interest."

Some specific opportunities that NPS will gain by joining Internet2 include:

- Access to 204 research sites of Abiline high-speed communication network,
- Joining the Access Grid that supports large-scale distributed meetings, collaborative work sessions, tutorials and training around the globe,
- Access to Internet2 International partners,
- Using Internet2 as a testbed for studying peer-to-peer C2 communications,
- Using Internet2 as a testbed for virtual environments performance studies,
- Using Internet2 as a testbed for FORCEnet interoperability studies,
- Using Internet2 as NPS high end DL delivery system,
- Using Internet2 for Sensor Grid /FORCEnet QoS and end-to-end performance studies, etc.

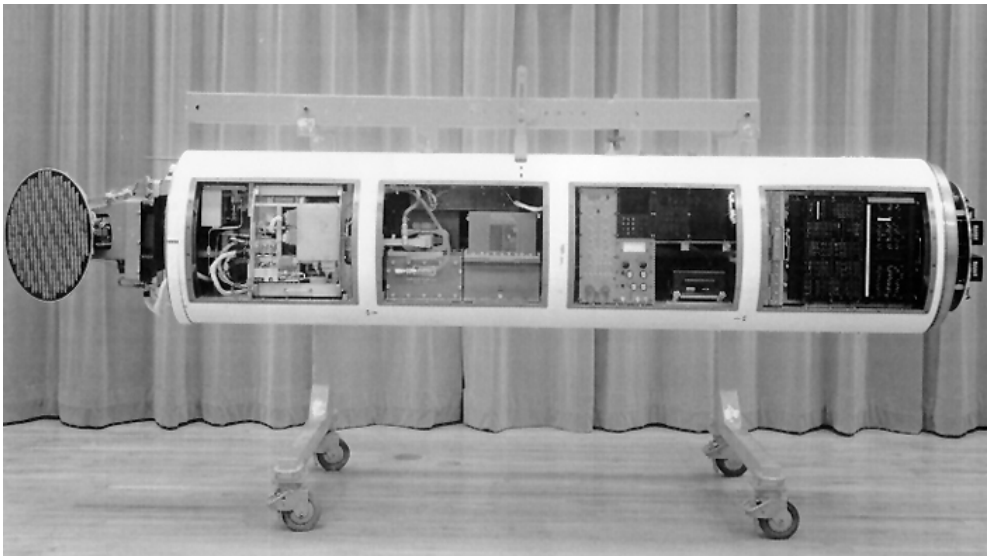
RADM David Ellison, USN, Superintendent of the Naval Postgraduate School, noted that "Internet2 membership signals national recognition of NPS excellence in IT research and education. Our faculty members look forward to contributing to this important national consortium."

N912 THREAT MISSILE SIMULATOR VALIDATION WORKING GROUP (SVWG) MEETS AT NPS

The N912 Threat Missile Simulator Validation Working Group (SVWG) was hosted by the NPS Center for Joint Services Electronic Warfare on 5-6 March 2002. The SVWG is sponsored by the Office of Naval Research (ONR 313) and chartered by N912 to validate all anti-ship cruise missile (ASCM) threat simulators. Representatives to the SVWG include OPNAV, PEO(TSC) PMS-473, Naval Research Laboratory, Naval Air Warfare Center-Weapons Division, COMOPTEVFOR, Office of Naval Intelligence, Naval Surface Warfare Center-Dahlgren Division and the Naval Sea Systems Command.

According to the chairman, **Professor Phillip E. Pace** of the Department of Electrical and Computer Engineering, the simulators/simulations are used to "support the full lifecycle and range of electronic warfare (EW) system techniques, tactics and integrated combat system research, development, test and evaluation (RDT&E)." The simulators also support operational testing of shipboard weapon systems and are used in acquisition milestone decisions. An AN/ALQ-170 programmable ASCM is shown below.

The procedures followed by the SVWG reflect the Department of Defense (DoD) guidance concerning ASCM threat simulators and include radio frequency (RF), infrared (IR) and computer simulations. The scope of operation of the SVWG includes conducting the validation process for each captive-carry simulator or computer simulation that simulates the emitted electromagnetic characteristics and/or processing functions of anti-ship cruise missiles and/or sensors which pose a threat to U.S. Naval systems.



AN/ALQ-170 programmable anti-ship cruise missile.

The meeting in March concentrated on prioritization of the assets that will be required for the upcoming NULKA off-board decoy tests as well as the AN/SLY-2 Advanced Integrated Electronic Warfare Systems (AIEWS) operational test and evaluation (OPEVAL). NPS faculty and students play a special role not only to provide the SVWG technical leadership but to also investigate algorithms to aid COMOPTEVFOR and PMS-473 in determining the EW effectiveness of shipboard electronic attack systems using captive-carry data from at-sea experiments.

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Pace, P.E., Zulaica, D., Nash, M.D., DiMattesa, A.D., and Hosmer, A.C., "Relative targeting architectures for captive-carry HIL missile simulator experiments," *IEEE Transactions on Aerospace and Electronic Systems*, Vol. 37, No. 3, pp. 810-823, July 2001.

Pace, P. E., Nishmura, B. H., Morris, W. M., and Surratt, R. E., "Effectiveness calculations in captive-carry HIL missile simulator experiments," *IEEE Transactions on Aerospace and Electronic Systems*, Vol. 34, pp. 124--136, January 1998.

NPS HOSTS GEOSPATIAL INFORMATION SYSTEMS TECHNOLOGY DAY, *continued from page 26*

fundamental fact of geography--that location is very important in people's lives--makes Geographic Information System (GIS) an important tool to the military and civilian planner. With the addition of a geographic reference tag, the location of supplies, personnel, equipment, and potential targets can be stored, analyzed, visualized and disseminated with ease and accuracy. Topics covered during the one-day event included: 1) an overview of GIS in Defense; 2) intelligence data dissemination over web-enabled GIS; 3) commercial deployment of meteorological data with GIS; 4) integration of GIS and simulation for mission rehearsal; and 5) GIS for homeland defense data.

CONFERENCES

MARINE FORECASTER'S WORKSHOP FOR THE NATIONAL WEATHER SERVICE HOSTED BY NPS

Department of Meteorology **Associate Professor Wendell Nuss** hosted a Marine Forecaster's Workshop for the National Weather Service. The workshop in its fifth year is aimed at educating Weather Service forecasters on the latest ideas that help them forecast winds over the ocean and waves. The workshop brings experts in coastal meteorology and oceanography from NPS, Naval Research Laboratory, National Oceanic and Atmospheric Agency, the Weather Channel, and universities to share their insights on winds and waves to transition these insights into operational use by forecasters. NPS METOC students participate as well to help carry these ideas to their subsequent fleet assignments.

THIRD ANNUAL CLASSIFIED ADVANCED TECHNOLOGY UPDATE (CATU) SCHEDULED FOR JULY

The Naval Postgraduate School is offering the Classified Advanced Technology Update (CATU) Short Course 22-26 July 2002. The CATU is intended for U.S. only, TOP SECRET/SCI-cleared military and civilian technical personnel who are interested in refreshing and updating their knowledge in the areas of advanced technology that support the mission of the Department of Defense. This year's theme will be Homeland Security and Defense, with an emphasis on applications and upgrades for intelligence, security, infrastructure protection, and counter-terrorism. Speakers from both industry and government have been selected based on their work in the technical areas and their recognized subject matter expertise. Course topics will include Cryptology, Information Operations, Overhead Reconnaissance, Digital Signal Processing, Navigation, Communications, High Power Microwave, and Geolocation.

Additional information and registration can be found online at http://www.sp.nsp.navy.mil/catu.

THE 18TH ANNUAL REVIEW OF PROGRESS ON APPLIED COMPUTATIONAL ELECTROMAGNETICS

During March the Applied Computational Electromagnetics Society (ACES) held its 18th annual conference at the Naval Postgraduate School. ACES was formed in 1985 as a computer modeling electromagnetics workshop with the goal of providing a forum for the discussion of computer modeling tools like the Numerical Electromagnetics Code (NEC). Today, members of the society worldwide are very active in a wide range of Computational Electromagnetics (CEM) research and development, all of which are well represented at the annual conference.

The annual ACES conference provides an opportunity for CEM enthusiasts to gather together and share ideas and successes as well as failures concerning the practical application of computational methods to current EM challenges. Presentations, courses, and workshops are offered in areas such as the validation and performance of computer codes and the underlying solution techniques; the development of new algorithms, computational techniques, and code enhancements and the application of these techniques to real problems.

In addition, ACES addresses model input/output data issues, the intention being to provide some standard input geometry file and output format to ease the application of meshing routines and data management.

The ACES conference runs for five days. This year it was held from March 18 to 23. While Monday and Friday were reserved for full and half day short courses, the remaining conference days each began with two plenary sessions of general interest. After the plenary sessions the conference split into three parallel sessions, and provided the one hundred fifty attendees with papers on a wide range of topics. Many of those that attend this conference are from academia and government organizations; a much smaller percentage is from industry. As usual, about 30% of the attendees were from foreign countries.

This year's short courses addressed theoretical and numerical topics, and different design issues. A typical short course presented an overview of numerical techniques relevant to a particular type of computational electromagnetic modeling. In depth discussions on how to create and use effective models to solve a specific class of problems are included. Nearly all courses demonstrated the use of CEM tools. Two of the short courses were presented in the form of Hands-on Workshops by Professor Branko Kodludzija of the University of Belgrade.

During the week, the major numerical techniques, their use, optimization and development were covered in a number of the sessions. For those actively involved in developing EM modeling tools, these sessions provided good insight into the manner in which this field is developing. It was also revealing to see how EM tools are applied to wireless com-

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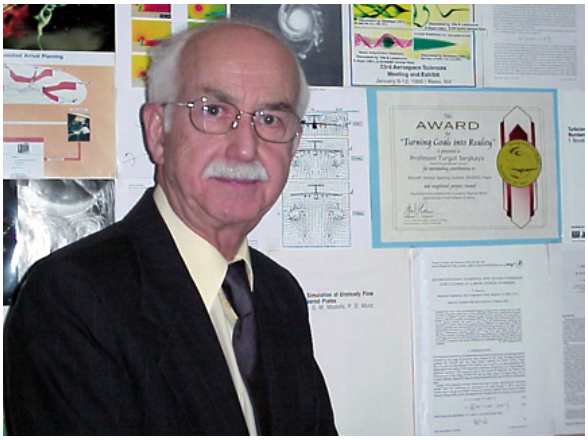
FACULTY AWARDS

NASA HONORS NPS DISTINGUISHED PROFESSOR

The National Aeronautics and Space Administration (NASA) has presented a prestigious award to **Distinguished Professor Turgut Sarpkaya** of the Department of Mechanical Engineering for his outstanding contributions to the Aircraft VOrtex Spacing System (AVOSS) Team and exceptional progress towards revolutionizing aviation by increasing capacity while maintaining a high degree of safety.

Since the time it has been shown that objects heavier than air can fly, the taking off and landing of large aircraft at single and parallel runways have become the most important problem of modern aviation. One of the major constraints on runway capacity is the separation required between successive arrivals or departures. These separations are governed in part by the wake vortex separations necessary to ensure the safety of arriving and departing aircraft. The fact that each aircraft (e.g., a B-747) gives rise to two large trailing vortices (often visible in Monterey skies), each stronger than the largest tornado, one cannot space the leading and follower aircraft too closely. Otherwise the vortices of one aircraft will tear apart the follower aircraft. Thus, there must be sufficient space between the landing (and taking off) of aircraft depending on their weight, speed, elevation, and most importantly, on the environmental conditions (winds, shear, stratification, etc.). The restriction of aircraft landing per hour reduces the economical performance of airports and airlines and increases pollution, global warming, and fuel dependence on other nations. The super heavy aircraft will neutralize the capacity gain of large passenger decks by requiring additional track miles to separate the succeeding traffic. Clearly, the wake turbulence is an international concern that currently limits airport capacity and efficiency.



Distinguished Professor Turgut Sarpkaya

Alternatives are to build more airports to accommodate ever-increasing travel. But, the idea of covering up the land with concrete is not acceptable to the general public. Even if such increases can take place, they will only offset some of the problems in the short term and it will not be a major improvement since the complete aviation system is becoming saturated. A new, innovative solution must therefore be developed and implemented which makes use of the parts of the airspace system and airport infrastructure. One of the most promising solutions to increase capacity is to reduce separation distances between aircraft. In order words, instead of landing the aircraft at fixed time intervals regardless of their size and regardless of the prevailing environment conditions (as it is now), one must find the safe and optimum separation times by calculating the

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APPLIED COMPUTATIONAL ELECTROMAGNETICS, *continued from page 28*

munication and military problems. Antenna behavior, radar cross-section and most other areas of CEM require great accuracy, while propagation modeling is somewhat less precise. It is encouraging to see that Computational Electromagnetic modeling can provide accurate answers to specific problems.

One area of interest that was particularly well attended concerns Fast Hybrid Methods for the design of antennas and waveguide networks. The Electromagnetic Compatibility session addressed the use of CEM in design and testing of electronic and communication systems. As usual, the Method of Moments sessions were the largest, emphasizing the usage of the the Numerical Electromagnetics Code (NEC) and the Wires and Plates-Dielectric code (WIPL-D).

The Student Paper Competition session featured six papers covering a wide range of computational techniques. ACES is an excellent resource for those wishing to learn more about the application and the underlying theory of computational EM. Further information on ACES, including membership information, the call for papers for next year's conference, and contact information for ACES officers can be found at http://aces.ee.olemiss.edu/. This page also provides additional links to other computational electromagnetics pages that may be of interest.

FACULTY AWARDS

NPS SHUTTLE SOFTWARE RELIABILITY PIONEER RECEIVES TOP IEEE AWARD

The 2001 winner of the Institute of Electrical and Electronic Engineers (IEEE) Reliability Society's "Reliability Engineer of the Year" Award is **Professor Norman F. Schneidewind** of the Department of Information Sciences. The award reads: "In Recognition of Contributions to Software Reliability Modeling and Reliability Leadership of the Space Shuttle and Key National Purpose Programs." Dr. Schneidewind received the honor during the IEEE Reliability Society's annual awards banquet, held in January in conjunction with the professional groups annual Reliability and Maintainability Symposium. The award is presented to one individual each year whose work has significantly increased the reliability of hardware systems, software systems, or both.

The Schneidewind Model is a mathematical algorithm which, embodied in a computer program and run on a project's software-failure data, predicts the statistical likelihood that a safety-critical coding failure will occur within a specified time. Today, it is one of only four models officially endorsed by the American National Standards Institute and American Institute of Aeronautics and Astronautics Recommended Practice for Software Reliability.

Every Space Shuttle mission, Tomahawk cruise missile launch, and readiness validation for the nation's Trident nuclear missile force depends on the painstaking, visionary work of this 30-year professor of information sciences at NPS. All 400,000 lines of avionics software – the on-board computer code that controls and guides all aspects of the spacecrafts flight from launch, to on-orbit, through landing – have been given the NASA seal of approval after being checked and double checked for life- and mission-threatening errors by the *Schneidewind Software Reliability Model*.

Schneidewind first became involved with NASA and Shuttle safety in the wake of the January 1986 *Challenger* disaster. The success of his model there, he says, was a classic case of "survival of the fittest." After the *Challenger* explosion, Congress ordered everything about the Shuttle investigated with a fine-tooth comb, including the software," he said. "Even though software was cleared as the cause, Ted Keller, then in charge of Shuttle on board

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NASA HONORS NPS DISTINGUISHED PROFESSOR, *continued from page 29*

reduction in the strength of the wake vortices and thereby considerably reduce the separation times, almost doubling the air traffic, reducing our fuel dependence on others, air pollution, etc. This required the creation of vortex-decay models which can provide accurate real-time estimates of the length of time that a pair of trailing vortices will remain a hazard to any aircraft flying towards them. This has been NASA's revolutionizing aviation objective during the past ten years. The question has been addressed by many other industrial nations (Canada, England, France, and China just to name a few).

During the past three years, Distinguished Professor Turgut "Sarp" Sarpkaya conducted experiments and carried out a thorough and truly unique theoretical analysis, supported by NASA computers, and developed a mathematical model which provides real-time landing information to each and every aircraft in all weather conditions. The model has been subjected to extensive field tests at Memphis and Dallas/Fort Worth airports for inspiration, verification, and validation. The tests were most gratifying without an exception.

It is for the reasons cited above that NASA has presented Professor Sarpkaya with the "Turning Goals into Reality" award. The citation reads, in part, "for outstanding contributions to Aircraft VOrtex Spacing System and exceptional progress towards revolutionizing aviation by increasing capacity while maintaining a high degree of safety." It is expected that Sarpkaya's model will be used by many other nations.

As to the question of "why him and not others around the world?" Professor Sarpkaya replied "I have been working on vortex motions for about fifty years, and I happened to be at the right time, at the right place, with the proper concepts, computers and wind tunnel. The scope of the wake-hazard issue exceeds the resources of many nations. I am therefore most appreciative of NASA's Revolutionizing Aviation Objective and NASA's generous support of my contributions here at the Naval Postgraduate School towards the fulfillment of their objectives."

Professor Sarpkaya has received numerous awards during his career to include the Collingwood Prize, Sigma-Xi Research Award, Lewis F. Moody Award, Fluids Engineering Division Award of ASME, Freeman Scholar Award of ASME, and Offshore Mechanics and Arctic Engineering Award.

SOFTWARE RELIABILITY PIONEER RECEIVES TOP IEEE AWARD, *continued from page 30*

flight control and guidance (avionics) software at IBM Federal Systems Division for NASA, wanted to have better confidence measures for future Shuttle missions. They were looking at a number of software reliability models at the time, and called me in 1988. His model fit their failure data the best, and they decided to use it. So the Schneidewind model was the result of a lot of hard work, but its survival (at NASA) was because of a good "fit." Even though his model was the best first fit, Professor Schneidewind worked hard to make sure the match got even better. "With wine, the older it is, the better it is; but just the opposite is true with failure data," Schneidewind explained. "You want as current data as you can get. My model is also unique in that it is the only process to discard -- or put less weight on -- old data prior to the historical best fit point. It uses only the data from that point forward to predict future failures per a given time interval."

In addition to the U.S. Space Shuttle, Schneidewind's software reliability model is also critical for the safe and accurate functioning of the nation's strategic submarine-based Trident nuclear missile force, as well as the Navy's ship-launched Tomahawk cruise missiles. His software reliability model has been used on a number of major programs at the Naval Surface Warfare Center, including in assessing fire-control software for the Trident strategic missile system and the Tomahawk cruise missile system. Both applications assessed the reliability of the respective systems to meet very high reliability objectives. Dr. Schneidewind's model was one of only a few that was able to successfully capture the behavior of the data and allow not only reliability assessments, but also trade-off analyses relating to limited resources such as testing time.

The criteria for the Reliability Engineer of the Year Award are excellence and current relevance of professional contributions, and service to IEEE and the IEEE Reliability Society. According to Dr. Sam Keene of the IEEE Reliability Society's Awards Committee, "In this regard, Professor Schneidewind stands out. He is a true pioneer in the field of software reliability who has pushed the technology envelope while also becoming involved with high-visibility landmark national programs, like the Space Shuttle. His Schneidewind Model is widely deployed, accepted, and used around the world, and he is continuously updating and improving it. Professor Schneidewind is also actively involved in upgrading standards in our field."

Professor Schneidewind is quick to share credit and to place his accomplishments in context. "No software reliability

Professor Norm Schneidewind (left) receives "Reliability Engineer of the Year" Award.

model is run in a vacuum," he explained. "Though my algorithm is executed on an ongoing basis, at least quarterly, at the Johnson Space Center in Houston, its just one tool in the Shuttle manager's tool kit that he can apply to decide whether to go ahead with a launch. Reliability is a probability concept, and the best way to think about it is that its a confidence building tool. If all the other safety checks, like testing and inspections, turn out positive and *in addition* my model is run and predicts the time to next safety-critical failure is longer than the duration of the entire mission, thats strong added evidence to go ahead."

Professor Schneidewind came to the Naval Postgraduate School from industry, where he had been just as much of a pioneer. His history of how IBM outsmarted UNIVAC, where Schneidewind was the latter's sole representative for scientific computers in the Los Angeles area in the 1950s, is one of only two "Vendor Pioneers" articles in Robert Glass, *In the Beginning: Personal Recollections of Software Pioneers*. Before coming to NPS, Schneidewind also worked for Hughes Aircraft, Planning Research Corporation, and System Development Corporation.

In 1992, Professor Schneidewind was elected a Fellow of the IEEE, an honor bestowed on less than one percent of the worldwide professional society's members. He was awarded the IEEE Computer Society's Outstanding Contri-

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FACULTY NEWS

GRADUATE SCHOOL OF BUSINESS AND PUBLIC POLICY

T. Abdel-Hamid, "Illusion of Control in Obesity Treatment," WMC 2002 Health Sciences Simulation Conference," February 2002.

V. Butler, V. Molina, **M. Nissen,** and **W. Gates**, "Characterizing Sailor and Command Enlisted Assignment Preferences," Navy Manpower Research and Analysis Conference, Center for Naval Analysis, Alexandria, VA, 14-15 February 2002.

W. R. Gates and **M. E. Nissen,** "Agent- and Web-based Employment Marketplaces in the U.S. Department of Defense," in: A. Gronlund (ed.), *Electronic Government: Design, Applications and Management,* Idea Group Publishing (2002).

W. R. Gates and **M. E. Nissen**, "Agent-Based Electronic Employment Markets," NPRST Workshop on Sailor Career Management, Millington, TN, February 2002.

K. J. Gergen, S. McNamee, and **F. J. Barrett,** "Toward Transformative Dialogue," *International Journal of Public Administration,* 24(7&8)(2002), pp. 679-707.

B. Hirsch and **S. Mehay**, "Evaluating the Labor Market Experiences of Veterans Using a Matched Comparison Group Design," Southern Economic Association Annual Meetings, Tampa, FL, November 2001.

L.R. Jones, F. Thompson and W. Zumeta, "Public Management for the New Millennium: Developing Relevant and Integrated Professional Curricula." *The International Public Management Review*, 2/2 2002: 18-38.

J. L. McCaffery and **L.R. Jones**, *Public Budgeting and Financial Management in the Federal Government*, Greenwich, CT: Information Age Press, 2001.

L.R. Jones, "Public Management Reform A Symposium," *The International Public Management Review*, Vol. 2, Issue 1, 2001, pp. 1-52.

L.R. Jones, "Symposium on Public Management Reform and E-Government," *International Public Management Journal*, Vol. 4, Issue 2, 2001.

L.R. Jones, F. Thompson, and W. Zumeta, "Public Management for the New Millennium: Developing Relevant and Integrated Professional Curricula," *The International Public Management Review*, Vol. 2, Issue 2, 2001, pp. 19-38.

G. Koh, **M. Nissen** and **W. Gates**, "A Redesign of the U.S. Navy's Enlisted Assignment Process," Navy Manpower Research and Analysis Conference, Center for Naval Analysis, Alexandria, VA, 14-15 February 2002.

M.A. Malina and F.H Selto, "Communication and Controlling Strategy: An Empirical Study of the Effectiveness of the Balanced Scorecard," *Journal of Management Accounting Research*, Vol. 13 (2001), pp. 47-90.

S. Mehay and W. Bowman, "Cost-Benefit Analysis of Navy's Graduate Education Program," Second Annual Navy Workforce Conference, Center for Naval Analysis, Alexandria, VA, 15 February 2002.

S. Mehay and W. Bowman, "Return on Investment in Navy Graduate Education Programs," Graduate Education Leadership Meeting, Monterey, CA, 17 January 2002.

S. Mehay, "Manpower Research in the Manpower Systems Analysis Curriculum at NPS," Second Annual Navy Workforce Conference, Center for Naval Analysis, Alexandria, VA, 15 February 2002.

M.E. Nissen, "An Extended Model of Knowledge-Flow Dynamics," *Communications of the Association for Information Systems*, 8 (2002), pp. 251-266.

M.E Nissen and E. Oxendine, "Integrating Knowledge Process and System Design for Naval Battle Groups," in: M. Khosrowpour (Ed.), *Advanced Topics in Information Resources Management*, Idea Group Publishing (2002).

M.E. Nissen, **K.F. Snider,** and **I.A. Lewis**, "U.S. Defense Acquisition Research Program: A New Look," in: D. Slevin, D. Cleland and J. Pinto (eds.), *The Frontiers of Project Management Research*, Newtown Square, PA: Project Management Institute (2002), Ch. 6, pp. 115-134.

W. Owen, "An Education Consortium for Product Development Leadership," ASEE 2002 Conference, 16-19 June 2002, Montreal, Canada.

K.F. Snider, **F.J. Barrett**, and R.

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SOFTWARE RELIABILITY PIONEER RECEIVES TOP IEEE AWARD, *continued from page 31*

bution Award as well as its Meritorious Service Award, in 1993. Schneidewind is a member of the IEEE Reliability Society's Administrative Committee, and sits on the management board of the IEEE Software Engineering Standards Committee. He chaired the working group that produced the IEEE Standard for a Software Quality Metrics Methodology, and organized a software maintenance workshop at NPS, in 1983, that evolved into the International Conference on Software Maintenance. Professor Schneidewind has received Certificates for Outstanding Research Achievement from the Naval Postgraduate School in 1992 and 1998, and is Associate Editor of both *IEEE Transactions on Software Engineering* and the *Journal of Experimental Software Engineering*.

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Tenkasi, Considerations in Acquisition Lessons Learned System Design, *Acquisition Review Quarterly,* 9 (1) (2002), pp. 67-84.

K.F. Snider and M.F. Walkner, "Best Practices and Protests: Toward Effective Use of Past Performance as a Criterion in Source Selections," *Journal of Public Procurement*, Vol. 1, Issue 1, pp. 96-122.

K.W. Thomas, "Introduction to Conflict Management," *Improving Performance Using the TKI*, Palo Alto, CA: Consulting Psychologists Press, 2002.

GRADUATE SCHOOL OF ENGINEERING AND APPLIED SCIENCES

Aeronautics and Astronautics

J.L Fobes, *FAA Technology Base Program for Mitigating the Effects of Weapons of Mass Destruction Against Transportation Systems: Research, Development and Implementation Opportunities (October 00 March 01)*, Federal Aviation Administration, 2002, DOT/FAA/AR/02/33, [distribution restricted by 14 CFR Part 191].

J.L Fobes, *DOT/FAA Counter-Terrorism Technology Base: Mitigating the Effects of Weapons of Mass Destruction with Research, Development, and Implementation Opportunities (April June 01),* Federal Aviation Administration, 2002, DOT/FAA/AR-02/32, [distribution restricted by 14 CFR Part 191].

J.L Fobes, *DOT/FAA Counter-Terrorism Technology Base: Mitigating the Effects of Weapons of Mass Destruction with Research, Development, and Implementation (July 1 September 01),* Federal Aviation Administration, 2002, DOT/FAA/AR-02/11, [distribution restricted by 14 CFR Part 191].

J.L Fobes, *DOT/FAA Counter-Terrorism Technology Base: Mitigating the Effects of Weapons of Mass Destruction with Research, Development, and Implementation (October November 01),* Federal Aviation Administration, 2002, DOT/FAA/AR-02/12, [distribution restricted by 14 CFR Part 191].

J.L. Fobes, *Contents Guide to the DOT.FAA Counter-Terrorism Technology Base (August 00 August 01),* Federal Aviation Administration, 2002, DOT/FAA/AR-02/10, [distribution restricted by 14 CFR Part 191].

J.L. Fobes, *Enhancing Security for the Transportation Modes*. Federal Aviation Administration, 2001, DOT/FAA/AR-01/110, [distribution restricted by 14 CFR Part 191].

J.L. Fobes, "The DOT Counter-Terrorism Technology Base," Aerospace Medical Association 73rd Annual Scientific Meeting, 5 May 2002, Montreal, Canada.

Electrical and Computer Engineering

D. Copeland and **P. E. Pace**, "Detection and Analysis of FMCW and P-4 Polyphase LPI Waveforms Using Quadrature Mirror Trees," IEEE International Conference on Acoustics, Speech and Signal Processing, ICASSP 2002 #1412, 17 May 2002.

D.J. Fouts and **P.E. Pace**, "Digital Imaging Architecture," ONR EW S&T Gathering, 23 May 2002.

D.J. Fouts and **P.E. Pace**, "Electronic Attack System-on-a-Chip," ONR EW S&T Gathering, 23 May 2002.

D. Jenn, C. Babb and **P. E. Pace**, "High Resolution Wideband DF Using the Robust Symmetrical Number System," Radio Direction Finding Symposium, San Antonio, TX, May 2002.

P. Milne and **P. E. Pace**, "Wigner Distribution and Analysis of FMCW and P-4 Polyphase LPI Waveforms," IEEE International Conference on Acoustics, Speech and Signal Processing, ICASSP 2002 #1411, 17 May 2002.

I. Retsas, **R. Pieper**, **R. Cristi**, "Watermark Recovery with a DCT Based Scheme Employing Nonuniform Imbedding," 34th SouthEastern Symposium on System Theory, 18 March 2002, pp 157-161.

D. Styer and **P. E. Pace**, "Two-channel RSNS Dynamic Range," *IEEE Transactions on Circuits and Systems-I: Fundamental Theory and Applications*, Vol. 49, No. 3, pp. 395-397, March 2002.

Mathematics

C.F. Borges and T.A. Pasteva, "Total Least Squares Fitting of Bezier and B-Spline Curves to Ordered Data," *Computer Aided Geometric Design*, Vol. 19, No. 4, 2002, pp. 275-289.

B. Neta, S. Reich, and H. D. Victory, "Galerkin Spectral Synthesis Methods for Diffusion Equations with General Boundary Conditions," *Annals of Nuclear Energy*, Vol. 29, (2002), pp. 913-927.

Prof. B. Neta served a Technical Chair at the 2002 AAS/AIAA Spaceflight Mechanics Meeting, San Antonio, TX, 27-30 January 2002.

Mechanical Engineering

J. E. Dunne, V.E. Smith, **A. Gopinath,** and **I. Dutta**, "Modeling the Effects of Cycling of a Localized Heat Source on the Durability of a Flip Chip Package with Defects," 52nd Electronic Components and Technology Conference (ECTC), San Diego, CA, May 2002.

I. Dutta, A. Gopinath and C. Marshall, "Underfill Constraint Effects during Thermomechanical Cycling of Flip-Chip Solder Joints," *Journal of Electronic Materials,* Vol. 31, No. 4, pp. 253-264, April 2002.

T. Sarpkaya, (2002), "Experiments on the Stability of Sinusoidally Oscillating Flow over a Circular Cylinder," *Journal of Fluid Mechanics*, Vol. 457, pp.

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157-180.

Prof. T. Sarpkaya presented an invited Keynote paper at the Congress of the International Union of Theoretical and Applied Mechanics (IUTAM), (in Touluose, France, on 15 April), on "Taylor-Gortler Instability in Time Dependent Flow over Curved Surfaces" which is also published in the *Proceedings of the IUTAM-2002* Congress, pp. 1-12. Prof. Sarpkaya also made six other presentations at various European institutions on time-dependent flows, vortex methods, and free-surface flows.

Distinguished Professor Russell L. Elsberry of the Department of Meteorology was named the first recipient of the Richard Hagemeyer award at the Interdepartmental Hurricane Conference during March 2002. This award honors long-term contributions to the improvement of forecasts and warnings of tropical cyclones. Because Richard Hagemeyer was active in international coordination, the award also recognizes Elsberry's involvement in the World Meteorological Organization (WMO) tropical cyclone forecasting and research activities. He has edited books from two previous International Workshops on Tropical Cyclones (IWTC) and is the Director of IWTC-V, which will be held in Cairns, Australia on 3-12 December 2002. He was recently re-appointed to a four-year term as the Rapporteur for Tropical Cyclones for the WMO Working Group on Tropical Meteorology Research. In addition, he serves as the Science Coordinator for the U. S. Weather Research Program on Hurricane Landfall.

Meteorology

Prof. C.-P. Chang delivered invited papers or keynote speeches on several subjects of monsoon meteorology at the following meetings:

- NASA-IPRC-CLIVAR Workshop on Decadal Climate Variability, Monoa, HI, January 2001.
- World Meteorological Organization Conference on Monsoon Forecasting from Days to Years, Delhi, India, March 2001.
- International Workshop on Variations of the East Asian Monsoon, Taipei, Taiwan, March 2001.
- International Scientific Conference on SCSMEX (South China Sea Monsoon Experiment), Shanghai, China, April 2001.
- Eighth Scientific Assembly of International Association of Meteorology and Atmospheric Sciences, Session on ENSO Monsoon Relationship, Innsbruck, Austria, July 2001.
- Third International Symposium on Asian Monsoon System, Okinawa, Japan, December 2001.
- Second Asia-Pacific Network Workshop on the effect of West Pacific Warm Pool and ENSO on Asian monsoon, Macao, China, February 2002.

T. Murphee, F. Schwing, **B. Ford**, **P. Hildebrand**, and P. Green-Jessen, "Climate Variations in the Northeast Pacific: Dynamic Similarities and Links to the Northwest Atlantic," Ocean Sciences Meeting, Honolulu, HI, February 2002.

T. Murphee, F. Schwing, **B. Ford, P. Hildebrand**, and P. Green-Jessen, "Dynamic Similarities in North Pacific North American Climate Variations," Pacific Climate Workshop, Pacific Grove, CA, March 2002.

F. Schwing, **T. Murphee**, S. Bograd, and P. Green-Jessen, "Decadal Regime Shifts: Physical Mechanisms and Ecosystem Consequences," Pacific Climate Workshop, Pacific Grove, CA, March 2002.

D. Sullivan, **T. Murphee, B. Ford,** J. Zande, S. Butcher, N. Crane, and J. Hall, "A Strategy for Improving Marine Technical Education," Ocean Sciences Meeting, Honolulu, HI, February 2002.

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The Naval War College has invited **Professor Charles Calvano**, Department of Mechanical Engineering, to serve as a member of the working group which will establish the requirements for a new ship concept, the Littoral Combat Ship (LCS) a part of the Navy's transformation strategy. The LCS is envisioned to be a relatively small ship capable of performing missions in inshore waters where it would be impractical or unwise to commit larger, higher-value ships. OPNAV N76, has asked the War College to assemble a team to examine the needs for such a ship as part of a larger strategy of developing a family of ships which will ensure the Navy continues to have the entire range of capabilities needed for homeland defense, assured access and power projection.

Professor Calvano's Total Ship Systems Engineering (TSSE) students have produced a number of innovative designs in recent years, some of which have influenced the ongoing exploration of the nature of these future ships. The 2000 and 2001 TSSE designs of a small, fast littoral ship for network centric operations (*SEA LANCE*) and of a small, fast unmanned air vehicle ship (*SEA ARCHER*) both included concepts which are part of these ongoing Navy discussions. Professor Calvano's ship design experience will provide needed skills and experience for the LCS Requirements Development team, which had its kick-off meeting in early March and will continue to develop requirements over a period of additional months.

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Oceanography

F. Arduin, and **T.H.C. Herbers**, Bragg scattering of random surface gravity waves by irregular sea bed topography, *Journal of Fluid Mechanics*, **451**, 1-33, 2002.

A. Yu Benilov and **L.N. Ly** (2002). Modeling of Surface Waves Breaking Effects in the Ocean Upper Layer. *Mathematical & Computer Modelling*, 35, 191-213.

E.P. Bjorkstedt, **L.K. Rosenfeld**, B.A., Grantham, Y. Shkedy, and J. Roughgarden, 2002, Distributions of larval rockfish (Sebastes spp.) across nearshore fronts in a coastal upwelling region, *Marine Ecology Progress Series*, in press.

F.P. Chavez, R. Barber, F. Chai, Y. Chao, A. DeVogelaere, J. Kindle, R. Maffione, B. Marinovic, J. McWilliams, and **J. Paduan**, 2002: On the need for simulations of coastal ocean physics and ecosystems (SCOPE). *Eos Trans. AGU*, 83 (4), Ocean Science Meeting Suppl, Abstract OS11O-07.

P.C. Chu, C. Cintron, S.D. Haeger, and R.E. Keenan, "Acoustic mine detection using the Navy's CASS/GRAB model," 5th International Symposium on Technology and Mine Problem, Naval Postgraduate School, Monterey, CA, 21-25 April 2002.

P.C. Chu, A.F. Gilles, and P. Fleischer, "Hydrodynamics of Falling Mine in Water Column," 5th International Symposium on Technology and Mine Problem, Naval Postgraduate School, Monterey, CA, 21-25 April 2002.

P.C. Chu, L.M. Ivanov, and **C.W. Fan**, 2002: Backward Fokke-Planck equation for determining model valid prediction period. *Journal of Geophysical Research*, in press.

P.C. Chu, L.M. Ivanov, L.H. Kantha, O.V. Melnichenko, and Y.A. Poberezhny, 2002: Power law decay in model predictability skill. *Geophysical Research Letters*, in press.

P.C. Chu, L.M. Ivanov, T.M. Margolina, and O.V. Melnichenko, 2002: On probabilistic stability of an atmosphere model to various amplitude perturbations. *Journal of the Atmospheric Sciences*, in press.

P.C. Chu, B.B. Ma, and **Y.C. Chen**, 2002: Spatial and temporal variabilities of the South China Sea thermoline structure and circulation. *Acta Oceanologica Sinica*, in press.

P.C. Chu, T.B. Smith, and S.D. Haeger, "Mine impact prediction experiment," 5th International Symposium on Technology and Mine Problem, Naval Postgraduate School, Monterey, CA, 21-25 April 2002.

Prof. P. Chu was elected to the board of directors, the Society of Counter-Ordnance Technology, 2002-2005.

R. Durazo, I. Shulman, **J. Paduan**, **L. Rosenfeld**, and **S. Ramp**, 2002: Modelling and model-data comparisons in the Monterey bay area. *Eos Trans. AGU*, 83 (4), Ocean Sci. Meeting Suppl, Abstract OS41M-02.

T.H.C. Herber, S. Elgar, N.A. Sarap, and R.T. Guza, Nonlinear dispersion of surface gravity waves in shallow water, *Journal of Physical Oceanography*, **32**(4), 1181-1193, 2002.

C.J. Jang Noh, Y.T. Yamagata, **P.C. Chu**, and C.H. Kim, 2002: Simulation of more realistic upper ocean process from an OGMC with a new ocean mixed layer model. *Journal of Physical Oceanography*, in press.

P.M. Kosro, and **J.D. Paduan**, 2002: Shore-based mapping of ocean surface currents at long range using 5 MHz backscatter. *Eos Trans. AGU*, 83 (4), Ocean Sci. Meeting Suppl, Abstract OS21E-101.

E. Kunze, **L.K. Rosenfeld**, G.S. Carter, and M.C. Gregg, 2002, Internal waves in Monterey Submarine Canyon, *Journal of Physical Oceanography*, 32: 1890-1913.

P. Luong and **L.N. Ly** (2002). Variable Resolution Multi-Block Grid and Dual-Level Parallelism in Coastal Ocean Modelling. *High Performance Computing Contributions to DoD Mission Success 2002* (Submitted).

L.N. Ly, and **A. Yu Benilov** (2002). Air-Sea Interaction: Surface Waves. *Encyclopedia of Atmospheric Sciences*. Ed. By J. Holton, J. Pyle and J. Curry. Academic Press. (Invited Submitted).

L.N. Ly, and **R.W. Garwood, Jr.** (2002). An Ocean Circulation Model With Surface Wave Parameterization. *Applied Numerical Mathematics*, 40, 351-366.

J.D. Paduan, **L.D. Rosenfeld**, and **M.S. Cook**, 2002: Estimating barotropic tidal currents using very long records from HF radar. *Eos Trans. AGU*, 83 (4), Ocean Sci. Meeting Suppl, Abstract OS41E-73.

Prof. J. Paduan co-organized the Second International Radiowave Oceanography Workshop (ROW-2), which was held near Brest, France, 15-18 April 2002.

Prof. J. Paduan is a member of the OCEAN-US steering committee and participated in a workshop in March empowered to define national priorities for proposed ocean observing systems.

E.T. Petruncio, **J.D. Paduan**, and **L.K. Rosenfeld**, 2002, Numerical simulations of the internal tide in a submarine canyon, *Ocean Modelling*, in press.

I. Shulman, S. Haddock, D. McGillicuddy, **J. Paduan**, **L. Rosenfeld**, **S. Ramp**, J. Kindle, and P. Bissett, 2002: Numerical modeling of bioluminescence in the coastal ocean. *Eos Trans. AGU*, 83 (4), Ocean Sci. Meeting Suppl, Abstract OS32S-03.

I. Shulman, C.-R. Wu, J.K. Lewis, **J.D. Paduan**, **L.K. Rosenfeld**, J.C.

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Kindle, **S.R. Ramp**, and **C.A. Collins**, 2002, High resolution modeling and data assimilation in the Monterey Bay area, *Continental Shelf Research*, in press.

J.F. Vesecky, J.A. Drake, C.C. Teague, D.M. Fernandez, C. Whelan, M.A. Plume, **J.D. Paduan**, and P.E. Hansen, 2002: Comparison of surface current measurements by different HF radar systems with each other and with ADCP current measurements. *Eos Trans. AGU*, 83 (4), Ocean Science Meeting Suppl, Abstract OS12A-97.

J.P. Xu, M.A. Noble, S. L. Eittreim, **L.K. Rosenfeld**, F. B. Schwing, and C.H. Pilskaln, 2002. Distribution and transport of suspended particulate matter in Monterey Canyon, California, *Marine Geology*, 181: 215-234.

Physics

B. Denardo, "Temperature of a light bulb filament," *Physics Teacher*, Vol. 40, pp. 101-105 (2002).

GRADUATE SCHOOL OF OPERATIONS AND INFORMATION SCIENCES

Computer Science

C.E. Irvine, and **T. Levin**, "A Cautionary Note Regarding the Data Integrity Capacity of Certain Secure Systems," *Integrity, Internal Control and Security in Information Systems*, ed. M. Gertz, E. Guldentops, L. Strous, Kluwer Academic Publishers, Norwell, MA, pp. 3-25, 2002.

N. C. Rowe and A. Zaky, "Load Balancing of Parallelized Information Filters," *IEEE Transactions on Data and Knowledge Engineering*, Vol. 14, No. 2 (March/April 2002), 456-461.

N.C. Rowe, "Distributed Intrusion Detection in Software Decoys," ARL/AHPCRC Workshop on Network Intrusion Detection, Aberdeen, MD, March 2002.

E. Spyropoulou, C. Agar, **T. Levin**, and **C. Irvine**, "Ipsec Modulation for Quality of Security Service," *Proceedings of the International Systems Security Engineering Conference*, Orlando, FL, March 2002.

Information Sciences

N.F. Schneidwind: "Modelling the Fault Correction Process," *Proceedings of the Twelfth International Symposium on Software Reliability Engineering*, Hong Kong, 27-30 November, 2001, pp. 185-190.

N.F. Schneidwind, Panelist: "Everything You Wanted to Know About SRE But Didnt Know Who to Ask," Twelfth International Symposium on Software Reliability Engineering, IEEE Computer Society Press, Hong Kong, 27-30 November 2001.

N.F. Schneidwind, Tutorial, "SRE of Web Site Construction," Twelfth International Symposium on Software Reliability Engineering, Hong Kong, 27-30 November 2001, 41 pp.

N.F. Schneidwind, "Using Excel to Implement Software Reliability Models," Workshop on Software Assessment, Twelfth International Symposium on Software Reliability Engineering, Hong Kong, 27-30 November 2001, 29 pp.

N.F. Schneidwind, "Web Site Maintainability," *Proceedings of the Seventh Workshop of Empirical Studies of Software Maintenance*, Florence, Italy, 9 November 2001, pp. 29-30.

N.F. Schneidwind, "Investigation of the Risk to Software Reliability and Maintainability of Requirements Changes," *Proceedings of the International Conference on Software Maintenance*, Florence, Italy, 7-9 November 2001, pp. 127-136.

Prof. N. Schneidewind was interviewed on National Public Radio at the Troy State University Rosa Parks Library and Museum in Montgomery, AL, in April regarding his work on the Space Shuttle and computer security. In addition, he was the invited speaker at the Troy State University Montgomery Third Annual Colloquium on Information Technology.

Prof. N. Schneidewind presented a short course on Software Reliability and Metrics to students of the Temasek Laboratories, National University of Singapore, 3-4 December 2001.

Operations Research

Profs. K. Wood and **L. Williams** have been named Distinguished Visiting Professors at the National Security Agency (NSA) for summer 2002. They will be advisors for the Agency's Summer Program in Operations Research Technology (SPORT), which is a competitive program that brings in graduate stu-

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The Military Operations Research Society (MORS) and the Military Applications Society (MAS) Council of INFORMS have recognized **Professor Al Washburn** as one of this year's *MORS Journal* Award Winners, for the paper he co-authored with Ryusuke Hohzaki, "The Diesel Submarine Flaming Datum Problem." Washburns paper was one of two papers selected by the committee. Both were equally worthy of recognition and both will share in the award. The award will be presented at the MAS Annual Meeting in Memphis during the Fifth International Military Applications Symposium Conference, 3-5 June 2002. In addition, MORS will publicly acknowledge the award winners at its Plenary Session at Ft. Leavenworth later in the month.

FEATURED PROJECT

DEVELOPMENT OF AFFORDABLE GUIDED AUTONOMOUS PARACHUTES , *continued from page 3*

The first step in the precision air delivery process is to broadcast a supply request that includes information on where and when it is needed on the ground (Figure 1a). One scenario under investigation is for a fighter aircraft or an Unmanned Air Vehicle to respond to this request and upon arrival at the assigned drop zone (DZ) to drop a wind dropsonde (Figure 1b). The wind profile acquired during this drop is broadcast to the delivery aircraft and allows computation of the reference trajectory (RT) and of the Computed Air Release Point (CARP). The delivery aircraft will then be navigated to that point for air delivery of the materiel (payload). Should the wind estimate and calculation of CARP be perfect and the aircrew gets the aircraft to this point precisely, then the parachute would fly along the reference trajectory towards the target area with no control inputs required (Figure 1c). However, wind estimation is not a precise science. Furthermore, calculation of the CARP relies on less than perfect estimates of parachute aerodynamics and the flight crews cannot precisely hit CARP for each airdrop mission (especially in case of massive (multiple) deliveries). Therefore, the AGAS GNC system is used to correct these potential errors as well as any areas navigating the aircraft to predicted release points.

The ultimate goal of the AGAS system is to allow delivery aircraft to accurately drop payloads at or above 5500*m*, keeping the aircraft out of the range of shoulder fired ground to air missiles. Another benefit of the system is the ability to pre-address each bundle in a load and to guide the individual bundles to their own pre-programmed TA. Obviously, in order to accomplish these goals, the AGAS system needs to be simple, affordable, durable, and reusable (it should survive multiple drops without any repairs). It should not require major modifications to the standard delivery systems harness or bundle, major modifications to the cargo parachute, or a significant amount of rigger training.

As a result, the AGAS design concept employs a commercial Global Positioning System (GPS) receiver and a heading reference as navigation sensors, an inexpensive guidance computer to determine and activate the desired control inputs, and application of Pneumatic Muscle Actuators (PMAs) developed by Vertigo Inc. to generate control inputs. The navigation system and guidance computer are secured to an existing container delivery system, while PMAs are attached to each of four parachute risers and to the container (Figure 1d). Control is affected by lengthening one or two adjacent risers. Upon deployment of the system from the aircraft, the guidance computer steers the system along pre-planned RT. The AGAS concept relies on sufficient control authority to be produced to overcome errors in

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FACULTY NEWS, *continued from page 36*

dents from around the country to work on important NSA problems. SPORT has turned out some impressive analysis in past years, and has proven to be an effective recruiting mechanism for NSA.

Prof. S.M. Sanchez has been appointed Deputy Editor of *Naval Research Logistics* and **Prof. R. Rosenthal** is back as Editor-in-Chief.

SCHOOL OF INTERNATIONAL GRADUATE STUDIES

Defense Resources Management Institute

D.E. Duckro, **D.W. Quinn**, and **S.J. Gardner** (2002), "Neural Network Pruning with Tukey-Kramer Multiple Comparison Procedure," *Neural Computation*, 14(5), 1149-1168.

R. McNab was invited to join the Editorial Board of *Public Finance and Management*, an academic journal focusing on international issues in the areas of budgeting, public administration, and public management.

R. McNab and J. Martinez-Vasquez. "Cross Country Evidence on the Relationship Between Fiscal Decentralization, Inflation, and Growth," *Papers and Proceedings of the National Tax Association 2001 Annual Meeting*.

THE MODELING, VIRTUAL ENVIRONMENTS, AND SIMULATION (MOVES) INSTITUTE

Prof. M. Zyda has been nominated by the National Research Council (NRC) to serve on one of the three panels which will be reviewing the National Aeronautics Space Administration's Pioneering Revolutionary Technology (PRT) Program. Over 300 recommendations were made for the 39 slots on the three panels. Prof. Zyda has also served as a member of the NRC's Committee on "Virtuality Reality Research and Development" and was chair of the NRC's Computer Science and Telecommunications Board Committee on "Modeling and Simulation: Linking Entertainment and Defense."

DEVELOPMENT OF AFFORDABLE GUIDED AUTONOMOUS PARACHUTES, *continued from page 37*

wind estimation and the point of release of the system from the aircraft. Following subsections briefly discuss main components of the developed and flight-tested G-12 based AGAS.

Parachute

In general, AGAS may be implemented on any circular parachute (a flat circular parachute is the one that when laid out on the ground forms a circle). To date C-9 and G-12 parachutes[25-28] were modeled to demonstrate feasibility of the AGAS concept. Although C-9 was initially designed as an ejection seat parachute, it is a standard flat circular parachute as is the larger G-12 cargo parachute on which AGAS was ultimately be used. Some general data on these parachutes can be found in the Table 1.

- In this table, d_0 denotes the nominal diameter of the parachute, d_P - inflated canopy diameter, C_{D0} - drag coefficient, and l_0 - suspension line length.
- Equilibrium rate of descent is given by the formula

$$V_d = \sqrt{2mg(C_{D0}S_{0p})^{-1}}$$

where p is a mass density of air at desired altitude.

A cargo box used with the G-12 parachute for the AGAS demonstration is a prototype adopted from an A-22 delivery container with the payload capacity of 2200 lb. It is suspended from the system and houses the GNC system, PMAs, and instrumentation system. A standard G-12 uses Y-bridle pairs separated into four equal length risers. The parachute is packed into a standard G-12 deployment bag.

Parameter	C-9	G-12	G-11A
d_0 (m)	8.5	19.5	30.5
d_P / d_0	0.67	0.67	0.67
No. of suspension lines	28	64	120
l_0 / d_0	0.82	0.80	0.90
C_{D0}	0.68	0.73	0.68
Parachute weight (kg)	5.1	59	97.5
Payload weight (kg)	91	998	1588
Descent rate at sea level (m/s)	6.1	8.5	6.7

Table 1. Parachute Data

The PMAs (Figure 2a) are stowed in the riser extension sleeve that is part of the G-12 deployment bag (Figure 2b).

Actuators and Pneumatic Control System

To provide control inputs for AGAS, Vertigo, Inc. developed PMAs (Figure 2a) that are braided fiber tubes with neoprene inner sleeves that can be pressurized[32-34]. Upon pressurization,

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Figure 2. At left, vertigos PMAs (a); and above, G-12 parachute and PMAs in deployment bag (b).

DEVELOPMENT OF AFFORDABLE GUIDED AUTONOMOUS PARACHUTES, *continued from page 38*

the PMA contracts in length from 7.6*m* to 5.8*m* and expands in diameter. Upon venting it does the opposite.

When three of four PMAs are pressurized (filled) and one is activated (vented) this action "deforms" the parachute creating an asymmetrical shape, essentially shifting the center of pressure, and providing a drive or slip condition. This forces the parachute to glide in the opposite direction of the control action (vented PMA). Two adjacent PMAs can be activated simultaneously. Figure 3 shows both possibilities (one and two PMAs activated) realized in CDF-based simulation[35] and observed in the flight test during the airdrops at YPG.

The volume of the onboard nitrogen tank limits the number of possible fills for all four PMAs to 32 per drop. PMA fill and vent times remain the constant 5...6 seconds throughout each drop (regardless of the volume of gas remaining in the tanks). Table 2 characterizes control authority available to the GNC system of the AGAS.

Number of PMAs Activated	0	1	2
Descent rate V_x at 3000m (m/s)	8.43	8.16	7.93
Glide ratio (GR)	0	0.37	0.52

Table 2. AGAS Performance

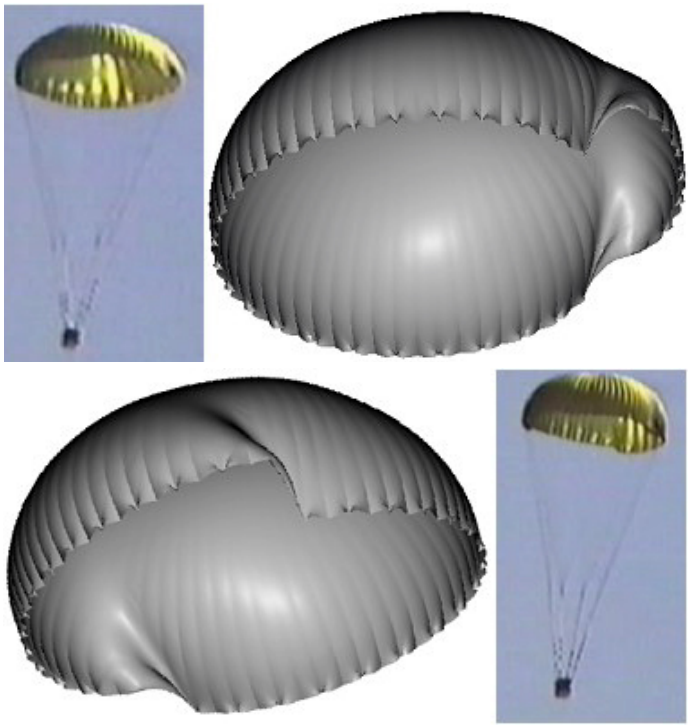

Figure 3. Top: One (a) and bottom: two (b) PMAs actuated (vented).

The PMAs' control system (PCS) also developed by Vertigo, Inc. resides in a specially designed container of 0.4*m* height (Figure 4a)[34]. It consists of a high-pressure recharge circuit (225*atm*), two 44*atm* accumulator tanks, pressure reduction units, valves, and low-pressure circuit feeding PMAs (10.2*atm*). Nitrogen rather than helium is used in the latest version of AGAS as less dependent to temperature leaps. The PCS container covered with a protective polyethylene and foam occupies the space around G-12 parachute canopy atop of a standard cargo container (Figure 4b). It is secured to the top of the payload bundle, strapped and tied to the A-22 harness. The PMA fill hoses are taped to the A-22 risers and the riser clevises are tied together with cotton webbing.

The A-22 harness risers are connected to the Kevlar loops on the bottom ends of the PMAs and the PMA fill hoses are then attached to the PMAs. When these attachments have been tightened and secured, the parachute is lowered onto the top of the PCS container. The parachute is tied to the A-22 harness in

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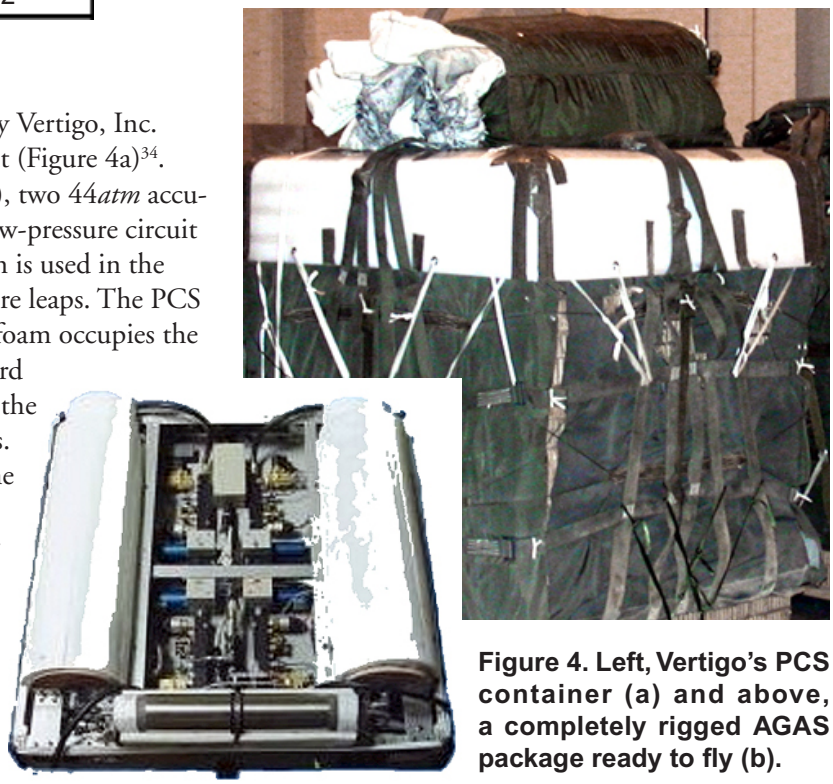

Figure 4. Left, Vertigo's PCS container (a) and above, a completely rigged AGAS package ready to fly (b).

DEVELOPMENT OF AFFORDABLE GUIDED AUTONOMOUS PARACHUTES, *continued from page 39*

four places. The flyaway lanyard that arms the AGAS pneumatic system is connected to the parachute deployment bag, then a non-breakaway extraction parachute is attached to the G-12 parachute and the static line is stowed.

The full weight of the AGAS system (including PMAs control system, tanks, hoses, PMAs, container, batteries, sensor suit, and GNC computer) is about 80*kg*. When fully charged with gas the system weights about 11*kg* more.

The GNC electronics package, which is installed into a box in the payload, is connected to the AGAS valve control unit. When the system rigging is complete, the system is pressurized with compressed nitrogen gas and the pneumatic system batteries are charged. The main power switch and main pressure valve remain off until the system is loaded in the aircraft.

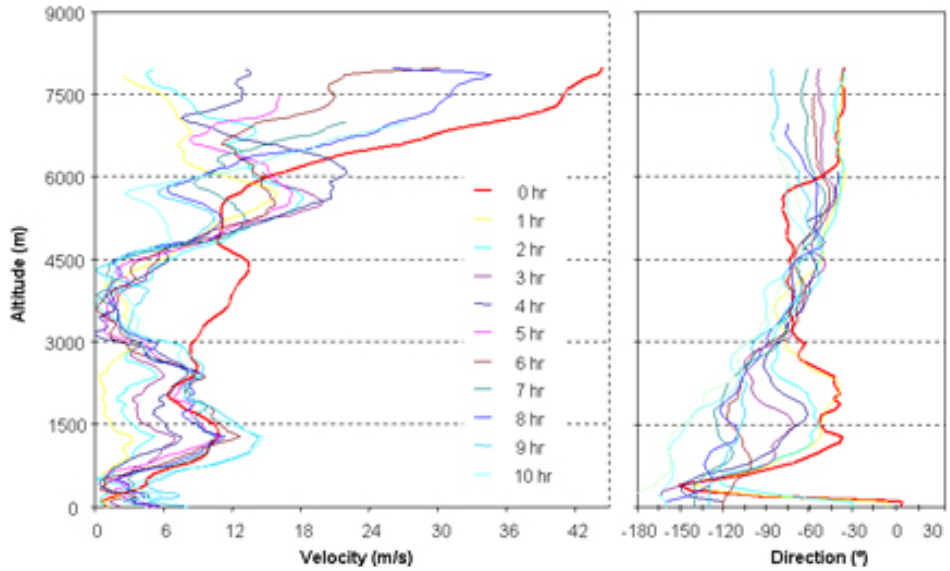

Figure 5. Measured wind velocity and direction versus altitude.

CARP and RT Computation

Figures 5 and 6 illustrate the need for the latest available wind profile in the DZ when pre-computing RT. Figure 5 includes plots of the magnitude and direction of the wind measured by eleven Rawinsonde balloons (Figure 7) released at one-hour intervals at the YPG "Tower M" DZ. It is seen that not only the magnitude of the wind changes significantly in time, but also that the wind may switch directions.

Figure 6 includes simulation results obtained at NPS that demonstrate what might happen to an uncontrolled parachute if released at later hours from the CARP computed for the hour 0.

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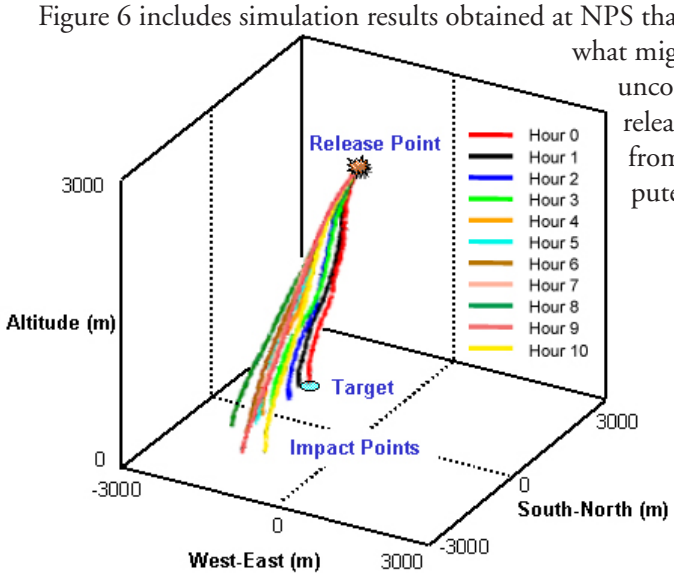

Figure 6 (left). Uncontrolled trajectories with the different wind profiles. Figure 7 (right). Rawinsonde balloon.

DEVELOPMENT OF AFFORDABLE GUIDED AUTONOMOUS PARACHUTES, *continued from page 40*

Clearly, even a one-hour delay may cause significant errors at the impact point (IP).

Presently as a part of the AGAS effort Draper Labs and PSI developed a highly sophisticated system that provides accurate prognosis of the wind over the DZ to be used for generation of the CARP and the RT[36]. At the moment this system consists of two field laptops. One of them (Precision Air Delivery Planning System (PAPS) PC) resides aboard a C-130 carrier aircraft and is linked to the aircrafts data bus. Its software is designed by Draper Labs to produce CARP and RT and relies on the best available wind profile generated by PSI's (Planning Systems Inc.) software residing on the second WindPADS (Wind-Profile Precision Aerial Delivery System) PC.

To derive preliminary CARP prior to flight, Planner PC is initialized with the set of required data (nominal DZ location, AGAS characteristics including its payload properties, pre-release location of the AGAS in the aircraft cargo bay, aircraft characteristics, nominal payload release altitude, and even the likely uncertainties in the entire input data set). Using an Ethernet connection it also accepts forecast wind and atmospheric density field data over the DZ provided by WindPADS PC. These fields are produced by the three-dimensional Mesoscale Model, 5th-generation (MM5) forecast field executed on a stationary computer on the ground based on the data provided by the last available Rawinsonde balloon. These high-resolution forecast fields have a horizontal grid spacing of 1.1*km* with appropriately scaled vertical resolution.

The PAPS PC's data bus connection is used in a read-only mode to obtain and record the aircraft's position, velocity, attitude, and wind-at-altitude data. This data is used to track aircraft location relative to the DZ to enable Planner prediction of the expected time for key events leading up to payload release. The Planner can also accept in-flight user updates to modify the designated TA. This can also be an update provided en route from the ground. When the carrier aircraft nears the DZ at the cruise altitude, a dropsonde is deployed from the carrier aircraft to measure the wind/density profile over/near the DZ following an initial pass through a dropsonde CARP. A transmitted, raw dropsonde RF data signal is received by WindPADS PC through the aircraft UHF antenna, and is processed to produce horizontal wind components as a function of location and time along the dropsonde descent trajectory. The top of the wind profile may also be supplemented with aircraft's wind-at-altitude data produced at the time of dropsonde release.

The updated wind profile near TA is processed in a WindPADS PC's routine that assimilates the new information with the initial MM5 forecast data to produce an accurate, 3D wind and density forecast data set. The Planner PC retrieves this data, produces CARP and RT, and transmits them through a serial port to a wireless transmitter that provides this data set to the AGAS while on-board the carrier aircraft. In an operational implementation, the Planner PC is supposed to determine a desired approach direction for the CARP, and display corresponding navigation data including flight path to the CARP and time-window prompts for permitted release to the crew.

GNC Algorithm Development

As discussed above the actuation box for PMAs developed by Vertigo is capable of only bang-bang control. Optimal control analysis conducted at NPS suggested that bang-bang is also the optimal control strategy and produced an important concept of an operating angle. This motivated a basic control concept for AGAS. Since the time-optimal control strategy was shown to minimize the number of actuations for a planar model this strategy was employed to get the parachute to within a predefined altitude-dependent TA (defined by inner and outer cones discussed next) and then for the remainder of descent to stay within this area. In addition, this basic strategy must be robust to uncertainties in yaw motion. These considerations were used to develop the NPS GNC algorithm[28] for AGAS and are detailed next.

Basic Control Architecture

Considering the relatively low glide ratio demonstrated in flight test (see Table 2) AGAS can only overcome less than 4*m/s* wind. It is therefore imperative that the control system steers the parachute along a pre-specified RT obtained from most recent wind prediction. This can be done by comparing the current GPS position of the parachute with the desired one on RT at a given altitude to obtain the position error $\vec{P}_e(h)$.

This position error $\vec{P}_e(h)$ is computed in the local coordinate system with an origin in the TA and is then converted to the body axis using an Euler angle rotation ${}^{B}_{I}R$ computed using yaw angle only. The resulting body-axis error $\vec{P}_B$ is then used to identify error angle (EA). In turn EA is then used to define what PMA (i = 1,...,4) must be activated (by definition EA is counted from PMA #3 counterclockwise, i.e.

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DEVELOPMENT OF AFFORDABLE GUIDED AUTONOMOUS PARACHUTES, *continued from page 41*

in the situation shown as example on Figure 8 PMAs #2 and #3 would be activated (vented).

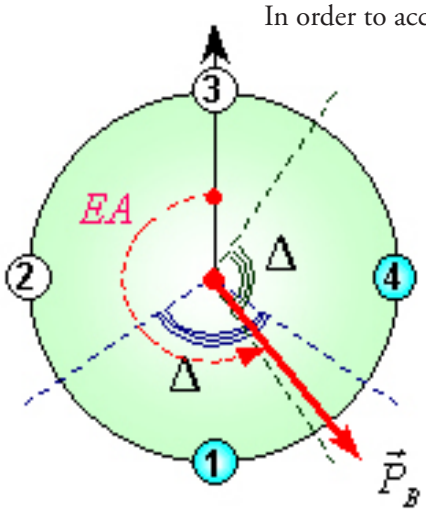

Figure 8. Control-activation rule.

In order to account for the refill time and sensors errors the operating angle was set to $\Delta \approx 2.5$ instead of $\Delta = \pi$. On the earliest AGAS versions refill time was not constant and was equal to about 20 *sec* at the end, that for the yaw rate of $2^o/s$ gives around 40°. This still allows the activation of a single control input or two simultaneous control inputs without significant degradation of AGAS performance.

Outer and Inner Cones

First of all, the initial error after deployment should not exceed a certain value because of AGAS' limited control authority. This area of attraction has the radius R_A around RT that can be roughly estimated by a simple formula:

$R_A(h) = 0.8 k_\Delta G R_{max} h$, where $k_\Delta \approx \Delta\pi^{-1}$.

To eliminate unnecessary actuations of PMAs a tolerance (outer) cone was established (Figure 9). Its radius at CARP (at an altitude of 3000*m*) is $R_{outer}(3000)$ = 200m-radius and it decreases linearly to $R_{outer}(0)$ = 100m-radius circle at the TA (at ground level). Should the magnitude of the position error in the lateral plane be outside of this tolerance cone a control is activated to steer the system back to the planned RT.

When the system is within the inner cone R_{inner} (which is set to 60*m*-radius regardless of altitude) the control is disabled and the parachute drifts with the wind (R_{inner} was selected to account for the refill time) until outer cone is reached and control is activated again. The basic control strategy uses the following **activation rule**: both the tolerance cone and the operating angle constraints must be active for a given PMA to be actuated.

Robustness Issues

The control algorithm outlined above was flight tested at YPG. As expected the number of PMA actuations was unacceptably high. This resulted in a premature emptying of PCS tanks. Analysis of flight test data indicated that this was caused by frequent heading changes and that these changes occurred when one of the adjacent PMAs was actuated while the other one was in transition from vent to full or vice versa. Figure 19 explains this phenomenon. If one PMA is activated (vented) and adjacent PMA is performing a transition from one state to another this causes a yaw moment $\bar{M}_e$. This moment can be useful (when the direction of rotation of the vector $\bar{P}_B$ is opposite to the direction of, or harmful (vice

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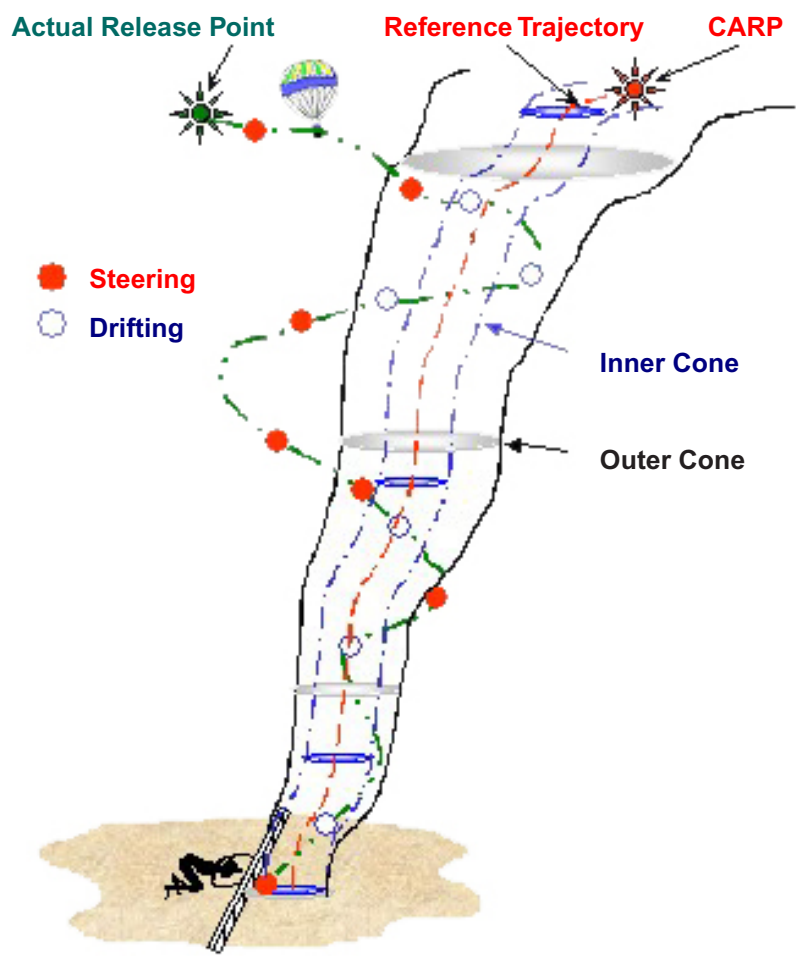


Figure 9. Outer and inner cones.

DEVELOPMENT OF AFFORDABLE GUIDED AUTONOMOUS PARACHUTES, *continued from page 42*

versa). In the latter case the rotation of the parachute under the action of $\vec{M}_e$ causes a deactivation command to the PMA that was just activated. Moreover during this deactivation the useful moment in turn makes the situation even worse. This case is shown in Figure 10.

To eliminate unnecessary activations delay logic in each PMA channel was introduced. Any new command that requires change in the PMA state triggers the delay timer. While the delay timer is active no command is executed including the triggering command. At the end of the delay the timer is reset and the first available command is executed until the next command that requires change in the PMA state triggers the delay timer again.

The number of unnecessary actuations can also be reduced by introducing hysteresis as shown in Figure 11. Both delay and hysteresis angle values can be adjusted as a function of system dynamics and in principle achieve the same result.

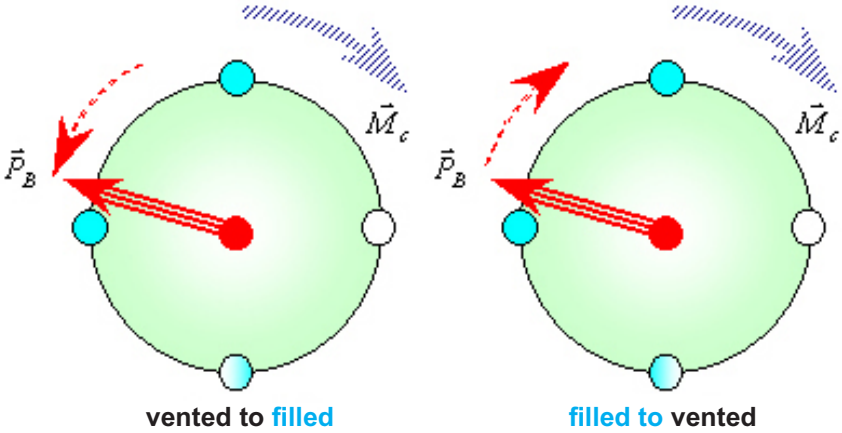


Figure 10 (above). Positive (left) and negative effect of PMA transition moment.

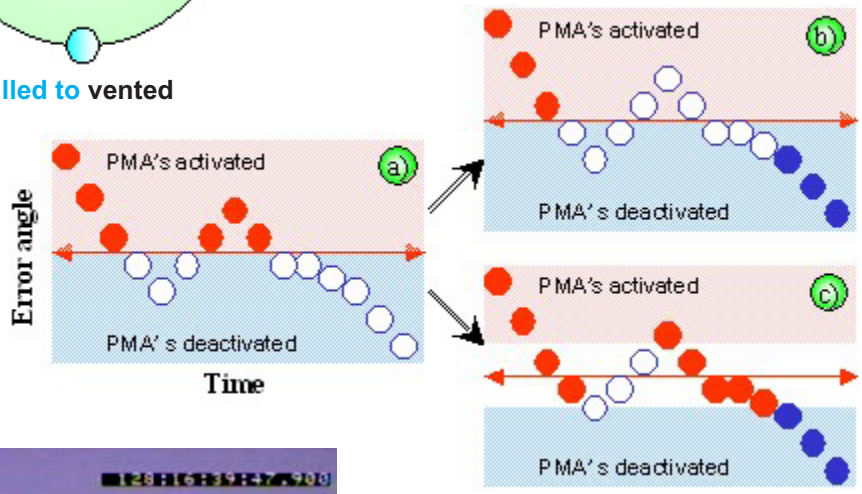
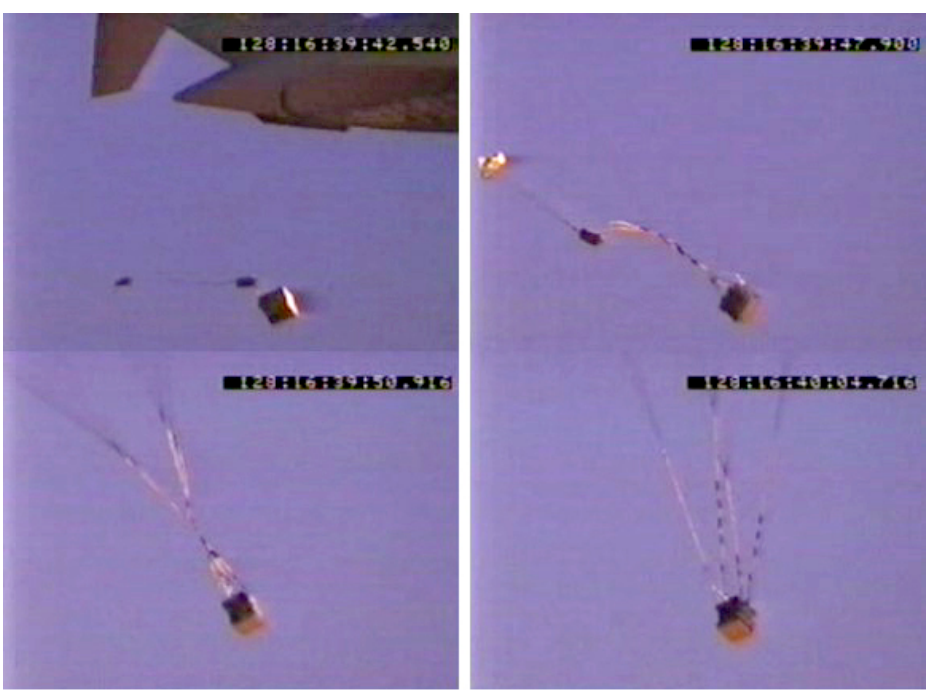


Figure 11 (right). Two ways of decreasing the influence of yaw oscillations.

Figure 12 (below). AGAS deployment and risers untwisting sequence.



Deployment Delay

As a safety precaution the GNC system starts implementing control commands 25 seconds after initial deployment. This time is needed for AGAS to be released, for main canopy to be fully deployed and for risers to untwist as shown in Figure 12.

By design the initial shock during deployment is absorbed by 6-ton Kevlar load lines. So all PMAs are initially vented (when vented they are longer than Kevlar load lines). The first command sent and

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executed after 25-second deployment delay is to fill all PMAs (as shown in Figure 13). After an additional 5*sec* any other command can be executed.

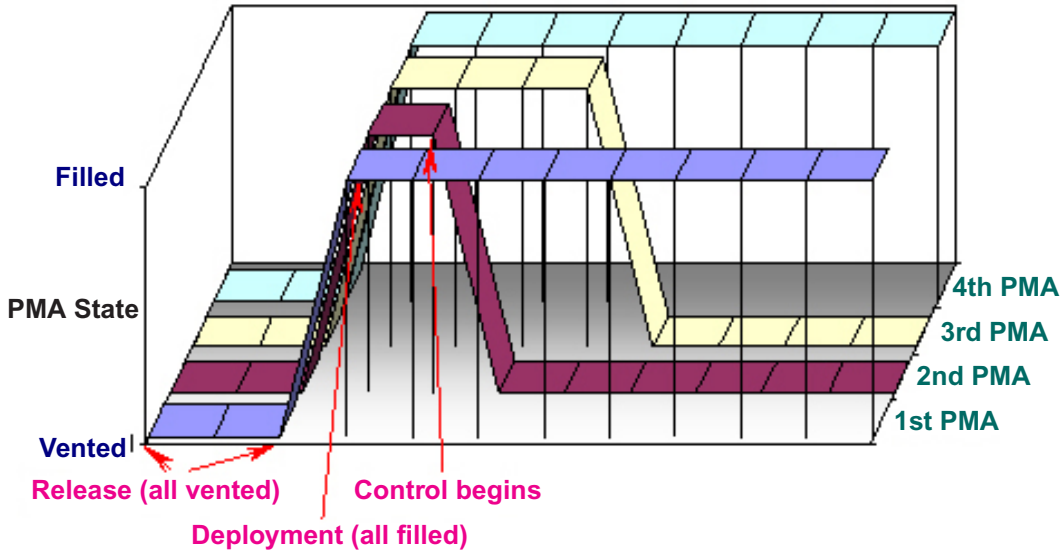

Figure 13. Control history immediately after release.

Flight Test

A total of about 15 controlled drops were made at YPG to test the AGAS concept. The final demonstration took place at YPG during the Precision Airdrop Technology Conference and Demonstration (PATCAD) on September 13th and 14th, 2001[31]. During preliminary tests a ground station was used to control AGAS via a wireless modem[29]. The AGAS sent its current position and heading to the ground station, the ground station processed the data using the flight control algorithm and then issued appropriate commands to the AGAS GNC. For the final drops all GNC algorithms were executed aboard AGAS. The downlink message was used for real-time monitoring during the drop.

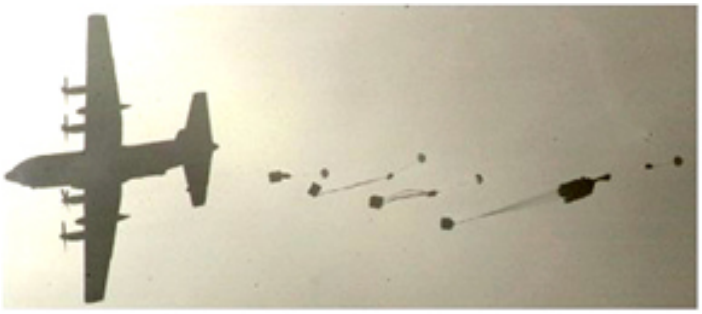

Figure 14. Deployment sequence.

Flight Test Set-up

According to the general procedure after AGAS had been rigged, pressurized, and charged, it was taken to the scales to be weighed, and a communication link check was also performed. Next, the system was loaded onto the aircraft and the main valve was opened.

When the aircraft was at a drop altitude and before it started its cold pass over the DZ, the main power switch was turned on and the GNC hardware was armed. As the plane arrived at the CARP, the AGAS system was deployed, as well as a door-deployed wind-pack bundle that was weighted to descend at the same rate as the AGAS system (to provide real wind profile during the drop for the future analysis). Figure 14 shows the sequence of deployment during PATCAD demonstration. To make the difference between the non-controlled and controlled parachute more clear two standard

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DEVELOPMENT OF AFFORDABLE GUIDED AUTONOMOUS PARACHUTES, *continued from page 44*

G-12 and two AGAS (followed by the wind-pack) were deployed simultaneously.

After landing (Figure 15) everything was checked, rigged again and prepared for the next drop.

Figure 15. After the drop.

Flight Data Analysis

Several same-weight category systems including both circular parachutes and parafoils were demonstrated at PATCAD. AGAS performed better than others. The miss distance for the four AGAS systems released was less than 78*m* as opposed to 140...1370*m* for uncontrolled parachutes (see Table 3).

Date	Test Item	Weight (kg)	IP miss (m)
9/13/01	*WindPack*	21	515.1
	STD G-12	724	512.2
	STD G-12	773	141.9
	AGAS-1	**726**	**76**
	AGAS-2	**726**	**78**
09/14/01	*WindPack*	21	1048.6
	STD G-12	726	1371.6
	AGAS-4	**726**	**55.5**

Table 3. PATCAD results

Figure 16. Two AGAS steering towards CARP.

Figure 16 shows that the same control algorithm being employed by two AGAS led to the impact of two systems during the first drop. For the second drop different TA were input into the GNC systems of the two parachutes to avoid possible collision.

Figure 17 demonstrates the integral data for two first-day drops from the altitude of 3000*m*. The 30-*min* old wind data was used to compute the RT. It is seen that regardless a large initial error both AGAS steered to the TA fairly

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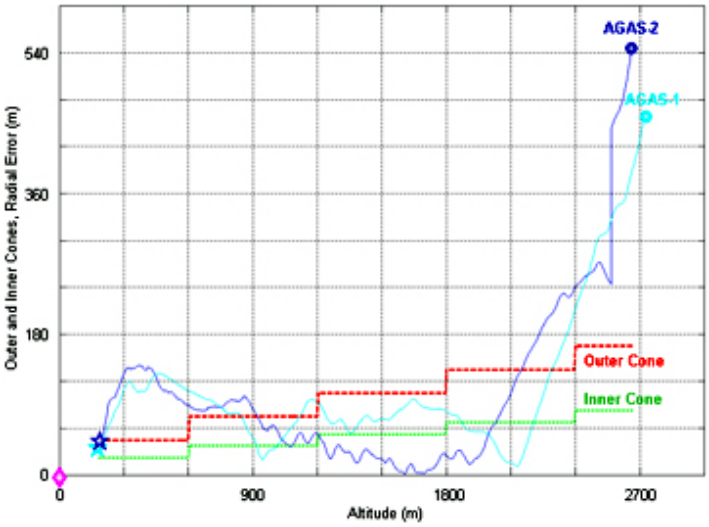

Figure 17. September 13, 2001 3000m drops.

DEVELOPMENT OF AFFORDABLE GUIDED AUTONOMOUS PARACHUTES, *continued from page 45*

well, 17 and 18 PMA activations were needed to hit the target with approximately the same miss distance.

Figure 18 presents the same kind of data for the second set of AGAS on September 14, 2001 (released at 5000*m*). The wind profile used for this drop was two hours old. Observe that in spite of coincidence of the AGAS-4 actual release point with its CARP because of bad wind estimate, the parachute drifts out of RT for the first 1000*m*. However upon leaving the outer cone it is steered back inside. As soon as the PMAs inflate upon entering the inner cone the AGAS proceeds to drift out again.

Figure 19 shows the control-related data for the AGAS-4. 28 PMA fills were needed to hit the target with a 55*m* miss.

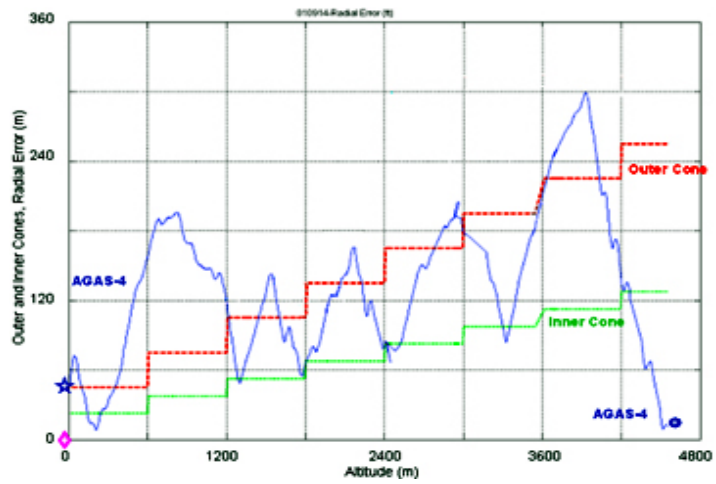

Figure 18. September 14, 2001 4500 m drops.

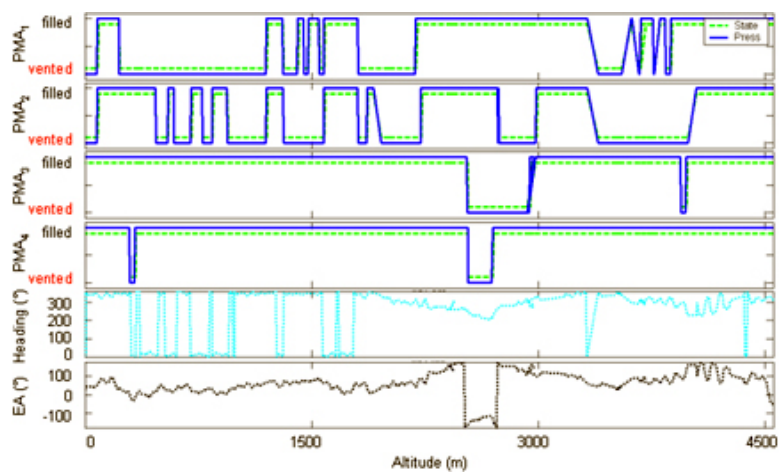

Figure 19. AGAS-2 control data.

Present and Future Work

Results presented in this article showed feasibility of the AGAS concept. A bang-bang control strategy imposed by the PMA hardware was developed to successfully drive AGAS to TA within prescribed circular error in flight tests at YPG. The key to the success of this strategy were concepts of operating angle motivated by optimal control analysis as well as inner and outer cones and hysteresis included to improve performance robustness.

Establishment of Aerodynamic Decelerator Systems Center

The success of the AGAS effort has led to the establishment of the Aerodynamic Decelerator Systems Center (ADS-C). The center's membership includes the U.S. Army Natick Soldier Center, the U.S Army Yuma Proving Ground and the Naval Postgraduate School and is governed by a Board of Directors, chaired by Natick with members from all three organizations. Presently the main focus of the Center's activities is to identify technology areas that are critical to the success of precision air delivery but lack in maturity or are unavailable due to proprietary issues The goal is to address these areas and to form partnerships with other government organizations, academia and industry to bring these areas to technological maturity and transition them to development programs and eventual fielding. The main emphasis of the current efforts at the Center is the development of GNC algorithms for high-glide precision air delivery systems. Other areas of interest include the development of rapid-prototyping methods supporting ADS initiatives and the development of affordable, portable and robust instrumentation suites for full data collection from airdropped and ground-launched systems. Work with joint partners includes computational fluid dynamics for improved initial aerodynamic modeling and system parameter estimation for dynamic model validation and enhanced aeromodeling from airdrop test data.

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In linear theories the development depends on diabatic heating due to cumulus convection. However, organized cumulus convection does not start until the initial disturbance reaches finite amplitude, when the validity of linear theories have already broken down. In the tropical West Pacific east of the Philippines, the summer monsoon is characterized by a low-level background flow, which is westerly (eastward) in the west and easterly (westward) in the east. With a simple barotropic model and considering only the zonal flow, it was demonstrated that the scale contraction by the confluent background flow, the nonlinear dynamics, the effect of the planetary vorticity gradient, and the convergence at scales larger than the disturbances are important for the energy and enstrophy accumulation near the region where the opposing zonal flows encounter each other. The accumulation continues when vorticity-conserving Rossby waves continuously propagate into the region from east. Longer waves experience less scale contraction and nonlinear effects, while shorter waves cannot hold a coherent structure against dispersive effects. Thus, the largest accumulation occurs for zonal wavelength around 2000 km.

With a realistic monsoon-type background flow, the model produces a northwestward propagation pattern with an approximately 8-day period and 3000 km wavelength, which is in general agreement with observed disturbances in the Northwest Pacific. The intensified disturbance may disperse energy upstream, leading to a series of trailing anticyclonic and cyclonic cells along the propagation path. When an opposing zonal flow is present, the energy dispersion leads to the formation of new disturbances in the confluence zone by a vortex *axi-symmetrization* dynamics. Thus, these results indicate that the scale contraction and nonlinear effects may cause a succession of tropical disturbances to develop without disturbance-scale diabatic effects.

Symmetrization is an important process for tropical vortices cyclones to organize and grow into tropical cyclones. This is an important issue and a major difficulty in tropical cyclone forecasting, in which the operational forecast capability is much better on tropical cyclone motion than on intensity change. In his thesis research, **LCDR Henry Miller, USN,** applied the barotropic spectral model to integrate annular

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bands of enhanced potential vorticity to simulate typhoon eyes with varying degrees of offset from the center of the vortex. He also conducted experiments to integrate offset monopoles of vorticity that simulates asymmetric convection in tropical storms. The experiments demonstrated the breakdown of the unstable typhoon eyes into a series of mesovortices that eventually relaxed to monopolar or tripolar final states (Figure 2). The offset monopoles formed spiral bands and became symmetric. Very quick transfer of kinetic energy occurred throughout the various stages of the processes. This work highlighted the importance of dynamics in addition to moist and boundary layer process in building the tropical cyclone strength.

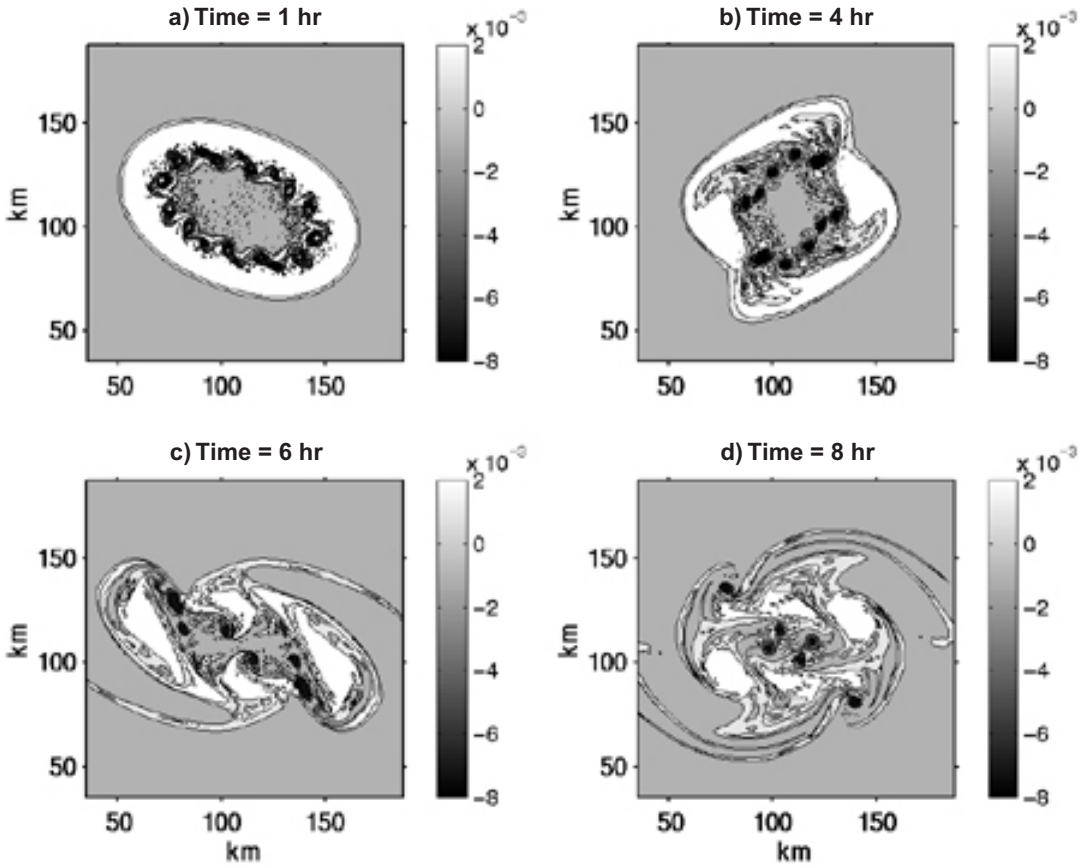

Figure 2. The evolution of the vorticity pattern of a large tropical cyclone eye that is initially symmetric.

At present the model is being expanded into a three dimensional model to include the vertical coupling of the system. This will allow the study of the effect of the tropical upper tropospheric trough on the disturbance development, a process that is often suspected for typhoon intensification but there is little understanding in the specific physical mechanisms involved.

Onset and Development of Weather Disturbances in the South and East Asia and the Neighboring Seas (Office of Naval Research)

This component studies the development and evolution of weather disturbances from the eastern Indian Ocean to around Southeast Asia and its vicinity. It consists of two approaches. In the observational studies the disturbances' space-time structures are studied by a combination of data sources that include station reports, satellite rainfall and scatterometer winds, model analyses, and field data collected during the South China Sea Monsoon Experiment. In the model simulation and prediction, the Navy's current operational global and regional prediction models are used. The process also involves the assessment of the analysis and prediction skills of Navy's operational models and the suitability of parameterization schemes (the assumptions of the sub-model grid physical processes) in representing these disturbances, and the identification of clues useful for model improvement efforts.

In late spring the cross-equatorial flow produces southwesterlies north of the equator, and convective systems are active in the northern tropics. The earliest onset of the summer monsoon occurs in the South China Sea and Bay of Bengal; when strong southwesterly winds develop and persist over a large span of the region, and heavy rainfall associated with convective disturbances develop. The rainfall marks the

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beginning of the East Asian summer monsoon rainbelt, which started to affect southeastern China and southern Japan, with convective vortices and heavy rainfall actively developing along the belt. The monsoon rainbelt alters between a stationary phase and a northward jump phase, finally setting down in a region that extends from northern China to Yellow Sea and Korea (Figure 3).

A major question that is important both scientifically and for military planning purposes is the timing of the South China Sea monsoon onset and the subsequent phased development of the monsoon rainbelt and convective disturbances. This timing marks the transition of the relatively tranquil pre-monsoon season to the disturbed monsoon season in various parts of Southeast and East Asia. For example, due to its inferior air force, the only time North Korea might expect some success from an all out attack to the south is around the 1-2 weeks of heavy cloudy weather in mid-late summer after the monsoon onset in the Yellow Sea and the Korea Peninsula.

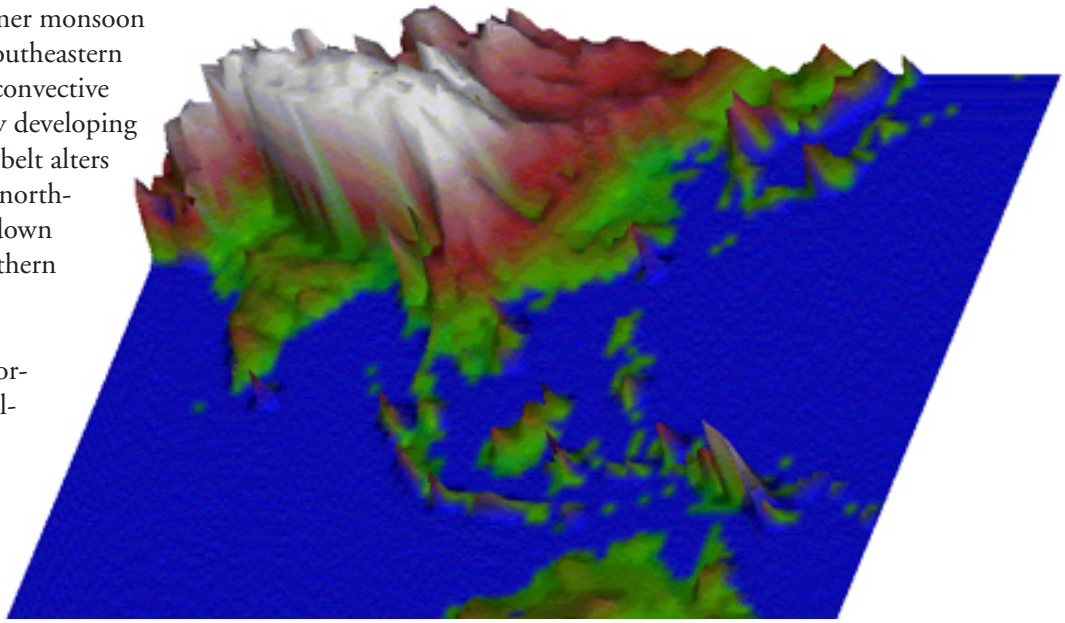

Figure 3. Schematic diagram indicating the late-spring onset of the Asian summer monsoon over the South China Sea and Bay of Bengal. The onset is manifested by the development of strong low-level southwesterly winds that persist over a large span of the region, and heavy rainfall associated with convective disturbances. The rainfall marks the beginning of the East Asian summer monsoon rainbelt, which started to affect southeastern China and southern Japan, with convective vortices and heavy rainfall actively developing along the belt. The monsoon rainbelt alters between a stationary phase and a northward jump phase, finally setting down in a region that extends from northern China to the Yellow Sea and Korea.

The research at NPS has yielded important results on the onset and development mechanisms for the summer monsoon. In particular, the traditional view that the monsoon onset is largely a tropical process is shown to be substantially incomplete. For example, **LCDR Eric Gedult von Jungenfeld's** thesis research of analyzing 20-year's onset process of the South China Sea monsoon discovered that a major factor in determining the timing is the variation of the low-level northeasterly wind over the extratropical midlatitudes. Diagnosis and simulation studies with the use of Navy's regional operational model showed that midlatitude baroclinic (strong thermal gradient and vertical wind shear) processes played major roles in both the timing of the onset and the enhancement of the severe weather-producing vortices along the East Asian summer monsoon rainbelt. The baroclinic processes include both the lee-side cyclogenesis mechanism on the southeast foothills of the Tibetan Plateau, the lower atmospheric frontogenesis mechanism as the higher latitude air moves into east and southeast China, and the upper-level "tropopause folding" mechanism in which strong potential vorticity of the very stable stratospheric air is injected into the tropospheric weather systems causing the latter to intensify.

During the winter monsoon, the most disturbed weather associated with deep cumulus convection and heavy rainfall occur in the island-sea complex of the maritime continent in Southeast Asia. This region encompasses Indonesia, Malaysia, Singapore, Borneo, Philippines, and the surrounding land and oceanic regions. The winter monsoon season is marked by northeasterly winds across the northern hemisphere subtropics and a shift of the Inter-tropical Convergence Zone – the main convection belt to the equator and further south. Here the convective disturbances, with their torrential rainfall and

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strong winds, significantly affect Navy operations.

The convective disturbances are often enhanced by two types of external disturbances, with markedly different time scales, that move into the region. On the longer scale is the active convective phase of the Maddan-Julian Oscillation (MJO) originating from the Indian Ocean. Its time scale varies from one to two months and is an important feature of tropical climate variations. When the active phase of MJO enters the maritime continent the associated strong westerly winds and cloud clusters tend to boost the development of convective vortices. On the shorter scale is the sudden acceleration of low-level northeasterly winds across the South China Sea, called cold surges, which can develop within 24 hours over a vast area that extends from the southern coast of China to the equator. Thesis research done by **Capt Sylvia Taylor, USAF,** and **LT John Simms, USN,** demonstrated that when the cold surges quickly penetrate into the southern tropics, intense convection disturbances and even tropical cyclones may develop, in particular if the surges occur during an active MJO phase (Figure 4). A current project is to analyze the development of Typhoon Vamei near Singapore the day after Christmas 2001. Typhoon Vamei was the first recorded tropical cyclone development within one degree of the equator. The unexpected >60 knots winds caused considerable damage to the *USS Nimitz* as it was returning from the Afghanistan theater.

The Interannual Variations of the Asian Monsoon and Its Relationship with El Niño-Southern Oscillations (National Oceanic Atmospheric Agency)

The Asian monsoon undergoes strong interannual variability that cause anomalous disturbance weather activities and drought-flood conditions over a region that includes two third of the world population and is of primary U.S. economic and security interests. This component studies the property and structure of the variability and its possible relationship with global changes and other climate systems, particularly the El Niño-Southern Oscillation (ENSO).

An important variability in the vast monsoon region is

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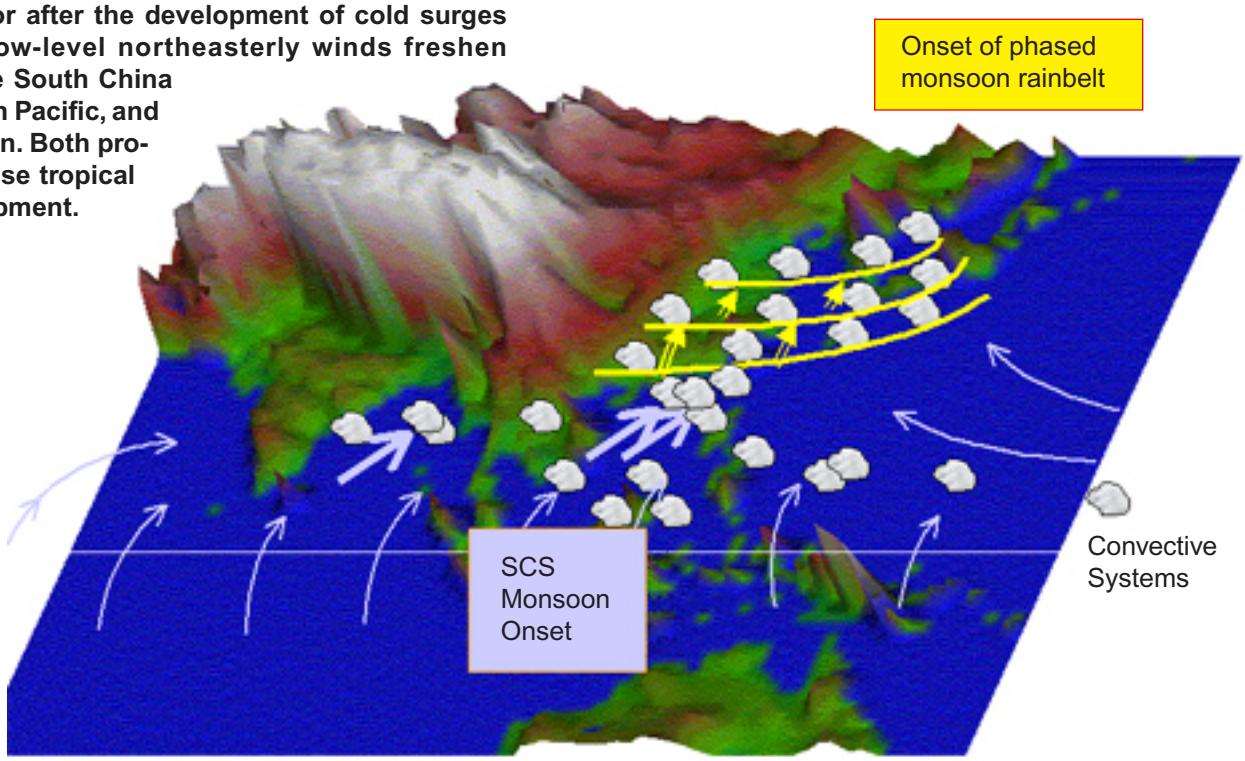
Figure 4. Schematic diagram indicating the development of tropical convective disturbances over the maritime continent during the Asian winter monsoon. The development of strong winds and torrential rainfall often occurs as the active phase of the Maddan-Julian Oscillation moves into the region from the equatorial Indian Ocean, or after the development of cold surges in which the low-level northeasterly winds freshen rapidly over the South China Sea, the western Pacific, and the Indian Ocean. Both processes can cause tropical cyclone development.



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the nearly biennial oscillation of the rainfall and wind, which is often observed in many parts of South and East Asia, the Indian Ocean, tropical West Pacific, and Australia and East Africa. There is also evidence that the oscillation exist in the sea-surface temperature (SST) and upper-ocean thermal fields. This trend of nearly once a year reversal of the rainfall and wind anomalies during the summer and winter monsoon seasons is called the tropospheric biennial oscillation (TBO), which is distinct from the quasi-biennial oscillation of the equatorial zonal wind in the stratosphere that was discovered much earlier. Although the TBO at different locations have the similar two-year periodicity, there are great variations in its behavior, structure and variability. There have long been hypotheses that the TBO in the monsoon region is related to the tendency of a similar periodicity in the eastern equatorial Pacific SST, the ENSO events whose strongest manifestations are the El Niño (warmer SST) and La Niña (cooler SST) events. However, many questions exist, in particular the question on how the sign of the anomaly of the winter monsoon (convection center over maritime continent and Australia) tend to follow that of the summer monsoon (convection center over South Asia), and what are the roles of the cross-seasonal interaction of the Indian Ocean and tropical Pacific.

The questions were addressed in a simple analytical model by **Professor C. P. Chang** and Dr. Tim Li when he was a Research Assistant Professor at NPS. They demonstrated that the combined effects of four feedback mechanisms: the SST-monsoon, the sea surface evaporation-wind, the monsoon convection-equatorial tropospheric overturning, and sea surface wind-thermocline, can give rise to the seasonal evolution of TBO (Figure 5). The theory explains why TBO can maintain the same phase from northern summer to northern winter and why a reversed phase of TBO can last three locally inactive seasons to affect the next year's monsoon. This theory proposed that instead of being a "weaker sister" and a passive respondent to the ENSO variations, the TBO is primarily driven by the Asian monsoon system and plays an active role in the interaction with ENSO.

Based on previous strong El Niño events, prediction of the effects of the record-breaking 1997-98 El Niño on the precipitation anomalies in North America and the equatorial maritime continent were quite successful. However, the prediction of large deficits in rainfall over Australia and South Asia did not materialize. Recently, the Chang-Li theory was used as the basis to study the interactions of the two oscillations. The results show that the nonlinear interaction of the two modes may produce a variety of solutions that may explain the complexity of the observed monsoon-ENSO relationship.

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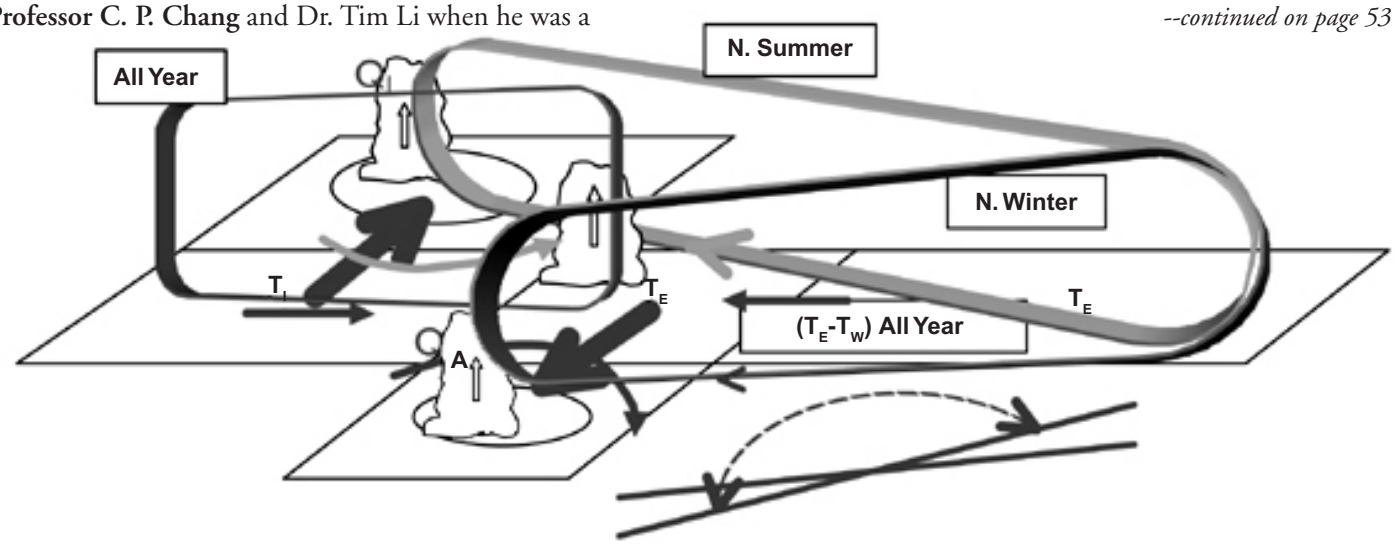

Figure 5. Schematic diagram summarizing the important atmosphere-ocean interactions that lead to the tropospheric biennial oscillation. The primary sea-surface temperature change mechanism is through wind-evaporation feedback for the Indian Ocean, thermocline tilting for the eastern equatorial Pacific, and both for the western equatorial Pacific. The western equatorial Pacific plays the key roles both in allowing the northern summer monsoon to influence the northern winter monsoon, and in the maintenance of the Indian Ocean surface wind anomalies until the next monsoon by linking the feedback of the Australian monsoon to the Indian Ocean.

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Another study focused on the weakening of the relationship between South Asian summer monsoon and ENSO during the recent decades. There were hypotheses that this weakening relationship is a result of global changes that involve a shift in tropical Pacific rainfall patterns and the global warming. Our study, using historical data of land surface temperature, surface air temperature, SST and rainfall, brought out the possible influence of the continental scale warming of the Eurasian landmass, and the effect of the North Atlantic Oscillation-Arctic Oscillation. The latter is an interannual and inter-decadal scale oscillation of pressure and other variables observed at the atmospheric surface and various levels. The result of this work was published as a highlighted article in the *Journal of Climate*.

Presently, the project is studying the variability of monsoon rainfall in the equatorial belt, particularly the effect of the Indian Ocean SST and surface wind variations on the interannual variability of winter monsoon rainfall in the vicinity of Malaysia and Indonesia. Visiting Ph. D. student **Zhuo Wang** from the University of Hawaii is working on the teleconnection effects of the East Asian and West Pacific monsoon variability, which during certain flow regimes appears to impact significantly the climate variation in North America.

Forecast of Cloud Cover Over the Maritime Continent (Naval Sea Systems Command)

This component, a collaborative project with the Ministry of Defense of the Republic of Singapore, studies the mesoscale distribution and variability of cloud cover over the maritime continent and develops empirical forecast models of cloud cover in the region.

In the U.S., cloud cover forecast is done through a combination of synoptic (conceptual) models and regional numerical weather prediction (NWP) models. The approach of Model Output Statistics (MOS) is also used to increase the usability of NWP. Normally, the cloud-producing weather is influenced by midlatitude systems such as fronts or extratropical cyclones. The understanding of these systems is fairly complete, and there are available synoptic models describing the typical distribution of different types of clouds (cirrus, stratus, stratocumulus, etc.) and the different cloud height that depend on the position relative to the frontal surface, the slope and intensity of the front, etc. The regional NWP forecast also provides additional useful information for cloud forecast, such as the inversion height off the west coast. In this case the forecast of the anticipated level and depth of the cloud becomes a relatively straightforward procedure.

Forecasting of convective cloud distribution and variation in the maritime continent region is inherently more difficult than stable type clouds in the midlatitude region; the latter can form only in the presence of larger-scale organizing mechanisms. The tropical convective clouds are often the results of local conditional instability that operates on short-term spatial and temporal scales. As such, they are more chaotic and have very limited predictability. Furthermore, NWP models are very inaccurate in the tropics and especially in deep convective regions. Even the best global models have not been able to simulate the Inter-Tropical Convergence Zone well, and certainly not the details of the monsoon troughs. Also, if the forecast is to rely on MOS rather than direct NWP forecasts, several years of past forecast outputs from the same model will be required to generate the consistent and homogeneous data for the statistical modeling. As of now, no regional NWP model can demonstrate consistent forecast skill over the maritime continent, so model adjustment must continue. Furthermore, ground based observations over the Southeast Asia have been very sparse in both space and time, rendering the NWP-MOS approach unfeasible for the foreseeable future.

Despite these difficulties, there are strong operational requirements, such as search and rescue missions, which need cloud cover forecast guidance over this region. In this study the high-resolution multi-channel IR data from the Japanese Geostationary Meteorological Satellite and ground-based airport weather reports over the past several years are compared to develop seasonal, diurnal and persistence climatologies of cloud cover at different parts of the region. The resulting climatological forecast models are combined with a synoptic approach using NWP model analyses and satellite scatterometer winds to determine possible effects of several large-scale atmospheric motion systems, including the Maddan-Julian oscillation, monsoonal surges, and cross-equatorial flow that affect the weather in the region.

The highly organized structure of the diurnal cycle, which is a result of the terrain-sea distribution and interactions with seasonal change of the monsoon flow, is an important basis for the predictability of cloud on time intervals of less than one day over the region. Based on thesis research carried out by **LCDR Donna Singelaub**, **USN**, **LT Michael Nickline, USN**,

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and **LT Greg Jimenez, USN,** the mean seasonal march of the maximum diurnal variation of deep convection in the South China Sea vicinity has an arching path between the southern equatorial zone and the northern subtropics, with Indochina serving as the land bridge between the two regions. This diurnal climatology was based on analysis of cloud-top black body temperature for the last 20 years. During the past five years multi-channel satellite IR data are available from the GMS satellite. These data are now processed through a "neph-analysis" which attempts to assign height levels to the clouds. The results will also be compared with NWP model-analyzed atmospheric temperature profiles to calibrate the cloud height. The satellite derived cloud information will be further compared with available airport observations to determine the different characters and biases of the two types of data.

On the annual time scale, the cloud cover over the area is strongly affected by the annual cycle, as this is the region of strong seasonal changes between the northern summer (southwesterly) and northern winter (northeasterly) monsoon. The seasonal cycle may also be disturbed by longer climate events, particularly the interannual variation due to El Niño-Southern Oscillation. For time scales less than the annual cycle, the eastward propagating MJO provides a mechanism that can be analyzed to study intraseasonal cloud variations. Since there is strong interannual and seasonal variation of MJO, the identification and forecasting of the MJO is itself a problem that needs to be studied. This project will evaluate the feasibility of identifying the MJO propagation patterns as a guidance to predict dry or wet weather on a weekly scale. Other large-scale systems that will be studied include the monsoonal surges and cross-equatorial flow. Interactions of these large-scale motion systems can modify the diurnal cycles in the region to produce significant time and geographical variations of cloud variability. There will be situations where the diurnal cycle is disrupted or suppressed by the large scale or synoptic scale disturbances. The analysis of these interactions will be the bases for developing the synoptic model for cloud forecast.

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and defensive detection. Hence a final area of study will be the electrical properties of wi-fi, 3G, and Bluetooth networks in the context of stealth operations.

- *Wireless Propagation*: Successful design and operation of wireless networks requires an understanding of the propagation of microwave signals in the various environments (urban, indoor, battlefield, shipboard, etc.) where the systems will be used.
- *Wireless Signals Intelligence*: Approaches to detection, interception, classification and exploitation of wireless signals in different frequency bands will need to be developed.
- *Navy-Specific Applications:* In addition to general-purpose network connectivity for mobile PDAs, wearable PCs, laptop PCs, and other computers, 802.11 wireless LANs and Bluetooth technology offer many unique productivity-improvement opportunities for Navy-specific applications such as development and deployment of wireless gages and sensors onboard ships.
- *Electromagnetic Interference and Compatibility (EMI/EMC):* To permanently install wireless LANs onboard naval ships, wireless LAN components must be tested and certified against MIL-STD with respect to electromagnetic interference (EMI) and electromagnetic compatibility (EMC). Commercial wireless LAN components comply with FCC Part 15 requirements, but may not comply with MIL-STD requirements.
- *Heterogenous Wireless Testbed*. A wireless testbed will be required to investigate enabling technologies, interference and compatibility and wireless applications. The testbed will permit analysis of performance, scalability, interoperability and integration of emerging standards and technologies for wireless digital networks. The testbed will feature heterogeneous open source and commercial-off-the-shelf components, as well as specialized high-assurance components for trustworthy enforcement of security for Navy enterprise applications. The testbed will permit emulation and analysis of shipboard wireless applications to ensure security and Quality of Service in battle conditions.

The initial focus of the Center will be on the analysis and use of commercial-off-the-shelf (COTS) mobile devices and communications technologies. Some additional research areas include:

- *Future Enabling Technologies*. Investigate future enabling wireless technologies such as spatial filtering (e.g. adaptive beamforming), transmit/receive diversity (e.g. multiple input output systems) and related signal processing. These technologies will enhance capacity and provide resistance to jamming and interference.

CONFERENCE CALENDAR

UPCOMING CONFERENCES/SHORT COURSES/MEETINGS AT NPS

Date	Title	Sponsor
4-6 June 2002	Military Sensing Symposia (MSS) Specialty Group Meeting on Infrared Countermeasures	BAE Systems, Inc.
10-13 June 2002	2002 Command and Control Research Technology Symposium	DoD C4ISR Cooperative Research Program under the direction of the Assistant Secretary of Defense for C3I
14-15 June 2002	Burke Dental Symposium	Naval Postgraduate School
25-28 June 2002	Military Sensing Symposia (MSS) Tri-Service Radar Symposium	Naval Research Laboratory
22-26 July 2002	Classified Technology Review and Update	Naval Postgraduate School
29 July-16 August 2002	Swedish National Defense College Short Course	Naval Postgraduate School
30 July-1 August 2002	BMDO Technology Conference	American Institute of Aeronautics and Astronautics
18-19 October 2002	Symposium on New Trends in Nonlinear Dynamics and Control and Their Applications	Naval Postgraduate School, Air Force Office of Scientific Research, and Southern Illinois University at Carbondale
22-25 October 2002	NECDC	Los Alamos National Laboratory
5-7 November 2002	AIAA Missile Sciences Conference	American Institute of Aeronautics and Astronautics
12-14 November 2002	5th Annual Directed Energy Conference	Directed Energy Professional Society
18-21 November 2002	Aircraft Survivability Symposium 2002 Combat Survivability: UAVs and Manned Aircrafts	National Defense Industrial Association

NPS has excellent facilities for hosting conferences, workshops, symposia, and meetings. The wide range of facilities can accommodate both small and large groups. Additional rooms are available for smaller functions or breakout sessions. Conferences classified through SECRET can be accommodated on the NPS campus. Sensitive Compartmented Information Facility (SCIF) facilities exist and may be available for small groups on a more restricted basis. For more information, contact the NPS Conference Coordinator, Stephanie Brand, at 831-656-2426 or by e-mail, sbrand@nps.navy.mil.

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